Metaphor

Key to Critical and Creative Thinking

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Abstract

The purpose of the following article is to present a theoretical model of metaphors and to show how that model is useful in analyzing exemplars of critical and creative thought. Nothing is more basic to reflective thinking than root metaphors. They constitute the wellspring from which critical and creative thinking flows. When critical and creative thinking interact with one another, they create an exemplar in the history of ideas.

Keywords: critical thinking, creative thinking, root metaphors, model, exemplars

Introduction

Metaphor is the ultimate measure of mind. Aristotle (2020) seems to have grasped this idea when he wrote: "The greatest thing by far is to be a master of metaphor; it is the one thing that cannot be learned from others; and it is also a sign of genius, since a good metaphor implies an intuitive perception of the similarity of the dissimilar." Metaphor is part and parcel to the activity of critical and creative thinking. It is the *sine qua non* of imagination. All the major revolutions in human thought have been sparked by insightful metaphors. From Plato's parable of the cave to Wheeler's "black holes," there is a thought-provoking metaphor peeking out from behind every great idea.

What does it mean to engage in critical and creative thinking?

Much has been written about the topic. We undertake critical thinking whenever we call attention to the shortcomings or fallacies in conventional patterns of thought or action. Reciprocally, when we add a new idea or technique to the culture, we participate in the process of creativity. Unfortunately, these two activities are frequently seen as separate from one another when, in reality, they are joined at the hip. Critical and creative thinking are merely opposite sides of the same coin. Critical thinking is at one and the same time creative thinking. Darwin's theory of evolution, which challenged the religious metaphor of divine creation, provided a new and powerful way of looking at the story of life on this planet.

The following article is based on the contention that academic disciplines—religion, history, humanities, sciences, and the arts—comprise a cognitive prism or synthetic metaphor through which we view and make sense of our experiences. Language is the chief instrument for preserving and conveying these mental images. Our picture of the world consists of two primary types of metaphors, simple and complex. Simple metaphors are created whenever we speak of one thing as if it were another. Moral aphorisms offering sage advice: "A bird in the hand is worth two in the bush." Works of literature such as Shakespeare's line: "What a piece of work is man." Personal judgments we make about others: "He is playing with half-a-deck." Religious references like Paul's New Testaments quote: "For now we see through a glass darkly." Poetic expressions such as Browning saying: "Ah, but a man's reach should exceed his grasp, or what's a heaven for." Finally, jokes of all kinds are simple metaphors. What did Dracula say when he walked into Pete's Restaurant? "I have my heart set on a steak/stake."

Complex metaphors, on the other hand, take the form of theoretical systems used to explain the world around us. The geocentric theory of the universe and its replacement by the heliocentric system offers us an excellent example of both critical and creative thinking. Aristotle adopted the geocentric theory, which became sanctified by the medieval church. The view that the earth was the center of the universe stood as established doctrine for 1,500 years. It was not seriously challenged until Copernicus made his observations. Copernicus argued that a heliocentric system would greatly simplify our picture of the heavens. Copernicus' heliocentric theory was greatly expanded by Galileo, Newton, and Einstein (Brinton, 1965, p. 267).

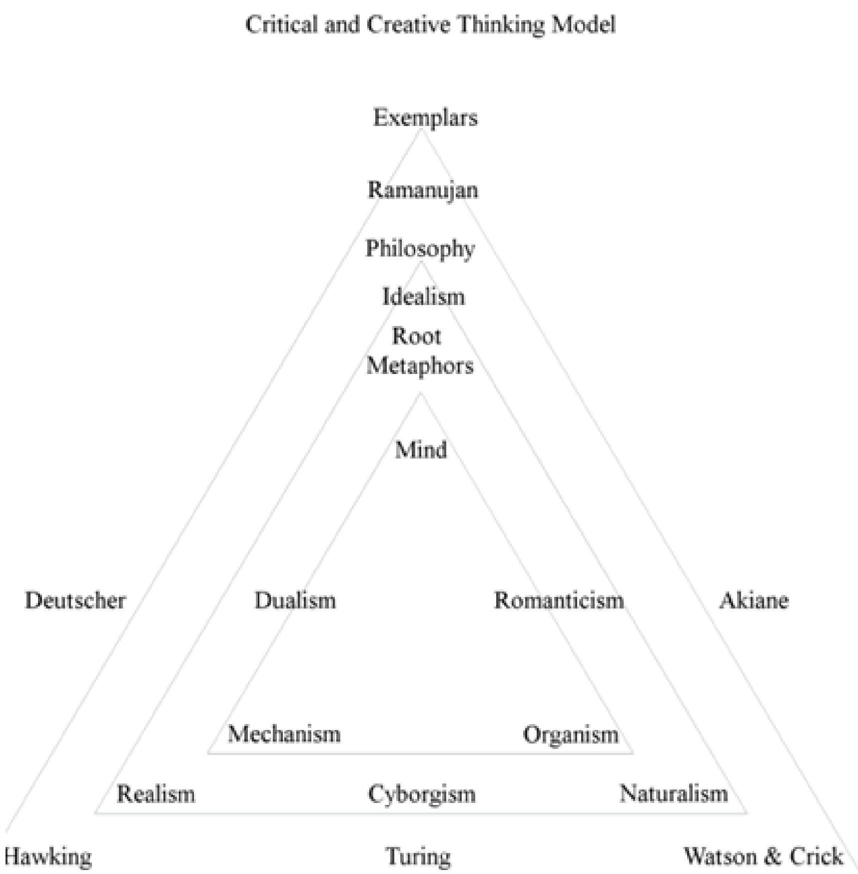
What does it mean to know? Kant (1781/1958) posed an answer that is fundamental to understanding the thinking lying behind the present article. Kant made a distinction between phenomena and noumena. Phenomena are those sense experiences flowing to us from the external world. The mind acts upon these experiences and turns them into knowledge. Noumena, on the other hand, are what Kant called things in themselves. "The concept of a noumenon is necessary, to prevent sensible intuition from being extended to things in themselves, and thus to limit the objective validity of sense knowledge" (p. 155). Kant's insight is echoed by the findings of quantum physics. Musser (2018, June) tells us: "In physics and, more generally, in the natural sciences, space and time are the foundation of all theories. Yet we never see spacetime directly. Rather we infer its existence from our everyday experience" (p. 58).

