Artistic Genius and Creative Cognition

Paul Thagard
University of Waterloo
Draft 5, July, 2013

Thagard, P. (forthcoming). Artistic genius and creative cognition. In D. K. Simonton (Ed.), *Wiley-Blackwell Handbook of Genius*. Oxford: Wiley-Blackwell.

INTRODUCTION

There are highly creative people in all domains of human productivity, including scientific discovery, technological invention, social innovation, and artistic imagination. All of these kinds of creativity require mental operations that generate ideas and other products that are both new and valuable. The main question addressed in this chapter is: What are the processes that produce artistic imagination? I propose hypotheses about creativity that are generalized from research on scientific and technological thinking, and then examine how well those hypotheses apply to the visual, literary, and musical arts. The examination considers the work of 14 leading figures who might plausibly be considered geniuses, drawn from 7 artistic fields: painting, architecture, novels, poetry, philosophy, music, and dance.

I need to indicate what I mean by "creative" and "genius". In line with many other investigators of creativity, I count a product as creative if it is new (novel, original), valuable (important, useful, appropriate, correct, accurate) and surprising (unexpected, non-obvious). (See e.g. Boden, 2004; Kaufman & Sternberg, 2010); Simonton, 2012). The products of creativity range broadly from specific things such as a sculpture, to events such as a performance, to mental representations such as concepts and hypotheses, to methods such as artistic styles. A full theory of creativity needs to account for the generation of new and valuable products of all these kinds. To my knowledge, the generation of methods has been neglected in research on creativity, but we will see that

production of new procedures is an important part of creativity in the arts as well as in science and technology.

I take a genius to be a person who is extraordinarily creative, that is, someone who produces a large number of very new and highly valuable things, events, mental representations, or methods. This definition applies well to many famous figures in the arts, and justifies selection of the following 14 figures whose work can be used to evaluate hypotheses about artistic imagination: da Vinci and O'Keeffe in painting, Wright and Le Corubusier in architecture, Dickinson and Yeats in poetry, Tolstoy and Joyce in novels, J. S. Mill and Russell in philosophy, Beethoven and the Beatles in music, and Duncan and Graham in dance. Obviously these figures are only samples of artistic imagination and genius, but their centrality in their respective fields makes them legitimate subjects for initial evaluation of hypotheses that can then receive further scrutiny. In my usage, a genius is not someone with a high IQ, but rather a person with a substantial record of very high creativity. My investigation concerns the cognitive mechanisms that enable people to be artistically creative, not the various psychological correlates of creativity such as personality traits.

With more space and time, I would have included additional geniuses, such as Rodin and More in sculpture, Hitchcock and Spielberg in film, and Shakespeare and O'Neill in drama. My discussion of the arts is not exhaustive, as it neglects some forms of visual arts such as photography and printmaking, some forms of literature such as history and biography, and ignores the culinary arts of cooking and brewing. I leave it to readers to evaluate whether my hypotheses also apply to these fields.

HYPOTHESES

I now propose 8 conjectures about the cognitive processes that explain artistic genius, drawing on many previous works on creativity (e.g. Boden, 2004; Dunbar and Fugelsang, 2005; Hofstadter, 1995; Kaufman and Sternberg, 2010; Nersessian, 2008; Simonton, 1988, 2004; Thagard, 1988, 1992, 1999, 2012).

A1. Artistic creativity often produces new methods as well as new things, events, and mental representations. Methods include styles, techniques, and instruments; I call their generation *procedural creativity*.

A2. Artistic creativity is goal directed. The goals of artists are different from those of scientists and inventors, but artistic creativity is far from random or blind, often involving reasoning from ends to means that accomplish those ends. The general goals can include achievement and fame, whereas specific goals concern the accomplishment of particular projects.

A3. Artistic creativity of a high degree (i.e. resulting in products that are very new and very valuable) usually requires *rejection* of previous ideas and practices.

A4. Artistic creativity is emotional, with emotions functioning to provide motivation, focus, and evaluation. These functions operate at the level of particular projects as well as whole careers. Some artists, particularly painters and poets, also work to display emotions.

A5. Artistic creativity requires the combination of mental representations into new ones. I have dubbed this the "combinatorial conjecture" (Thagard, 2012), but the idea goes back at least to Dugald Stewart (1792). The mental representations used in the

arts are highly diverse, going well beyond primarily verbal representations such as concepts and hypotheses to include images that can be visual, auditory, and kinesthetic.

A6. Artistic creativity is inspired by two primary cognitive processes: association and analogy. Association is the psychological process that occurs when the activation of some mental representations spreads to the activation of others, which can then be combined into something original (Collins and Loftus, 1975; Schröder and Thagard, 2013). Analogy occurs when an artist uses a previous case as inspiration: the case serves as a source to construct an artistic target, where there is a systematic mapping between the source and the target (Holyoak and Thagard, 1995). Inspiration does not result from the Muses, divine visitation, or Platonic grasping of heavenly forms, but from mental processes of association and analogy. Association is less organized than analogy, which requires a systematic mapping between a source and a target. In association, an observation or memory merely suggests representations that can be combined with ones already active to produce new combinations.

A7. Artistic creativity requires chaining of small creative products into larger projects, where the whole itself is especially new and valuable. Chaining is the process of stringing together creative products into larger creative works such as songs and novels, in the context of problem solving that generates means to accomplish ends. The novelty and value of a work is the result of a series of combinations that are chained together, where the creativity of the whole is an emergent property of the creativity of the parts. (On parts, wholes, and emergence, see Findlay and Thagard, 2012).

A8. Artistic creativity is a social as well as a psychological process, because the productions of individual artists are facilitated by interactions with other people. Geniuses are rarely solitary.

These 8 hypotheses will be further spelled out in the discussion of 14 geniuses. Figure 1 provides a rough sketch of how the cognitive and emotional processes in A1-A8 interact. Motivation and environmental contexts spur means-ends reasoning that can lead to analogies and associations that inspire new combinations, which are chained together into creative products. Emotions such as curiosity, happiness, and frustration are both inputs and outputs to the motivations and evaluations that initiate and guide the generation of new and valuable results. For models of the interaction of cognition and emotion in science and everyday life, see Thagard (2006a).

