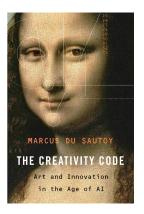**Book review to appear in the journal *Perspectives on Science and Christian Faith***

THE CREATIVITY CODE: Art and Innovation in the Age of AI by Marcus du Sautoy. Cambridge, MA: Belknap (Harvard) Press, 2019. 295 pages plus preface and acknowledgments. Hardback; $30.00. ISBN: 9780674988132.

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Following his international bestseller *The Music of the Primes,* mathematician and science popularizer Marcus du Sautoy, Simonyi Professor for the Public Understanding of Science at Oxford University, takes lay readers on a vibrant tour of the world of creativity and the history of attempts at automating the creative process. In so doing, he touches on deep questions of what it means to be human.

In his first chapter, du Sautoy poses what he terms the "Lovelace Test" of computer creativity, an analogy to the well-known "Turing Test" for determining machine intelligence and in homage to computing pioneer Ada Lovelace. Lovelace's musings on the future applications of computers to creative pursuits form a recurring theme throughout the book.

"To pass the Lovelace Test, an algorithm has to produce something that is truly creative. The process has to be repeatable... and the programmer has to be unable to explain how the algorithm produced its output" (p. 6).

As for what counts as "creative," du Sautoy specifies that it must be *new*, *surprising*, and *of value.* Furthermore, "For a machine to be deemed truly creative, its contribution has to be more than an expression of the creativity of its coder or the person who built its dataset" (p. 6).

So begins a discussion of *human* creativity, drawing on the work of cognitive scientist Margaret Boden, who identified three main types of creativity: exploratory (pushing the boundaries while keeping to the rules), combinational (achieving a synthesis by combining different constructs), and transformational (complete game-changers). du Sautoy describes examples of these from the worlds of art, music and mathematics, and notes that while computers may do well at exploratory and combinational creativity, transformational creativity is not yet well enough understood to be taught to humans, let alone machines. However, Boden believes that 97 percent of human creativity is of the exploration type, and thus machines present a potential 'threat' to overturn the human dominance in creative accomplishment.

Some might wonder what a mathematician knows of creativity, as du Sautoy concedes, "mathematicians are a bit of a misunderstood breed" (p. 145). In Chapter 9, "The Art of Mathematics," he relates his quandary as a young man upon encountering the work of the great

G.H. Hardy, who wrote, "A mathematician, like a painter or a poet, is a maker of patterns... The mathematician's patterns, like the painters or the poet's, must be beautiful; the ideas like the colors or the words must fit together in a harmonious way." (*A Mathematician's Apology*, Cambridge University Press, 2004). du Sautoy confesses that, up to that point, "I'd never imagined mathematics to be a creative subject, but as I read Hardy's little book it seemed like the aesthetic sensibilities were as important as the logical correctness of the ideas" (p. 141). Echoes of this appear in Douglas Hoftstader's famous *Gödel, Escher, Bach* (Basic Books, 1979) and William Dunham's lovely *Journey Through Genius* (Penguin Books, 1991), in which the great theorems of mathematics are presented as enduring masterpieces of art. To these discussions, du Sautoy adds the metaphor of mathematics as *story*: "I believe a good proof has many things in common with a great story or a great composition in that it takes its listeners on a journey of transformation and change" (p. 229). He ties this in well with AI efforts toward story-generation and essay-writing. (He even concedes at the end that a portion of the book's text was generated by an AI authorship tool.)

It is an apt analogy, for narrative is a skill that du Sautoy shares with other successful science communicators, telling stories from history as well as from personal encounters with a host of leading computer scientists, artists and musicians – names like art curator Hans-Ulrich Obrist and musician Brian Eno. du Sautoy's lofty academic position provides him with the privilege of access to such luminaries, allowing for off-handed remarks such as the beginning to Chapter 3 about the development of the *AlphaGo* program which soundly defeated the world's top-ranked player in the game of *Go*: "I was sitting next to [DeepMind co-founder] Demis Hassabis at one of the Royal Society's meetings..." (p. 218). du Sautoy's personal story is woven throughout the book, from his own experiences in contributing to the mathematical study of symmetry to his appreciation for art and music. *The Creativity Code* contains narratives about the development of, if not *every* attempt at machine-based creativity, a vast panoply of major and minor systems throughout history, e.g., from the dice-based compositional games of Mozart to the neural nets of *DeepBach*, and from Gerhard Richter's *4900 Farben* to the *Next Rambrandt* of Microsoft and TU-Delft, from early choose-your-own-adventure stories to the interactive narratives of Mark Riedl's *Scheherazade-IF*.

Toward the end, the intensity and depth of feeling in the book escalate. After surveying developments in the fields of music, art, poetry, and more, he shares his own musings on mathematics via AI, in which one can feel his *personal* stake, e.g., in concerns over computers taking over his livelihood. Remarks made earlier by artists and musicians about whether a computer-generated piece is not merely *new* but also *surprising* and *valuable* take on a new poignancy, as in his lament about the mathematical proof-generating program *Mizar*: "I left the DeepMind offices rather downcast...what I had seen was like a mindless machine cranking out mathematical Muzak." He then shares a quote from mathematician Henri Poincare who might as well have been speaking of songwriting: "To create consists precisely in not making useless combinations. Creation is discernment, choice..." (p. 228).

Unlike his Simonyi Professor predecessor Richard Dawkins, du Sautoy demonstrates no antipathy toward religion, yet his musings on human identity and religious motivations for art at times ring strangely superficial in comparison to the other topics he covers so deftly. At one point, without any hint of irony, he tells a story about how religion arose from humans' need to

tell stories to explain the world around them. Almost the entirety of the book is concerned with the *how* of creativity (i.e., in the processes), as well as concerns about the implications for the future employment of artists, writers, musicians, and indeed mathematicians in the face of AI advances. These lead naturally to the capstone final chapter, "Why We Create," in which he quotes from psychologist Carl Rogers and author Paul Coelho on the roots of creativity as a human need to communicate, and to bind communities together. While du Sautoy doesn't go on to provide it, these reasons form a subset of a Christian response to the *why* of human creativity, e.g., as seen in the works of theologian/musician Steven Guthrie, who likens creativity to gift-giving: "God invites us into the ecology of gift that is at the center of God's own life....God's intention is that we would like God, be agents capable of giving to others" (*Creator Spirit: The Holy Spirit and the Art of Becoming Human,* Baker Academic, 2011).

The Creativity Code is current with respect to AI developments up until the time it went to press. However, this was prior to the debut of the 'Transformer' language models in early 2019, which far surpassed many people's conceptions of the capabilities of generative language models, even inspiring widespread concerns regarding their potential misuse (for example, see J. Vincent, "OpenAI's New Multitalented AI Writes, Translates, and Slanders", *The Verge*, Feb 14, 2019). Thus in reading the later chapters on AI, language, and text-creation, one wonders how different an updated edition of this book would read in light of these developments. With AI changing so quickly, it may be impossible to produce a book that will stand the test of time in every respect, and it remains to be seen what other 'updates' the coming years will bring as far as AI's capabilities. Yet, as both as a comprehensive historical survey and as an authoritative statement of values about creativity, du Sautoy's book will remain a significant contribution and should be read by anyone interested in the intersection of AI and creativity.

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