All abstract or disciplined knowledge is rooted in a limited number of metaphors. Pepper (1972) presents a persuasive case for how root metaphors mold thinking. There is a simple root metaphor lying at the heart of every complex intellectual system. "A world hypothesis is determined by its root metaphor" (p. 96). Root metaphors are useful tools for analyzing abstract systems of thought. They act as keys for "unlocking the doors to those cognitive closets which constitute the literature of structural hypotheses in philosophy and science" (p. 149). Identifying root metaphors is an essential step in becoming a critical and creative thinker.

The organizational schematic underlying the present article offers an imaginative way of looking at the history of ideas as well as the twin processes of critical and creative thinking. The model represents a road map for moving from one topic to the next. The reader may wish to return to the model (Figure 1) when it is not clear how one topic relates to another. The whole model is built around the idea of an expanding body of knowledge. Root metaphors give rise to related philosophies, which in turn support the emergence of academic disciplines or abstract systems of thought. Academic disciplines are composed of principal thinkers, exemplars, who are engaged in pushing forward the frontiers of knowledge. The exemplars provide clear illustrations of critical and creative thinking at its best.

How should one read the model? First, root metaphors are at the center of everything. These are—Mechanism, Organism, Mind—located on the inner triangle. Second, these three metaphors support the principal philosophies—Realism, Naturalism, Idealism—which are located on the second triangle. Composite philosophies are placed at midpoints on connecting lines. Lastly, major thinkers or exemplars are displayed at appropriate locations around the third triangle.

Figure 1



Principal Philosophies

Realism

Background. The mechanistic metaphor underscores the philosophy of realism. Realists believe our senses inform us about a real world external to ourselves. Atoms, planets, and stars are all real; they are not illusions or figments of our imagination. A real world of things exists whether we choose to recognize it or not. Realists contend the most significant features of the universe are its laws. The laws of the universe are not subject to our whims. The mind, metaphorically, operates like a camera taking pictures of the world. When we have a complete picture of reality, we can talk about knowing the truth.

Many scientists have found a comfortable philosophical home in realism. The following three physicists-mathematicians—Weinberg, Greene, and Tegmark—are all contemporary realists. Weinberg (1992) tells us "As a physicist, I perceive scientific explanations and laws as things that are what they are and cannot be made up as I go along" (p. 46). Greene (2003), like most realists, has a correspondence theory of truth. The mind works by absorbing images from the world around us. "The universe in a sense guides us toward truths, because those truths are the things that govern what we see. If we're all being governed by what we see, we're all being steered in the same direction" (p. 70). Tegmark (2014) makes a well reasoned argument for a real universe made of mathematics. "So the bottom line is that if you believe in an external reality independent of humans, then you must also believe that our physical reality is a mathematical structure. Everything in our world is purely mathematical" (p. 8).

Newton, following Galileo's lead, became the primary architect for a mechanistic metaphor for the cosmos. The Law of Gravity became the central construct around which Newton organized his theory. Newton viewed the cosmos as a three-dimensional, closed system in which all the heavenly bodies, through the workings of gravity, checked and balanced one another's movements. "Newton's universe," says Kaku (2006) "was like a gigantic clock wound up at the beginning of time by God which has been ticking away ever since" (p. 26). Space, time, and matter were all separate entities. Space and time were absolute. Time flowed uniformly from the past, through the present, and into the future. A rigid determinism was implicit in Newton's cosmos. All events followed necessarily from natural laws. To measure these occurrences, Newton developed the calculus. "Newton's method," says Jones (1982), "even more than his deciphering the planetary order, is the intellectual legacy of the Enlightenment. And at the core of this method is its mathematical predictive capacity" (p. 36).

Einstein stood Newton's common sense universe on its head. Where did his creative genius come from? His insights, he tells us, came in the form of intuition. "To these elementary laws there leads no logical path, but only intuition, supported by being sympathetically in touch with experience" (Kneller, 1978, p. 165). Einstein fused space and time into a new dimension, spacetime. Gravity, according to Musser (2018, June), was no longer "a force that propagates through space but a feature of spacetime itself. When you throw a ball high into the air, it arcs back to the ground because Earth distorts the spacetime around it, so that the paths of the ball and the ground intersect again" (p. 65). Both Newton and Einstein were devoted realists, believing in a deterministic universe. All events are determined by natural laws. Freedom of will is an illusion. Kaku (2006) cites Einstein as saying: "I am a determinist, compelled to act as if free will existed, because if I wish to live in a civilized society, I must act responsibly" (p. 154).