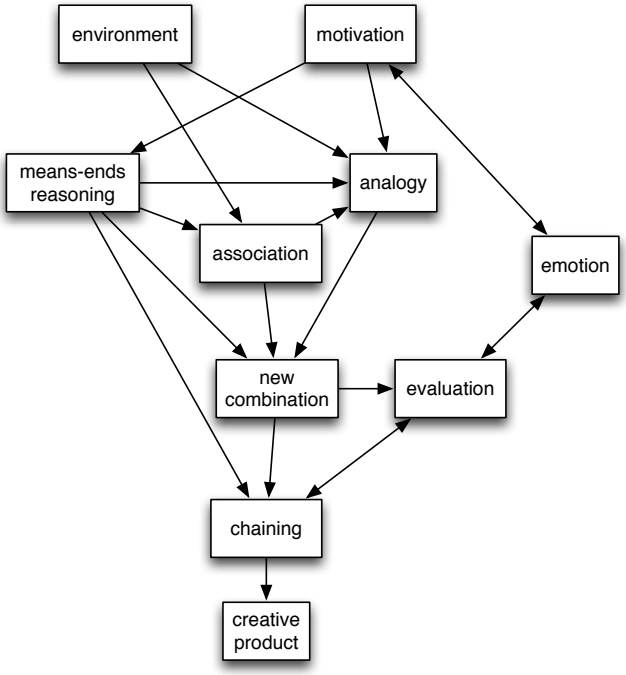

Figure 1. Cognitive and emotional processes in artistic creativity, omitting social processes.

VISUAL ARTS

For many people, the term "art" suggests mainly the visual arts that include painting, drawing, sculpture, photography, printmaking, and filmmaking. I will also be concerned with literary and musical arts, but begin with two visual arts, painting and architecture.

Painting

The word "genius" often brings to mind the name of Leonardo da Vinci (1415-1519), who is famed not only for marvelous paintings but also for many inventions. He was polymorphously productive, but I will use him as an exemplar of extreme creativity in painting. My other painter is Georgia O'Keeffe (1887-1986), one of my favorite twentieth-century artists. Leonardo produced relatively few paintings that have survived, along with many exquisite drawings; but works such as the *Mona Lisa*, *The Last Supper*, and the Vitruvian man have become famous exemplars of visual art. O'Keeffe created hundreds of works and was the first woman painter to receive wide recognition. My discussion is primarily based on da Vinci (2008), Lisle (1980), McCurdy (2005), Nicholl (2004), O'Keeffe (1976), Ormiston (2011), and Robinson (1989).

Both Leonardo and O'Keeffe were creative in the production of many new and valuable works, but also in the generation of new methods (A1). Leonardo's procedural creativity was evident in the original methods that he described in his voluminous notebooks, such as (1) basing visualizations on a knowledge of human anatomy, (2) using geometrical perspective and other mathematical techniques, (3) depicting light and shade in ways based on scientific principles, and (4) displaying mental events in his subjects by

means of their physical gestures. In her late 20s, O'Keeffe developed a dramatic new way of producing abstractions of familiar objects that are infused with explosive emotions, erotic energy, and female sensibility.

Leonardo and O'Keeffe each had general goals concerning their artistic work and specific goals pursued in particular projects (A2). Leonardo wanted his paintings to represent things according to nature, and to capture both people and the intentions of their souls. He applied these goals in particular projects commissioned by patrons, where each project generated a set of more narrow goals based on the subject matter such as portraits or religious themes. Similarly, O'Keeffe realized that she had abstract shapes in her mind that were very different from those that existed in nature or in the work of other artists, and she aimed to translate these images into particular paintings. She was generally ambitious, self-confident, uncompromising, and absorbed in her work. Once she had an inspiration from natural objects such as flowers or landscapes, she labored to produce paintings that captured what she visualized.

Contrary to (A3), I have not found any indications that Leonardo viewed himself as rejecting previous approaches to painting, although he disparaged artists who sought gain rather than perfection. In contrast, O'Keeffe explicitly rejected realist painting as merely reproducing nature with a loss of beauty, and also rejected the idea of imitating the styles of other artists. Perhaps Leonardo's rejection of early approaches is implicit in the new methods he developed, whereas O'Keeffe's was more explicit, at least in retrospect.

There are two ways in which emotions can contribute to artistic creativity: as motivations for their work, and as elements that are displayed in their work. Leonardo

said that "the most important consideration is painting is that movements of each figure expresses its mental state, such as desire, scorn, anger, pity, and the like" (da Vinci, 2008, p. 168). Much speculation has surrounded the emotions behind the enigmatic expression of the Mona Lisa, but no one doubts that Leonardo was displaying some aspects of her emotional state. Leonardo's own emotions, shown in his scientific and technological works as well as in his painting, include curiosity and eagerness to achieve perfection. Because perfection was so hard to achieve, Leonardo abandoned many of his projects, presumably the result of negative emotional evaluations. O'Keeffe's work was accompanied and motivated by various emotions, ranging from euphoria to despair, and she directed emotional reactions prompted by life experiences into her work. Hence it seems that emotions were important contributors to the creativity of both Leonardo and O'Keeffe (A4).

According to the combinatorial conjecture, all creativity results in part from the novel combination of representations. For visual art, the most important representations are visual images, although verbal and even kinesthetic representations can also contribute, as in the gestures that Leonardo used to display emotions. The *Mona Lisa* combines images of the model's eyes, nose, mouth into a face, and combines these with representations of arms, chest, and hands into the unified woman, with additional combinations of background landscape representations. O'Keeffe's striking painting, *Ladder to the Moon,* juxtaposes images of mountains, a ladder, and a half moon into a magical combination. Hence all paintings confirm the combinatorial conjecture (A5), with the remark that the mental representations in question are mostly visual images rather than verbal representations. Manipulation of images using operations like

juxtaposition, zooming, and rotation is a powerful way of producing new combinations (Finke, Pinker, and Farah, 1989).

Other cognitive operations are often as important to creativity as combination. For Leonardo, some associations came from religious stories such as the Last Supper, where a verbal description stimulated a visual mental representation that Leonardo could replicate in a painting. O'Keeffe's associations included observations of many natural objects and scenes, such as flowers, lakes, skulls, and desert landscapes. As for Leonardo, the associations by themselves do not generate a painting alone, for they must serve to generate additional images that can be combined by repeated chaining into the whole work. Hence we can conclude that all the paintings of Leonardo and O'Keeffe resulted from cognitive operations of association and chaining (A6, A7).

Both Leonardo and O'Keeffe were so original in their mature work that they did not model what they did on other painters. Leonardo did, however, draw an analogy between visual beauty and musical harmony, and many people have viewed O'Keeffe's flowers as analogous to female genitalia. Like all painting based on physical models, the work of Leonardo and O'Keeffe can be understood as visual analogies. When Leonardo painted a person, and when O'Keeffe painted a flower or landscape, they were not simply copying an image. Rather, their paintings were roughly analogous to what they were painting, preserving some but not all of the properties and relations found in the original. Such painting is analogizing, not copying. Analogical transfer carries over some of the features of the original source to produce a target that generates the desired aesthetic effects, including emotional ones. Some abstract paintings, by artists such as

Kandinsky and Mondrian, are nonrepresentational and thus not analogous to anything in the world, although they can still have emotional effects.