Though Einstein was instrumental in helping to create quantum mechanics, he later had second thoughts about what it meant for an orderly universe. He was particularly distressed by Heisenberg's interpretation of quantum data. Gleiser (2018, June) quotes Heisenberg as saying: "What we observe is not nature in itself but nature exposed to our method of questioning," (p. 72). The idea that the universe could be at bottom capricious caused Einstein to say: "God does not play dice with the universe" (Boslough, 1989, p. 35). Quantum mechanics and general relativity, according to Kaku (2006), have left us with two very different pictures of the universe. "One for the bizarre subatomic world, where electrons can seemingly be in two places at the same time, and the other for the macroscopic world that we live in, which appears to obey the common sense laws of Newton" (pp. 155-156). Today's scientific quandary is similar to the medieval paradox surrounding the doctrine of the two truths, faith or reason.

Exemplar. Stephen Hawking had a vision of where his life was taking him. He once told Boslough (1989), "My goal is simple. It is a complete understanding of the universe, why it is as it is and why it exists at all" (p. 78). Hawking's vision led him to become one of the most prominent and creative physicists of the 20th century, even occupying the Newton Chair of Physics at Cambridge University. Hawking's life story began in 1942, when he was born into a rather bookish English family. His education followed the private school route, which in time led him to take an undergraduate degree at Oxford University. Having finished his degree at Oxford, Hawking enrolled at Cambridge University to pursue a Ph.D. degree in astrophysics. During his first year at Cambridge, Hawking began to show signs of amyotrophic lateral sclerosis, Lou Gehrig's disease. He was told that he would probably only have a couple of years to live. Thoughts of the disease caused him to slip into a state of depression. However, after two years passed and the symptoms of the disease had not gotten any worse, he returned once again to working on his graduate degree. During this period of his life, Hawking happened to attend a party where he met a young woman, Jane Wilde. The couple fell in love and married. Hawking would later say about his marriage, "Jane really gave me the will to live" (Boslough, 1989, p. 16).

In 1970 Hawking became permanently confined to a motorized wheelchair. His life provides us with an example of how the human spirit can overcome almost any hardship. Hawking's life became one devoted to thinking. Ideas were his tools of trade, his playthings, his recreation, his joy. From his wheelchair, Hawking pursued the adventure of his life—the quest to understand the nature of the universe. Where did everything come from, and what is its ultimate purpose? Hawking credited Friedman, a Russian mathematician, with having been the first person to propose the idea of an expanding universe. If the universe is expanding, it must have had a beginning. Everything started from a singularity that was infinitely dense and infinitely hot, the Big Bang. Hawking believed what happened in the first few fractions of a second following the Big Bang holds the key to understanding all the forces at work in the universe (Boslough, 1989, pp. 16-21).

How can we know what happened in the blink of an eye following the Big Bang? Hawking believed the answer could be found in the features of black holes, which represent an instance where the forces that created space and time are thrown into reverse. Hawking (1996) writes, "The work that Roger Penrose and I did between 1965 and 1970 showed that, according to general relativity, there must be a singularity of infinite density and space-time curvature within a black hole" (p. 114). Hawking (1996) continues, "When I did the calculations, I found to my surprise and annoyance, that even non-rotating black holes should apparently create and emit particles at a steady rate" (p. 133). Black holes were supposed to swallow up everything in their vicinity, including light. Where was the escaping radiation coming from? Hawking's (1996) equations led him to conclude that the radiation was coming "from the 'empty' space just outside the black hole's event horizon" (p. 134). Hawking (1996) tells us that his calculations for explaining how and why radiation escapes from black holes were arrived at by using "both of the great theories of this century, general relativity and quantum mechanics" (p. 142).

Einstein spent the last years of his life looking for a unified field theory—a way of combining the orderly universe predicted by general relativity with the unpredictable world of quantum mechanics. Unfortunately, Einstein's efforts lead to a dead end. Hawking, along with other physicists, joined the search for a theory of everything. To formulate such a theory would require a deep understanding of the nature of black holes because they demonstrate mathematical similarities to those that existed at the beginning of time (Boslough, 1989, pp. 47-48). Hawking took the first steps toward working out such a theory when he applied quantum mechanics to the understanding of black holes.

He came to believe that quantizing gravity was a preliminary step in developing a theory of everything. Hawking informs us, "To unify the four forces in a single mathematical explanation is the greatest quest in all science" (Boslough, 1989, p. 77). Hawking died in 2018, leaving behind the quest for a theory of everything for others to explore.

Naturalism

Background. The organic metaphor underscores the philosophical school of naturalism. Naturalism is one of the oldest continuing philosophical traditions in the western world. It runs back to Thales of Miletus who believed everything was composed of one simple substance, water. Thales is significant because he offered a naturalistic explanation for the phenomena and events we experience around us. Naturalists believe nature is all that there is. Mankind is merely one more part of a purely natural world. There is no need to postulate supernatural explanations for events touching our lives. If one of our family members should suddenly become seriously ill, our first thought is to dash him or her off to the hospital, not to the village shaman. Naturalism leans heavily on the scientific method as the only legitimate way of arriving at truth. Francis Bacon, who was the father of inductive logic, believed science was the *Novum Organum* for the modern mind (Brinton, 1965, p. 268).