Leonardo and O'Keeffe were fiercely independent in their artistic creativity, but no artist is an island, and both of them had social influences (A8) Leonardo learned various techniques from his teacher Verrocchio, even though he remarked that poor is the pupil who does not surpass his master. Leonardo also learned from Florence contemporaries such as Botticelli, and was stimulated by various patrons to produce specific pieces. O'Keeffe aggressively aimed for originality, but her work may have been influenced in subtle ways by fellow New York painters such as Arthur Dove and by her photographer husband Alfred Stieglitz. The processes that resulted in the stupendous visual artistry of Leonardo and O'Keeffe were largely cognitive and emotional, but social processes were at least somewhat relevant too.

Architecture

I count architecture as a visual art because it involves the design of viewable objects (buildings, furniture, parks, cities) with desirable aesthetic properties. Of course, it also has aspects of technology required to implement functional buildings. My two geniuses are the most influential architects of the twentieth century, Frank Lloyd Wright (1867-1959) and Le Corbusier (1887-1965, originally named Charles-Édouard Jeanneret), even though I have doubts about the value of the work of the latter, especially in urban planning. Both produced many designs for buildings that were widely imitated. In addition, both produced innovated furniture designs, and had a large impact on urban design through Wright's complexes of "Usonian" houses and Le Corbusier's radical plans for a "Radiant City". Both architects were also prolific authors of many

books, but my account is primarily based on the following works: Le Corbusier (1971, 2007), Huxtable (2004), Weber (2008), and Wright (1977).

In addition to producing new and influential visual designs for buildings, furniture, and cities, Frank Lloyd Wright and Le Corbusier also introduced new methods that are instances of procedural creativity (A1). They pioneered the use of reinforced concrete in buildings large and small, for example in Wrights' famous "Fallingwater" house and in Le Corbusier's Villa Savoye that employed concrete stilts. Wright's powers of visualization enabled him conceptualize a whole solution to a problem before committing it to paper. Le Corbusier insisted that geometry was the key to providing exact and reasonable designs for cities.

Both Wright and Le Corbusier had explicit and powerful goals that rejected many prevailing ideas about architectural design (A2, A3). Wright's prairie houses rejected the typical prairie dwelling of the day that he thought were ugly boxes lacking any sense of unity or space. In response, he set out to produce buildings with an organic simplicity in harmony with nature, eliminating standard features such as attics, dormers, and basements that he thought were unnatural. Le Corbusier similarly rejected the old architecture, declaring that decorative art is dead and that every great city must rebuild its centre. He proclaimed (2007, pp. 162-163): "Architecture is the art par excellence, one that attains a state of Platonic grandeur, mathematical order, speculation, perception of harmony through stirring formal relationships. These are the ends of architecture."

Wright is widely quoted as saying that the heart is the first feature of working minds, but he was not as explicit about the role of emotions in his work as Le Corbusier, who said that architecture is for stirring emotions, that there is no art without emotion,

and that people experience great happiness on feeling themselves create (A4). He insisted that the machine-like houses he designed had to be both practical and emotionally satisfying. In addition to wanting to bring geometric order to architecture and urban planning, Le Corbusier declared that passion can create drama out of inert stone. Hence emotion is an important part of architectural creativity.

(A5) hypothesizes that artistic creativity requires the combination of mental representations into new ones. In architecture, the most important kinds of representations are visual, which can operate in people's minds as images but also in the external world as drawings, scale models, and computer depictions. Other kinds of mental representations can also contribute to architectural creativity, including ones that are kinesthetic (opening a door), tactile (the texture of a wall), auditory (the sound of bell in a tower), and verbal (the concept of harmony). All architectural designs require combinations of multiple representations, for example in Wright's prairie houses that merged new kinds of walls, ceilings, roofs, doors, windows, and chimneys. Each of these used separate mental representations, but the overall design required combining them together using procedures operating on representations either in the head or in the world through manipulations of drawings or models. Wright's famous Taliesin house was a combination of stone and wood as they met in the surrounding hills. Similarly, Le Corbusier's novel designs for houses, tall apartment buildings, and urban complexes required putting together multiple representations, mostly visual, of the components of these structures, forming a whole out of the parts. For example, his modernist design for high-rise residential housing combined concrete walls, balconies, stilts, and a flat roof. Hence architectural creativity seems to confirm the combinatorial conjecture,

which has been more thoroughly examined in the creativity of 35 architects by Milosz (2012).

Besides combination, other cognitive operations can contribute to new and valuable designs. Wright gained inspiration from many verbal and visual sources, ranging from the writings of Emerson and Ruskin to the visual perception of Japanese houses and nature in the American southwest. Most of these inspirations are association, with one concept prompting another, but occasionally Wright's designs were more systematically analogical. He explicitly used the saguaro cactus as a model for apartment towers, and even sought analogies between architecture and the music of Beethoven. Le Corbusier's writings are rife with analogies, expressed in such metaphorical utterances as that a house is a machine for living in and that a city is a whirlpool. Le Corbusier was stirred by machines and structures of the new industrial age like airplanes, ocean liners, and grain silos. He also took inspiration from buildings he admired such as the Parthenon and American skyscrapers. Because of the complexities of buildings, no architect could imagine a complete design all at once, so chaining of representations is needed to combine serially the individual components. Hence the cognitive operations of association, analogy, and chaining all contribute to architectural creativity (A6, A7).

Despite the great originality of the minds of Wright and Le Corbusier, it is important to notice the social contributions to their designs. Wright produced most of his designs on his own, but interacted with many other architects including his early boss Louis Sullivan and the many architects who joined his Taliesin fellowship. Le Corbusier benefitted from interactions with his cousin and longtime partner Pierre Jeanneret, as well

as earlier influences such as the painter Amédée Ozenfant and the poet Paul Dermée. Hence architectural creativity is a social as well as a cognitive process (A8).

Architecture and painting are only two of the visual arts, which also include sculpture and photography. I suspect, however, that these fields would confirm my eight hypotheses in much the same way as the two that I have investigated, although sculpture would require more emphasis on representations of touch and muscle movements. Let us move on to arts that are more verbal than visual.

LITERARY ARTS

Literature includes various genres, including poetry, drama, novels, and non-fictional writing such as biography and history. I have picked three literary fields that pursue the writing of novels, poetry, and philosophy.