Darwin's theory of evolution has become one of the intellectual pillars of modern thought. The idea that humanity has evolved from simpler forms of life has had widespread influence on how we look at ourselves. Evolution has not only given rise to the human body, but it has served as the architect for the most complex organ in the world, the human brain. Paul MacLean, building on comparative anatomy, has formulated a triune brain theory (Sagan, 1977, pp. 53-83). The human brain, it turns out, is really three brains in one. Each brain has retained traces of behavior that were characteristic of earlier species. The oldest brain is the reptilian or R-complex. It is composed of the spinal cord, medulla, and pons. The reptilian brain contains the neural information necessary for reproduction and self-preservation. Aggression, territoriality, ritualistic displays, and established hierarchies are among the characteristics of reptilian behavior. Wrapped around the reptilian brain is the mammalian brain or limbic system. Humans share with other mammals the emotions of fear, anxiety, altruism, and love. The ability to remember is also housed in the mammalian brain. Finally, seated on top of the other two brains is the neo-cortex. Though other primates share in some of this brain tissue, none possess the storehouse made available to humans. The neo-cortex makes language, culture, and abstract thinking possible. All the traits we think of as distinctly human are features of the most recent evolutionary addition to our brains (Sagan, 1977, pp. 53-83).

Exemplars. The story of the discovery of DNA provides an illustration of how critical and creative thinking interact in order to advance human knowledge. The work of one scientist (or team) builds on the findings of another. A variety of scientists played important roles in discovering DNA (Markel, 2013, pp. 1-6). Friedrich Miescher, who was a Swiss chemist, determined in 1869 that DNA was comprised of sugar, phosphoric acid, and several nitrogen containing bases. Then, in 1944, Oswald Avery, Colin Maclead, and Maclyn McCarty determined that DNA carried the genetic information needed for reproduction. What they did not know, however, was how DNA was structurally arranged. Unlocking the secret of the structure of DNA became the work of Rosalind Franklin and Maurice Wilkins, who worked with X-ray crystallography, and James Watson and Francis Crick, who created the famous two-strand, double-helix model. Both teams published their findings in *Nature* in 1953. Having a working model of DNA has made possible a number of other discovers such as the genome, identification of persons using gene markers, and the promise of genetic engineering. The human species for the first time has the option of controlling its own evolution (Markel, 2013, pp. 1-6).

Idealism

Background. Spiritualism or mind has provided a fertile root metaphor for the growth of philosophical idealism, which reaches as far back as Plato, 380 B.C. Idealism holds that the world we experience with our senses is merely one of appearances. Reality lies behind the given in experience. The key to Plato's philosophy is contained in the parable of the cave. Plato asks us to imagine a group of prisoners chained by the neck and the leg inside a dark cave. All they have ever seen are dancing shadows on the walls, cast by the light of a fire burning at the entrance to the cave. One of the prisoners, however, finally escapes from the cave and walks out into the light of day. At first the prisoner is blinded by the brilliance of the light. In time he or she comes to see things as they really are. The story of the prisoner is symbolic of the journey of the soul as it seeks to know the true nature of things (Plato, 1968, pp. 227-231).

The picture of the universe emerging from investigations related to the big bang and quantum physics have given new life to philosophical idealism. Afshordi, Mann, and Pourhasan (2014) contend that, "Plato was on to something. We may all be living in a giant cosmic cave, created in the very first moments of existence" (p. 38). Our three-dimensional world is merely a shadow of a larger four-dimensional reality. The authors suggest that if we assume a holographic model for the big bang, it "resolves not only the main puzzles of uniformity and near flatness of standard cosmology without resorting to inflation but also nullifies the damaging effects of the initial singularity" (p. 43). If the universe is merely a hologram, then clearly we are back inside Plato's cave.

John Wheeler (1994) was one of the principal architects of the quantum world in which we find ourselves. He not only coined the term "black hole," but he placed human intelligence at the center of the cosmos. Quantum physics, Wheeler tells us, destroys the concept of a world as separate from human investigation. Even in the act of observing a simple electron, the observer must install the measuring equipment. What will the equipment measure, position or momentum; to measure one is to exclude the other. The act of measuring inevitably changes the state of the electron. The universe will never be quite the same. To truly describe what has happened, it is necessary to leave behind the old word "observer" and to replace it with a new word "participator." "In some strange sense," says Wheeler (1994), "this is a participatory universe" (p. 25). Mind is an active player helping to create the universe. The mind's reality-making powers can transcend time, allowing the experimenter to alter events that occurred in the past. Tegmark and Wheeler (2001) describe a delayed choice experiment in which "not only can a photon be in two places at once, but experimenters can choose, after the fact, whether the photon was in both places or just one" (p. 72).