Novels

Many brilliant novelists qualify as geniuses, but information about their creativity is not always available: I started with Jane Austen, but found that little is known about her creative processes because her family members destroyed most of her letters. Instead, I will discuss Leo Tolstoy (1828-1910), whose *War and Peace* is on many people's list of best novels, and James Joyce (1882-1941) whose later works are renowned for their literary innovations. My major sources are Christian (1985), Crankshaw (1974), Ellman (1959), O'Brien (1999), and Wilson (1988).

Both Tolstoy and Joyce wrote in various genres including plays and essays for Tolstoy and plays and poems for Joyce, but their major creative products were their novels. Joyce was more obviously a generator of new methods in the highly original writing styles he developed for *Ulysses* and *Finnegan's Wake*. I find the latter

unintelligible, but *Ulysses* is impressive for many innovations such as the use of multiple styles, stream of consciousness narration in an interior monologue, and an undependable narrator. Tolstoy was not nearly so radical, but originally combined genres with the mixture of fiction and history in *War and Peace*, and the intersection of fiction and moral commentary in *The Kreutzer Sonata*. Hence we can conclude that both Joyce and Tolstoy exhibited procedural creativity (A1).

Both Tolstoy and Joyce were highly productive as the result of having strong writing goals (A2). Tolstoy's early life was rather dissolute, but by his mid-twenties he was convinced that his career was literature – to write and write. He thought that literature had a moral purpose, a goal that became more and more central as he aged and grew more religious. Joyce wanted to be a famous writer by his early twenties, and also worked with more particular goals such as accurately portraying the city and people of Dublin. The general ambitions of these authors were complimented by specific goals that motivated particular writing projects.

Joyce strikingly rejected antecedent ideas about literary style (A3), but I have not found any indication that Tolstoy saw himself as rejecting previous ways of writing novels. Both Tolstoy and Joyce were passionate about writing, and often described emotional states of characters in their novels (A4). Tolstoy was particularly exquisite in portraying the miseries and delights in the minds of his characters. Joyce described important emotional changes in the evolution of Stephen Dedalus in *Portrait of the Artist as a Young Man,* from his religious upbringing to artistic pursuits.

All authors produce novel combinations of words in their sentences, but the combinations of mediocre authors are routine and uninteresting. Both Tolstoy and Joyce

produced conceptual combinations that are remarkable for being both surprising and faithful to the facts of human nature (A5). Novel combinations are particularly salient in the works of Joyce because of his neologisms and radical deviations from traditional style. Tolstoy also combined ideas in novel ways, for example in his discussions in *War and Peace* of the implausibility of the view that historical developments are the result of decisions of great men.

Other cognitive processes, including analogy, associaton, and chaining, also made major contributions to the creativity of Tolstoy and Joyce (A6, A7) Their novels are heavily autobiographical, as both writers drew on the experiences of themselves and their acquaintances to create realistic and interesting characters and plots. In this kind of analogical reasoning, the sources are the experiences of the authors and the targets are the fictional works to be produced. As usually happens in creative use of analogies, the targets are not just duplications of the sources, but are adapted for literary purposes and hence qualify as fiction rather than autobiography. In his novels, Tolstoy drew on his experiences as a soldier, aristocrat, and husband to create dramatic episodes. For example, the husband who killed his wife in *The Kreutzer Sonata* describes how he had his wife read his debauch-filled diaries before they were married, just as Tolstoy himself had done. Joyces' *Portrait of the Artist as a Young Man* is systematically derived from his own youth, and the character Stephen Dedalus carries over to *Ulysses,* which draws on many other experiences of Joyce and his friends. Moreover, the novel relies on a series of correspondences between the life of the Dublin character Leopold Bloom and Homer's Odysseus. Hence analogical thinking was crucial to the creative construction of the novels of Tolstoy and Joyce.

Association is less systematic than analogy: it requires only that a personal experience suggest aspects of a fictional character or event without a detailed mapping between the stimulus and the result. But association is no less inspirational than analogy, as it can start the author thinking along new and original lines. Both Tolstoy and Joyce benefitted from associations coming from many directions, including their own personal experiences, historical events, and stories. For example, Tolstoy's *Kreutzer Sonata* was inspired by an anecdote he heard about a man telling his life story on a train. Associations are heavily context specific, as Tolstoy's drew upon his life experiences in Russia, and Joyce strove to capture the essence of his experiences in Dublin.

Neither analogy nor association could produce a novel on its own, for episodes must be chained together into plots that can go on for hundreds of pages. Even an autobiographical novel depends on many analogies, i. e. many sources and targets as different episodes of the author's life get transformed into many episodes in the novel produced. Hence chaining complements analogy and association as cognitive mechanisms essential for the creative production of novels and other literary works. Many episodes of means-ends reasoning are required to craft sentences into paragraphs, paragraphs into chapters, and chapters into books.

Finally, we can notice that the production of creative novels is in part a social process, even for highly independent geniuses such as Tolstoy and Joyce (A8). For example, Tolstoy in his late twenties was part of a circle of writers associated with a periodical called *The Contemporary*. Joyce benefitted from reading Ibsen and from his associations with Yeats and Synge. Both had their works read by friends and editors before further revisions and publication. The cognitive mechanisms that produce creative

writing – combination, association, analogy, and chaining – are the major causes of literary creativity, but the relevant social mechanisms need also to be taken into account.

Poetry

Many great poets qualify as geniuses, but I will consider here two of my own favorites: Emily Dickinson (1830-1866) and William Butler Yeats (1865-1939). My main sources are their poems (Dickinson, 1983; Yeats, 1956) and biographies (Habegger, 2001; Jeffares, 2001; Yeats, 1965). The primary creative products of Dickinson and Yeats were poems, although Yeats also wrote many plays and essays. It is not easy to say whether Dickinson and Yeats exhibited procedural creativity in the invention of new methods (A1). Dickinson showed much more psychological insight than other poets of her era, but such insight can also be found in Shakespeare's sonnets. Her poems increasingly displayed assonant rhyme, broken meter, and unusual capitalization of nouns. Yeats drew originally on Irish history and mythology, but different inspirations do not constitute a new method. It therefore seems that these poets had only a small degree of procedural creativity, although their specific products were strongly new and valuable.

The professional goals of Dickinson and Yeats were very different, as she wrote primarily for herself and a few family members and friends, only publishing four poems in her lifetime. In contrast, he published many volumes of poetry and won the Nobel Prize for literature. Yeats (1965, p. 69) sought to be a great poet by writing out his emotions, and so did Dickinson (A2). I have not found any indication that Dickinson or Yeats thought of themselves as rejecting previous ways of writing poetry (A3), although Yeats explicitly rejected his father's Millian empiricist views when he said that people

who lean on logic and philosophy end up by starving the best part of the mind. Even a cursory glance at the poetry of Dickinson and Yeats displays their intense concern with human emotions (A4). Dickinson wrote about love, pain, trust, humility, bereavement, neglect, dread, fear, ecstasy, wrath, hate, loneliness, and gratitude.