Exemplars. Kipling (2022) tells us, "East is East, and West is West, and never the twain shall meet." But what if they should meet? The story of S. Ramanujan and G. H. Hardy records just such an encounter in the field of mathematics. Ramanujan was born in 1887 and grew up in a simple village in southern India. Hardy was born into an English family in 1877, where both parents were public school teachers. Ramanujan merely completed elementary and high school. (Though he received a scholarship for college, he flunked out because he refused to study any subject other than mathematics.) Hardy was a gifted student who received scholarships, ushering him along the elite track of English education, including Winchester and Trinity College at Cambridge University. Ramanujan respected all of the deities and rituals of the Hindu religion. Hardy became a lifelong atheist who rejected all religious pageantry. Ramanujan used mystical intuition to solve mathematical problems. He maintained that the goddess Namagiri came to him in dreams and placed mathematical insights on the tip of his tongue. Ramanujan is quoted as saying, "An equation for me has no meaning unless it expresses a thought of God" (Kanigel, 1991, p. 7). Hardy prized the use of rational analysis in the solution of mathematical problems. Mathematical theories had to be proved before they could be accepted. Hardy, however, made special allowance for Ramanujan's intuitive nature. "I was afraid that if I insisted unduly on matters which Ramanujan found irksome, I might destroy his confidence and break the spell of his inspiration" (Kanigel, 1991, p. 4). Of the two scholars, Ramanujan represents the more creative and intuitive side of the relationship; Hardy, on the other hand, clearly reflects the more critical and rational approach to pure mathematics.

Ramanujan wrote to Hardy in 1913, requesting help in publishing some of his work. He included with his letter samples of the mathematical problems he had been working on. Hardy was struck by Ramanujan's insights; he was able, with the help of many others, to bring Ramanujan to Trinity College, Cambridge University in 1914. The mathematics Ramanujan and Hardy completed during the next five years represents the apex of their mathematical work. The two men collaborated on 26 published papers covering a variety of mathematical topics.

When Ramanujan arrived in England, he brought with him two thick notebooks crammed with mathematical theories. The notebooks contained hundreds of theorems no one had ever seen before. Hardy insisted they had to be proved before they could be published. The two men spent countless hours working out the mathematical proofs for a few of them. Ramanujan was particularly interested in numerical series that ran to infinity. Partitions presented a noteworthy challenge. It had been generally believed that no formula could be created that would cover all of the cases of $p(n)$. Ramanujan set out to discover such a formula. What he and Hardy came up with became known as the circle method. Ramanujan postulated the number of terms in the series used to approximate $p(n)$ itself depended on n. This offered the key to unlocking the problem. Littlewood, who was another noted mathematician at Trinity College, wrote, "We owe the theorem to a singularly happy collaboration to two men, of quite unlike gifts, in which each contributed the best, most characteristic, and most fortunate work that was in him" (Kanigel, 1991, p. 253).

A century after Ramanujan's death, many of his theories are still alive and well. Mathematicians are still discovering insights contained in his works. Bleicher (2014, May) conducted an interview with Ono, who is a mathematician at Emory University. Ono described a letter he received from Berndt, another mathematician who had spent years working on Ramanujan's theorems. Berndt's letter contained six statements made by Ramanujan on modular forms. Brandt asked Ono to try to make sense out of them. Ono's first impression was to declare all 6 to be utterly bizarre. "I looked at them and said, no way. This is crap" (p. 72). Ono set out to prove Ramanujan wrong; however, the longer he worked on the statements the more he became convinced Ramanujan was right. Ramanujan had a gift for seeing connections between numbers that most mathematics simply overlooked. Ramanujan, for instance, noted a parallel between modular forms and partitions. "To Ono's bewilderment, Ramanujan's 6 statements linked the two fields in a profound way that no one had anticipated" (p. 74). Following Ramanujan's lead, Ono was able to demonstrate that partition congruence is not as rare as usually thought. Partition numbers have an inner logic of their own. Shortly before his death, Ramanujan was working on mock theta functions. "Physicists have recently begun using mock theta functions to study a property of black holes known as entropy" (p. 75).

Composite Philosophies

In addition to the three principal philosophies—realism, naturalism, and idealism—three composite philosophies have evolved. These philosophies—cyborgism, Romanticism, and dualism—are the result of fusing together two of the principal philosophies. Cyborgism represents a synthesis of realism and naturalism. A cyborg is a person who possesses both biological and mechanical attributes. Artificial limbs are one such example. Some of these limbs contain their own computer chips. Additionally, many researchers like to think of the human brain as an onboard computer. Romanticism represents a bonding of naturalism and spiritualism. It became a major theme in 19th century literature. Romantic thought had an equally profound effect on progressive education during the first half of the 20th century. Finally, dualism is a way of believing in realism and idealism at one and the same time. Humans are a prime example of a walking and talking dualist reality. People are said to have an immortal soul (idealism) and a physical body (realism). Most Christian faiths readily accept dualism as part of their theology.

Cyborgism

Background. Cyborgism is an awful sounding word, but all of the others—AI, robotics, biomechanics—are even less appealing. Additionally, cyborgism is less a formal philosophy than a loose collection of genetics, culture, and technology coming together. These factors are proving to be instrumental is carving out a new future. In the past, for example, humanity was the prisoner of evolution. Change came about very slowly. All of that has now changed. Through technology, humanity can take control of its own evolution. Max (2017) tells us that, "Technology now does much of the work and does it far faster, bolstering our physical skills, deepening our intellectual range, and allowing us to expand into new and more challenging environments" (p. 49). To illustrate his point, Max (2017) reports on a man who is thought to be the world's first official cyborg. Neil Harbisson was born with a rare condition known as achromatopsia, which prevents him from seeing color. He lived in a black and white world until he had an electronic device implanted in his skull. The device allows him, through the use of sound, to discover color. A fiber-optic sensor picks up the color in front of him and a microchip implanted in his skull converts those frequencies into vibrations on the back of his head. The sound frequencies turn his skull into a third ear. To make the whole system work, Harbisson has an antenna coming out of the back of his head. Harbisson says the input has begun to feel neither like sight nor hearing but a sixth sense all of its own (pp. 42-63).