The beauty and originality of their poems results in large part from the amazing metaphors produced by Dickinson and Yeats. Here are just a few examples:

Dickinson

Fame is a fickle food upon a shifting plate.

The brain is wider than the sky.

Hope is the thing with feathers.

Dying is a wild night and a new road.

Success is counted sweetest by those who ne'er succeed.

Yeats

Tread softly because you tread on my dreams.

But was there ever dog that praised his fleas?

But one man loved the pilgrim soul in you.

Was there another Troy for her to burn?

Time's bitter flood will rise, and your high beauty fall and be lost.

All of these examples, and many other non-metaphorical phrases in the two poets, require the novel combination of representations such as the words and concepts of *fame*, *fickle*, and *food*. Hence creative poetry strongly confirms the combinatorial conjecture (A5).

Holyoak and Thagard (1995, ch. 9) argue that rich metaphors have underlying analogies that provide systematic mappings between two domains. Dickinson and Yeats avoid routine metaphors like "my job is a jail" in favor of complex ones that develop such analogical mappings. For example, Dickinson develops the first metaphor above by working out the analogical correspondence in more detail:

Fame is a fickle food
Upon a shifting plate
Whose table once a
Guest but not
The second time is set.
Whose crumbs the crows inspect
And with ironic caw
Flap past it to the Farmer's Corn –
Men eat of it and die.

Hence the creative process of poetry requires the cognitive process of analogy as well as conceptual combination.

Additional cognitive processes required for poetic creativity include association and chaining. Association occurs when poets take inspiration from their personal lives or other experiences: experienced mental representations activate in working memory other representations that then get combined to produce original phrases like "The brain is wider than the sky". Dickinson led a very sheltered life, but drew inspiration from religion and her experiences with forlorn love and episodic grief. Yeats also wrote poems exhibiting despondent love, having received several marriage proposal rejections

from Maud Gonne. His poems also had many other associations, including Irish history and mythology, politics, and his interest in the occult. Association, representation combination, and analogy can merge to generate striking phrases, but the production of entire poems also requires the chaining together of phrases into one or more verses. It is evident, therefore, that at least four cognitive processes – combination, association, analogy, and chaining - contribute to poetic creativity (A6, A7).

The social life of Yeats was far richer than that of the reclusive Dickinson. In addition to the Rhymer's Club founded by Yeats in his 20s, he had many literary associates including Lady Gregory and William Synge. Dickinson, however, had only a few influences, particularly Thomas Higginson, whom she consulted for advice about writing. Hence the poetic creativity of Dickinson and Yeats fits with the hypothesis (A8) that the mechanisms of creativity are social as well as psychological.

Philosophy

It might seem odd to include philosophy among the literary arts, but I am using it here as representative of literary non-fiction, which also includes genres such as biography, history, and travel writing. There has been amazingly little discussion of philosophical creativity, despite the fact that many of the most distinguished thinkers of all time have been philosophers, for example Plato, Aristotle, Aquinas, Hobbes, Locke, Hume, Kant, Hegel, and Wittgenstein. I have examined two highly creative and productive philosophers who were also excellent writers, John Stuart Mill (1806-1873) and Bertrand Russell (1872-1979, Nobel Prize for Literature in 1950). Both wrote fine accounts of their intellectual histories (Mill, 1969; Russell 1959, 1967), and both created

elegant, comprehensible prose, avoiding the confusion of obscurity with profundity that has entrapped many philosophers.

As for all philosophers, the primary products of Mill and Russell are concepts, theories, articles, and books. Philosophers are often known for generating thought experiments, but Mill and Russell more commonly dealt with real-world situations, and my own view is that thought experiments are overrated (Thagard, forthcoming). Contrary to my expectation (A1) that geniuses display procedural creativity, Mill does not seem to have invented any methods not used by his philosophical predecessors: what are sometimes called "Mill's methods" were adapted from Francis Bacon and William Herschel. On the other hand, Russell pursued a radically new way of doing philosophy of mathematics that attempted to derive the truths from logical axioms, resulting in the three volumes of *Principia Mathematica*. The style of philosophy as logical analysis that he inaugurated with his 1905 theory of descriptions was also a procedural innovation.

Both Mill and Russell were intensely motivated by both intellectual and social goals (A2), with extensive writings on political matters as well as epistemological ones. Russell (1967, p. 13) eloquently stated what he lived for in his autobiography: "Three passions, simple but overwhelmingly strong, have governed my life: the longing for love, the search for knowledge, and unbearable pity for the suffering of mankind". Their intellectual and political goals led them to reject philosophical views that they had first adopted (A3): Mill had a traumatic break at the age of twenty with the narrow political views inculcated in him by his father, James Mill; Russell made a dramatic shift in his mid-twenties away from the idealist metaphysics of Kant and Hegel. Mill and Russell both strongly rejected the kinds of a priori intuitions that many philosophers in their days

and ours claim as a route to philosophical insight. As in the passage just quoted, Russell made it clear that his intellectual life was intensely emotional, and Mill said that the cultivation of feelings was one of the cardinal points in his ethical and philosophical creed (A4).

Does the combinatorial conjecture (A5) apply to philosophical creativity? Details are sketchy about how Mill generated his most important ideas concerning utilitarianism, liberty, inductive logic, and the subjection of women. He originated the use of the term "utilitarian" for a philosophical position based on the ideas about utility developed by his father's friend Jeremy Bentham. His 1869 advocacy of the emancipation of women rejected dominant attitudes using a utilitarian argument that the greatest good would be promoted by greater freedom and education for both sexes. Thus Mill combined concepts concerning the status of women with concepts drawn from utilitarian ethics. Russell also produced novel conceptual combinations. His theory of descriptions, designed to help interpret problematic statements such as "The present King of France is bald", did so by combining ideas about existence, uniqueness, and truth. Russell coined the term "logical atomism" to describe his early philosophy that combined the atomistic principle that the world contains isolable facts with the logical approach that Russell derived from Frege. Hence it is plausible that philosophical creativity, like that in science and technology, requires the combination of previously unconnected representations.

Mill and Russell also used other cognitive operations to produce their writings, which obviously required chaining together sentences into larger works (A7). Association operated in both their thought processes as they developed ideas suggested

from their extensive readings. Mill mentioned Plato, Wordsworth, Whewell and Comte as inspirations, and Russell said he benefitted from the works of Moore, Frege, Peano, and Cantor. I have not found any interesting cases of analogical creativity in Mill, whose discussion of analogy in the *System of Logic* is superficial. But Russell was inspired by the diagonal method that Cantor used in developing set theory to come up with his paradox about the set of things that are not members of themselves. Hence association and analogy can contribute to philosophical creativity (A6).