Computers have become an intimate part of our everyday lives. The architecture of the computer, however, has remained essentially the same since Alan Turing's World War II design. All modern computers—from supercomputers to smart phones—use a computing unit for making calculations and a separate storage unit for holding programs and data. Shuttling information back and forth between these two units takes time and energy. What if, conjecture Di Ventra and Pershin (2015), we were able to build a new generation of memcomputers that worked more like human brains (pp. 56-61). The brain uses neurons to both compute and store information. A memcomputer would have a single unit for performing both storage and processing functions, thus facilitating a great leap forward in speed and efficiency. "In computer terminology," according to Di Ventra and Pershin, "this is called polymorphism, the ability of one element to perform different operations depending on the type of input signal. Our brains possess this type of polymorphism . . . but our current machines do not have it" (p. 61). Finally, if we were successful in building a memcomputer, it might tell us some very interesting things about how our own brains work.

Exemplar. The story of the computer begins with Alan Turing. The creation of the computer has two parts, the theoretical and the practical. Turing expressed the theoretical in a paper he presented in 1936 while studying for his Ph.D. at Princeton University. Watson (2012) tells us that in his paper, "Turing demonstrated you could construct a single *Universal Machine"* that could solve any problem or perform any task for which a program could be written. Turing received the opportunity to turn his theories into practice during WWII. The Germans had invented the Enigma, a complex coding machine for sending messages to their navy. "Turing designed a electromechanical machine, called the Bombe, that searched through the permutations, and by the end of the war the British were able to read all daily German Naval Enigma traffic" (Watson, 2012, p. 2).

Turing's principal contribution to the present age lies in his design of the Turing machine, which connects logical instructions and actions of mind to a physical form. Turing's invention has become the foundation for all modern computers. His genius resides in his application of mathematical logic to the problems of physics. Indeed, according to Hodges (1995), "Turing made a bridge between the logical and the physical worlds, thought and action, which crossed conventional boundaries" (p. 3). The universal Turing machine made it possible to design one machine that was capable of performing a wide variety of different tasks. Turing's machine "embodies the essential principle of the computer: a single machine which can be turned to any well-defined task by being supplied with the appropriate program" (p. 3).

Turing helped to prepare the way for the current interest in artificial intelligence, AI. "In 1950" says Watson (2012), "he published a paper called, *Computing Machinery and Intelligence."* In his paper Turing offered the thesis that one day computers would become so powerful that they would literally be able to think. How could we tell if a computer was truly intelligent? Turing proposed the following test. "A judge sitting at a computer terminal types questions to two entities, one a person and the other a computer. The judge decides which entity is human and which the computer. If the judge is wrong, the computer has passed the Turing Test and is intelligent" (Watson, 2012, p. 5).

Turing's ideas are still of interest to contemporary mathematicians and physicists. According to Cubitt, Perez-Garcia, and Wolf (2018), though Turing is best known for his work on breaking the code on the Enigma during WWII, "among scientists, he is best known for his 1937 paper *On Computable Numbers* (p. 33). Turing was able to carefully define what it meant to "compute" something. "By giving a precise, mathematically rigorous formulation of what it meant to make a computation, Turing founded the modern field of computer science" (p. 33). Having constructed a mathematical model of a computer, Turing went on to prove there was a simple question no computer could ever decide. Can a computer running on a given input ever halt? "This question is known as the halting problem. At the time, this result was shocking. Mathematicians have become accustomed to the fact that any conjecture we are working on could be provable, disprovable or not decidable" (p. 33).

Romanticism

Background. Romanticism combines the naturalism of Francis Bacon with the philosophical idealism of Plato. The workings of the outer world are fused with those of the inner world. The principal figure responsible for accomplishing this new synthesis was Jean J. Rousseau, whose literary genius was one of moving the focus of philosophy away from the head (logic) and redirecting it toward the heart (intuition). Rousseau (1762/1955) was a rebel who rejected the established conventions of his time. He wrote with passion and power, declaring in the *Social Contract,* "Man is born free, and everywhere he is in chains" (p. 344). Humans were meant to be free, living in accordance with nature. The romantics' love of nature knew few bounds. They believed nature held within itself a mystical spirit of wisdom and goodness. Mankind could tune into this spirit through intuition. Feeling and emotion, not reason, would direct us toward the life of virtue. Thoreau (1854/1951) expressed his reverence for nature when he wrote in *Walden*, "I went to the woods because I wished to live deliberately, to front only the essential facts of life, to see if I could not learn what it had to teach, and not, when I came to die, discover that I had not lived" (p. 421).

Romantics were responsible for promoting a heightened sense of individualism. The individual person should resist the pressures to conform to social conventions. The true individual would be like Shelley's Prometheus, struggling to break free of his (or her) bonds. Melville (1851/1969) expressed a similar sentiment when he wrote, "Delight is to him—a far, far upward and inward delight—who against the proud gods and commodores of this earth, ever stands forth his own inexorable self" (p. 392). The romantics glorified self-expression as the essence of humanity itself. The freedom to think and to express one's ideas was of paramount importance. Emerson (1841/1951) captured the spirit of individualism in his essay on *Self Reliance* when he advised, "To believe your own thought, to believe that what is true for you in your private heart is true for all men—that is genius" (p. 583).