Finally, the creativity of Mill and Russell was clearly a social as well as a cognitive process (A8). In addition to the influences listed in the previous paragraph, Mill and Russell each enjoyed productive collaborations. Mill reported that his wife Harriet was a co-author of one of his most influential works, *On Liberty,* and Russell's *Principia Mathematica* was an intense collaboration with his former teacher, A. N. Whitehead. Philosophy is often caricatured as the efforts of solitary geniuses, but has a substantial social dimension (Collins, 1998; Thagard, 2006b).

MUSICAL ARTS

Music

There are many musical geniuses whose creativity is worth scrutiny, and I have chosen two of my favorites, classical and contemporary. Ludwig van Beethoven (1770-1827) composed marvelous symphonies and many other works, and scholars have examined carefully his work using the sketches he made while composing (Cooper, 1990; Davies, 2002; Lockwood, 1992). The Beatles (1960-1970) were the most successful popular group ever and their songs have been thoroughly analyzed (Mellers, 1973; O'Grady, 1983; Turner, 2012). Despite the great differences in the kinds of music they

produced, the processes of creativity operating in Beethoven and the Beatles had much in common. Almost all of the Beatles' famous songs resulted from the collaboration of John Lennon and Paul McCartney.

The most notable projects of Beethoven and the Beatles were the pieces of music they composed, but they were also innovative in the methods they adopted, showing their capacity for procedural creativity (A1). Beethoven used many ways of stimulating his musical creativity, including long walks, improvising on the piano, writing down sketches, and extensive revisions. The Beatles started by imitating established popular singers and songwriters, but by 1965 they had developed new electronic methods of recording songs that were not intended for public performance. Beethoven and the Beatles unavoidably had practical goals of receiving financial support for their work, but they also were passionate about artistic goals of producing new kinds of music (A2). Some of Beethoven's work had religious goals, and some of the Beatles' later works had social goals.

Beethoven did not radically reject the methods of his teachers Haydn and Mozart, but sometimes set out to shock his audiences with disruptive and alarming passages. After their initial popular success, the Beatles explicitly rejected the conventions of contemporary popular songs about love, and dramatically changed both the topics of their songs and the kinds of instruments they used (A3). Emotions such as joy, shock, and surprise contributed to Beethoven's compositions and the public's appreciation of them. The Beatles' early songs were mostly about the happiness of love, but some of the later work concerned negative emotions such as fear, loss, and despair (A4).

Musical genius confirms the conjecture that creativity requires the combination of mental representations (A5), but in music the representations are often auditory images rather than mental pictures or words. Beethoven's powers of auditory representation were so great that he continued to compose after he had become too deaf to hear the piano. Producing music requires combinations that are synchronic (combining notes into a chord, or voices into harmony) and diachronic (producing a melody as a series of notes or chords). Combination of representations is also required to imagine how different instruments will play a piece together. In addition to combinations of auditory representations, songs require integration of auditory and verbal representations, connecting lyrics to the music as in the last movement of Beethoven's Ninth Symphony and in all of the Beatles' hits. Some of the best of the Beatles' songs combined McCartney's tunes with Lennon's wordplay. Visual representations may also have operated in the background, as in the Beatles' song "Lucy in the Sky with Diamonds" and Beethoven's evocative Pastoral Symphony.

New combinations did not arise randomly, but rather were usually produced in the context of attempts to generate new compositions. A possible exception is Paul McCartney's melody for "Yesterday", which he said came to him while sleeping. External associations in which verbal or visual representations inspired musical compositions operated in Beethoven's mind with influences such as women, religion, history (e.g. Napoleon), and literature. The Beatles' many songs were inspired by a wide variety of associations, including relationships, other personal experiences, and drug trips. Occasionally, composers think analogically, as when Beethoven based some of his passages on folk melodies and reused portions of his previous work. Much of the

Beatles' early work was admittedly analogical, as they tried to copy and modify parts of works by their favorite singers/songwriters such as Chuck Berry, Roy Orbison, Smokey Robinson, and later Bob Dylan. One of the Beatles' songs, "Because", resulted from an inversion of Beethoven's "Moonlight Sonata"! In sum, the creative processes of Beethoven and the Beatles included inspiration by external associations and analogies (A6) along with means-ends reasoning and chaining (A7).

Beethoven's creative productions were not very social, although he benefited from his early lessons from Haydn and Mozart and from patrons such as Archduke Rudolf. In contrast, many of the early Lennon/McCartney songs were intensely collaborative, with them working together for hours to produce new melodies and lyrics. Later, their collaboration was more serial, with one of them producing most of a song and the other merely providing additional material. Other influences included the rest of the band (George Harrison and Ringo Star) as well as their arranger and producer, George Martin. Because of the partnership of Lennon and McCartney, the Beatles provide one of the best available artistic illustrations of how creativity can be a social process as well as a cognitive and affective one (A8).

Dance

Modern dance began in the early twentieth century as an alternative to the forms of popular dance found in many cultures and the stylized artistic form of classical ballet (Clarke and Crisp, 1981). Two of its most creative contributors were Isadora Duncan (1878-1927) and Martha Graham (1894-1991), and the following discussion is largely based on their autobiographies (Duncan, 1955; Graham, 1991).

Both Duncan and Graham generated many highly regarded products including particular performances, repeatedly performed choreographed dances, and methods. The new methods consisted of styles of performing, choreographing, and teaching that differed radically from previous popular and artistic procedures (A1). Both Duncan and Graham consciously rejected the techniques of conventional ballet and were highly motivated to produce new forms (A2, A3). Duncan sought fame, but she also had spiritual motivations to use dance to achieve the divine expression of the human spirit through the beauty and holiness of the body. Graham wanted to grow within herself, but also to do something in dance that was uniquely American. Graham started to choreograph in order to be able to show off her dancing, and even composed a dance called *Heretic* to capture how she thought of herself. Both Duncan and Graham found new ways of working with music and composers to produce novel fusions of sound and movement.

For both Duncan and Graham, dance was highly emotional (A4). Duncan endeavored to convey to the audience the emotions of the characters she was portraying, such as fear and sorrow, and to express the passions of the music. For Graham, dance came from desire, providing a kind of graph of the heart. In her performances, she was sincere in doing only what she felt. In teaching, she strove to give children the excitement of dance.

Much of the novelty and value of the work of Duncan and Graham resulted from new combinations (A5). Duncan's performances replaced ballet steps by flowing movements inspired by many kinds of motion, including trees, waves, snows, breezes, walks, and jumps. These movements integrated kinesthetic representations of bodily

positions and actions with visual representations of what the dance should look like and auditory representations of the musical accompaniment. In various works, Graham sought to combine movement and light, literary ideas and music, breathing and posture, images and emotions, and touch and motivation. Dance thus provides a wonderful example of how combination of multimodal representation can generate artistic creativity.