Exemplar. Alma Deutscher (2020) was born in 2005. She is the daughter of Janie Deutscher, who is a professor of literature, and Guy Deutscher, who is a linguist. Both of her parents are amateur musicians. Alma started playing the piano at age two, and she was also able to name all the notes. The following year she began to study the violin after her father bought her a toy one. She would play it for days on end until her parents decided to find her a teacher. At age four she was composing and improvising on the piano, and by age five she was busy writing her own compositions. When Alma was six, she composed her first piano sonata. At seven she completed her first short opera; at nine a violin concerto; at ten her first full-length opera; and at twelve she finished her first piano concerto (pp. 1-4).

Deutscher's (2020, December) first completed opera was called *The Sweeper of Dreams*. Parts of the score came to her in a dream. The first performance was in Israel in 2013. Alma's second opera was a full-length work based on the fairy-tale of Cinderella. Her version of the story differed from the traditional fairy-tale because music was a central part of the plot. Alma explained: "I didn't want Cinderella just to be pretty. I wanted her to have her own mind and her own spirit. And to be a little bit like me. So I decided that she would be a composer." An expanded version of the opera made its world premiere in Vienna in December of 2016. Alma made her debut at Carnegie Hall in December of 2019. Deutscher (2021, October) is currently studying to become a conductor at Vienna University of Music.

Deutscher (2022) was home-schooled by her parents, who believed that creativity requires both freedom and nurturing. They characterized Alma's musical creativity as part of her wider creative imagination. Her education, Deutscher believes, facilitated her ability to differentiate between moments of inspiration and those of hard work in polished piece of music. "When I try to get a melody it never comes to me. It usually comes either when I'm resting or when I'm just sitting at the piano improvising or when I'm skipping with my skipping rope" (pp. 3-7). Deutscher initially described her purple skipping rope as 'magical' and as part of her melodic inspiration. "I weave it around, and melodies pour into my head . . . I really thought it was the rope that gave me inspiration. Now I know it's not really the rope, it's the state of mind that I get into when I wave it around" (pp. 3-7).

Melodies also come to Deutscher (2022) in her dreams. Describing one such dream-composition, she said: "I woke up and didn't want to lose the melodies so I took my note book and wrote it all down, which took almost three hours. My parents didn't understand why I was so tired in the morning and I didn't want to get up" (pp. 3-7). Sections of her first opera, *The Sweeper of Dreams*, came to her fully formed in a dream.

Deutscher (2022) explains that the spontaneous flow of melodies should not be confused with the hard work involved in creating larger and more complex compositions. An initial idea or melody is only the first step in a long, laborious process. "Lots of people think that the difficult part of composing is to get the ideas, but actually that just comes to me. The difficult bit is then to sit down with that idea, to develop it, to combine it with other ideas in a coherent way" (pp. 3-7). Both parts, inspiration and hard work, are necessary parts of the creative process.

Deutscher (2022) music shows the clear influence of 19^{th} century Romanticism. She has often expressed her strong affinity to the musical language of Viennese Classics. She told the *New York Times* in 2019, "I lived in England, but I grew up on the music of Mozart, Schubert, Beethoven, and Haydn. Musically speaking, I think that Vienna's always been my home" (pp. 3-7). Deutscher, however, objects to the frequent newspaper headlines comparing her to Mozart. "I don't really want to be a little Mozart. I want to be Alma" (pp. 3-7).

Deutscher (2022) has often complained that some critics have told her that she should not compose beautiful melodies in the 21^{st} century because music must reflect the complexity and ugliness of the modern world. To such criticism Deutscher has always replied, "But I think that these people just got a little bit confused. If the world is so ugly, then what's the point of making it even uglier with ugly music?" (pp. 3-7). She wishes critics would stop trying to tell her what is allowed and what is not allowed.

Dualism

Background. Dualism represents the third composite philosophy, which is a wedding of realism and idealism. The thinker who was most responsible for articulating the metaphysics of dualism was the 17^{th} century French philosopher Rene Descartes. According to Descartes, the world is composed of two different substances, material and spiritual. Material substances are subject to the laws of science; spiritual substances are ethereal and possess freedom of will. Humanity is a prime example of the two substances coming together. The body is a machine; the soul is the seat of consciousness. "My soul," Descartes declared, "is not in my body like a pilot in a ship" (Urmson, 1965, p. 94). Rather, the soul is one with the body. It leaves the body when the body dies. Descartes believed the meeting place where the body and soul came together was in the pineal gland, which had only recently been discovered in his time.

James Hillman (1997), writing in *The Soul's Code,* often sounds more like a theologian than a psychologist. His thinking on human personality reflects a dualistic metaphysics. Hillman does not deny the influence of either heredity or environment in shaping human character. He believes, however, there is a third and more important factor, soul or daimon. "We bear from the start the image of a definite individual character with some enduring traits" (p. 4). Indeed, the soul may be responsible for selecting the right heredity and proper social environment that will allow the soul to realize its purposes here in this world.

Hillman (1997) uses an acorn metaphor when speaking about the formation of human character. Acorn theory "holds that each person bears a uniqueness that asks to be lived and that is already present before it can be lived" (p. 6). Our inner spiritual acorn supplies us with an image of our life and destiny. "As the force of fate, this image acts as a personal daimon, an accompanying guide who remembers your calling" (p. 39). Everyone enters the world with some particular calling, not just saints and sinners. One's calling is the "essential mystery at the heart of each human life" (p. 6).

Exemplar. Akiane Karamarik (2017) began life in 2005, delivered at home in a pool of warm water. Foreli, her mother, recalling her early impressions of her new baby, says she was "affectionate, sensitive, observant, and shy" (p. 4). Though her family showed little deference for religion, everything changed when Akiane reached the age of four. Foreli noted that Akiane "began to share her visions of heaven" (p. 7). Akiane would spend time alone in a spiritual world of her own choosing. Her spiritual interests soon became linked to her art work. One of her early drawings was of an angel, who Akiane claimed taught her how to draw.

Akiane (2017) is best known for having painted the face of Jesus. This painting, more than any of her other works, brought her to public attention as a child protégé. *The Prince of Peace: The Resurrection* is a good example of how Akiane combines realism and spiritualism in her paintings. Painting Jesus' face did not come to her as an intuitive insight. She spent many hours studying the faces of people who lived in her community in northern Idaho. Finally, she settled on a young man who lived in her community. He was introduced to her by an "acquaintance who brought her friend, a carpenter, right through the front door" (p. 26). At first the young man declined to serve as a model for the face of Jesus. Such an honor was a status he did not deserve. Later, however, he changed his mind, saying, “God wanted me to do it, but I have only three days before I have to cut my hair and beard” (p. 26). Akiane finished the painting in 40 hours.

Although Akiane’s (2017) first portrait of Jesus, *The Prince of Peace*, resembles the face of her model, she modified his features to more closely conform to those of the Jesus she saw in her dreams. The flowing light she painted into the picture is of particular interest. Akiane explained it in the following words, “The light side of His face represents heaven. And the dark side represents suffering on earth. His light eye in the dark shows that He’s with us in all our troubles, and He is the light when we need him” (p. 27). The second portrait she painted of Jesus, *Father Forgive Them*, showed Jesus’ hands reaching up toward heaven. Painting the hands presented Akiane with a host of new and frustrating problems. She had become a perfectionist in her work. While she was painting the hands, she kept repeating to herself, “I want this portrait to look real. Real, real, real, real” (p. 27).

When Akiane (2017) was ten years old, she was invited to the Museum of Religious Art in Iowa to show her work. The event was attended by thousands of people. Akiane was frequently asked which church she attended. She always answered the question by saying: “I belong to God” (p. 36). When asked why she selected Christianity rather than some other religion to use in her paintings, Akiane replied: “I didn’t choose Christianity; I chose Jesus. I am painting and writing what I am shown and what inspires me. I am a journalist artist. I don’t know much about the religions, but I know this: Love is our purpose” (p. 36). Another frequently asked question has been, “How would you describe your style of painting?” To which Akiane always answers: “Akianism—a blend of realism and imagination” (p. 36).

Conclusion

The model presented in this inquiry represents a cognitive prism or synthetic metaphor designed for analyzing and extracting meaning from complex metaphors. The inner triangle contains the heart of the design—the three root metaphors of mechanism, organism, and spiritualism or mind. The intermediate triangle contains the different schools of philosophy. Realism, naturalism, and idealism represent the principal schools. Cyborgism, romanticism, and dualism, reflect the composite philosophies. Taken together the inner and intermediate triangles comprise the core of the theoretical model. The outer triangle contains Exemplars drawn from different fields of inquiry. The present article selected Exemplars from a number of different disciplines in order to show the breadth of coverage made possible by the model. The topics could just as easily have been drawn from religion, science, music, art, psychology or education. All the academic disciplines lend themselves to such a metaphorical analysis.

How does the model enhance our understanding of the twin processes of critical and creative thinking? A timeworn metaphor reminds us that we stand on the shoulders of our ancestors. Past accomplishments provide the basis for future achievements. The idea of the "self-made man" is a contradiction in terms. Those things we prize the most—knowledge, language, culture—have all been delivered to us from the storehouse of previous human experience. Critical thinking begins by reviewing what is already known. Then, if we are persistent and lucky, we may have a moment of insight, discovery, or a creative way of looking at things. Hawking built his theories about black hole based on the work of Newton, Einstein and Heisenberg. Similarly, Watson and Crick looked at the research on crystals and experienced an epiphany. Ramanujan and Hardy cooperated to achieve what neither could accomplish separately. Turing utilized the mathematics and technology of his time to create a "thinking machine." The musical compositions of Alma Deutscher draw their inspiration from the romantic tradition. Finally, Akiane's best known work, *The face of Jesus*, represents a work of art reflecting both realism and spiritualism.

In sum, what is critical and creative thinking? To think critically is to think reflectively about relevant information and practices growing out of an intellectual discipline or field of inquiry. Creative thinking, on the other hand, takes the whole process one step beyond what is already known. Truly creative acts are often the work of genius. These two processes are intimately intertwined with one another so that frequently it is difficult to tell where one stops and the other begins. Taken together, critical and creative thinking represent the alpha and the omega of a productive mind.

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