What are the cognitive processes that led Duncan and Graham to produce new combinations? Both were motivated to produce original works, so part of their cognitive processing involved figuring out how to produce means that accomplished their goals. The motions that they arrived at by combining representations had to be chained together to produce whole dances (A7).

Both Duncan and Graham mentioned many different inspirations, which divide into analogies and associations (A6). Sometimes their associations were highly theoretical, as in the uses Duncan says she made of ideas from Beethoven, Nietzsche, and Wagner. Other associations are more observational, such as the images that Duncan got from Greek vases. Often music is the inspiration for dance movements, both as association of particular emotional expressions and as analogical transfer of the structure of the sounds to the structure of the movements. This might be called a *cross-modal* analogy, where the structure is carried over from representations in one modality (sound) to representations in another (muscle movement). Graham describes an even more striking instance of cross-modal analogizing, with a visual source. She describes her strong emotional reaction when she first saw abstract art by Kandinsky and vowed to make a dance like it, which she eventually did. Graham's other works were associated

many other ideas and experiences, including musical instruments, Mexican and Indian art, sex, various composers. She describes her technique as being based on breathing: "I have based everything I have done on the pulsation of life, which is, to me, the pulsation of breath." (Graham, 1991, p. 46). Cross-modal analogies also operate in the minds of painters (emotions -> visual images), poets (images -> words), and musicians (images -> sounds).

Duncan and Graham departed dramatically from previous styles of dance, but they did receive help from other people along the way (A8). Duncan was inspired by the ideas of Francois Delsarte, and encouraged by the music critic J. Fuller Maitland. Graham collaborated with many composers including Aaron Copland and Louis Horst. In sum, the contributions to modern dance of Isadora Duncan and Martha Graham provide vivid illustrations of the roles of motivations, emotions, combinations, associations, analogies, and social processes in processes of creative cognition.

COMPARISONS

Several kinds of comparisons show what can be learned from considering a generous sample of creative artists, relevant to answering the following questions: How does creativity differ across different fields of art and across different artists? How does creativity in the arts differ from creativity in science and technology? Fourteen artists are obviously too few to make definitive generalizations, but I will try to sketch some tentative conclusions.

The most obvious differences among the seven artistic fields I discussed is the primary form of mental representations. Painters and architects work primarily in visual images; novelists, poets, and philosopher work primarily in words; and musicians

and dancers work primarily with auditory and kinesthetic representations. Nevertheless, we saw abundant examples of mixing of kinds of representations, for example when painters are inspired by verbal ideas, writers are inspired by visual images, and dancers employ cross-modal analogies.

All seven artistic fields confirm hypotheses A1-A8 to a large extent, with all 14 artists displaying goals, emotions, combinations, associations, chaining, and social influences. Almost all of them also exhibited procedural creativity, rejection of previous approaches, and analogies, the work of a few artists was short on these dimensions, at least as far as I was able to determine from the sources I consulted. I was unable to identify new methods generated by Dickinson, Yeats, and Mill. Rejection of previous approaches did not seem central to da Vinci, Dickinson, Yeats, and Beethoven. I found no creative use of analogies in Mill. Overall, however, it is legitimate to conclude that procedural creativity, rejection of predecessors, and analogies do contribute much to artistic creativity.

Finally, we can ask how artistic creativity compares with scientific discovery and technological invention. There are clear differences with respect to goals: scientists generally aim for empirical findings and theories that explain them, whereas inventors aim for products with practical applications. Artists have many aims different from these, such as producing beauty, enjoyment, and insight. Clearly, however, the goals of artists have some overlap with those of scientists and inventors: many philosophers are often similar to scientists in seeking theoretical explanations, and most architects share with inventors the goal of producing objects that are practically useful. Like scientists

and inventors, artists employ means-ends reasoning, but their ends and therefore their means can be different.

In cognitive processes, there are many commonalities among creative scientists, inventors, and artists, as all gain from goals, emotions, combinations, associations, analogies, chaining, and social influences. Rejection of previous approaches is not universal among creative scientists and inventors, but certainly was powerfully active in thinkers such as Copernicus, Galileo, Darwin, Edison, and Einstein. Hence we can conclude that rejection of precedents often contributes to various kinds of creativity, even though it is not essential. In sum, we can say that although there are differences in the aims of artists, scientists, and inventors, their cognitive, affective and social processes are remarkably similar.

CONCLUSION

Aside from general confirmation of hypotheses A1-A8, I think that the most interesting results of this study of 14 artists are several findings that I had not anticipated. Based on previous work on creative analogies, I was looking for analogical thinking in each of the artists, but did not anticipate the different forms that analogies would take, including: using models as visual analogies in painting, using personal experience to generate characters and plots in novels, and analogies that cross modalities in dance. I was also surprised that some of the artists, although productively new and original, did not seem to be revolutionary in rejecting previous approaches in their respective fields.

The use of multiple modalities (visual, verbal, auditory, kinesthetic) by artists raises difficult questions about how minds operate in all these formats. One might postulate that the mind has a common underlying format, a language of thought, into

which all other formats can be translated. I think it is more plausible, however, to drop down to the neural level and identify the common representational mechanism as the patterns of firing in populations of interconnected neurons. The brain does not need to translate among mental sounds, words, and pictures, because all of these function in the brain as neural firings (Eliasmith, 2013). Neural processes for combining representations are described elsewhere (Thagard and Stewart, 2011; Thagard, 2012; Thagard, forthcoming-a). A full account of the neural mechanisms responsible for the psychological processes I have described will also need to take into account molecular processes such as the role of dopamine in positive emotions.

I hope that this study serves to show that artistic genius is no more mysterious than genius in more frequently studied fields. The production of many new and valuable works of art does not require the Muses or other supernatural interventions. Instead, artistic creativity can largely be explained by a sufficiently rich set of interlocking cognitive processes including motivation, emotion, combination, association, analogy and chaining.

Acknowledgements. I am grateful to Dean Simonton and Robert McCauley for helpful comments on an earlier draft. This research is supported by the Natural Sciences and Engineering Research Council of Canada.

REFERENCES

Boden, M. (2004). *The creative mind: Myths and mechanisms* (2nd ed.). London: Routledge.

Christian, R. F. (Ed.). (1985). *Tolstoy's diaries*. London: The Athlone Press.

Clarke, M., & Crisp, C. (1981). *The history of dance*. London: Orbis.

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review, 82*, 407-428.

Collins, R. (1998). *The sociology of philosophies: A global history of intellectual change*. Cambridge, MA: Harvard University Press.

Cooper, B. (1990). *Beethoven and the creative process*. Oxford: Clarendon Press.

Crankshaw, E. (1974). *Tolstoy: The making of a novelist*. London: Weidenfeld & Nicolson.

da Vinci, L. (2008). *Notebooks*. Oxford: Oxford University Press.

Davies, P. J. (2002). *The character of a genius: Beethoven in perspective*. Westport, CT: Greenwood Press.

Dickinson, E. (1983). *The collected poems of Emily Dickenson*. New York: Chatham River Press.

Dunbar, K., & Fugelsang, J. (2005). Scientific thinking and reasoning. In K. J. Holyoak & R. Morrison (Eds.), *Cambridge handbook of thinking and reasoning* (pp. 705-726). Cambridge: Cambridge University Press.

Duncan, I. (1955). *My life*. New York: Livewright.

Eliasmith, C. (2013). *How to build a brain*. Oxford: Oxford University Press.

Ellman, R. (1959). *James Joyce*. New York: Oxford University Press.

Findlay, S. D., & Thagard, P. (2012). How parts make up wholes. *Frontiers in Physiology, 3*. Retrieved from http://www.frontiersin.org/Journal/Abstract.aspx?s=1086&name=systems_biology&ART_DOI=10.3389/fphys.2012.00455 doi:10.3389/fphys.2012.00455

Finke, R., Pinker, S., & Farah, M. (1989). Reinterpreting visual patterns in mental imagery. *Cognitive Science, 13*, 51-78.

Graham, M. (1991). *Blood memory*. New York: Doubleday.

Habegger, A. (2001). *My wars are laid away in books: The life of Emily Dickinson*. New York: Random House.

Hofstadter, D. (1995). *Fluid concepts and creative analogies: Computer models of the fundamental mechanisms of thought*. New York: Basic Books.

Holyoak, K. J., & Thagard, P. (1995). *Mental leaps: Analogy in creative thought*. Cambridge, MA: MIT Press/Bradford Books.

Huxtable, A. L. (2004). *Frank Lloyd Wright*. New York: Viking.

Jeffares, A. N. (2001). *W. B. Yeats: A new biography*. London: Continuum.

Kaufman, J. C., & Sternberg, R. J. (Eds.). (2010). *The Cambridge handbook of creativity*. Cambridge: Cambridge University Press.

Le-Corbusier (1971). *The city of tomorrow and its planning* (F. Etchells, Trans. 3rd ed.). London: Architectural Press.

Le-Corbusier (2007). *Toward an architecture* (J. Goodman, Trans.). Los Angeles: J. Paul Getty Trust.

Lisle, L. (1980). *Portrait of an artists: A biography of Georgia O'Keeffe*. New York: Washington Square Press.

Lockwood, L. (1992). *Beethoven: Studies in the creative process*. Cambridge, MA: Harvard University Press.

McCurdy, E. (2005). *The mind of Leonardo da Vinci*. Mineola, NY: Dover.

Mellers, W. (1973). *Twilight of the gods: The Beatles in retrospect*. London: Faber & Faber.

Mill, J. S. (1969). *Autobiography*. Boston: Houghton Mifflin.

Milosz, M. (2012). Mental representations and creativity in architectural design. *Unpublished manuscript, University of Waterloo*.

Nersessian, N. (2008). *Creating scientific concepts*. Cambridge, MA: MIT Press.

Nicholl, C. (2004). *Leonardo da Vinci: Flights of the mind*. New York: Viking.

O'Brien, E. (1999). *James Joyce*. London: Weidenfeld & Nicolson.

O'Grady, T. J. (1983). *The Beatles: A musical evolution*. Boston: Twayne.

O'Keeffe, G. (1976). *Georgia O'Keeffe*. New York: Viking.

Ormiston, R. (2011). *Leonardo da Vinci: His life and works in 500 images*. Wigston, UK: Lorenz Books.

Robinson, R. (1989). *Georgia O'Keeffe: A life*. New York: Harper & Row.

Russell, B. (1959). *My philosophical development*. London: George Allen & Unwin.

Russell, B. (1967). *The autobiography of Bertrand Russell* (Vol. 1-3). London: George Allen & Unwin.

Schröder, T., & Thagard, P. (2013). The affective meanings of automatic social behaviors: Three mechanisms that explain priming. *Psychological Review, 120*, 255-280.

Simonton, D. (2012). Taking the US Patent Office creativity criteria seriously: A quantitative three-criterion definition and its implications. *Creativity research journal, 24*, 97-106.

Simonton, D. K. (1988). *Scientific genius: A psychology of science*. Cambridge: Cambridge University Press.

Simonton, D. K. (2004). *Creativity in science: Chance, logic, genius, and zeitgeist*. Cambridge: Cambridge University Press.

Stewart, D. (1792). *Elements of the philosophy of the human mind*. London: Strahan, Cadell, and Creech.

Thagard, P. (1988). *Computational philosophy of science*. Cambridge, MA: MIT Press.

Thagard, P. (1992). *Conceptual revolutions*. Princeton: Princeton University Press.

Thagard, P. (1999). *How scientists explain disease*. Princeton: Princeton University Press.

Thagard, P. (2006a). *Hot thought: Mechanisms and applications of emotional cognition*. Cambridge, MA: MIT Press.

Thagard, P. (2006b). How to collaborate: Procedural knowledge in the cooperative development of science. *Southern Journal of Philosophy, 44*(177-196).

Thagard, P. (2012). *The cognitive science of science: Explanation, discovery, and conceptual change*. Cambridge, MA: MIT Press.

Thagard, P. (forthcoming-a). Creative intuition: How EUREKA results from three neural mechanisms. In L. M. Osbeck & B. S. Held (Eds.), *Rational intuition: Philosophical roots, scientific investigations* Cambridge: Cambridge University Press.

Thagard, P. (forthcoming-b). Thought experiments considered harmful. *Perspectives on Science*.

Thagard, P., & Stewart, T. C. (2011). The Aha! experience: Creativity through emergent binding in neural networks. *Cognitive Science, 35*, 1-33.

Turner, S. (2012). *A hard day's write: The stories behind every Beatles song*: SevenOaks.

Weber, N. F. (2008). *Le Corbusier: A life*. New York: Knopf.

Wilson, A. N. (1988). *Tolstoy*. London: Hamish Hamilton.

Wright, F. W. (1977). *An autobiography*. New York: Horizon Press.

Yeats, W. B. (1956). *The collected poems of W. B. Yeats*. New York: Macmillan.

Yeats, W. B. (1965). *The autobiography of William Butler Yeats*. New York: Collier.