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Beyond the Creative Species

Making Machines That Make Art and Music

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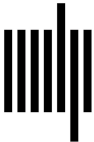
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Notes

Chapter 1

1. John Brockman, ed., *What to Think About Machines That Think: Today's Leading Thinkers on the Age of Machine Intelligence* (Harper Perennial, 2015).
2. Comment in an email discussion forum, archived at <https://www.southampton.ac.uk/~harnad/Hypermail/Explaining.Mind96/0069.html>.
3. Make no mistake, today's machines don't dream, but it is certainly a compelling idea that a machine could dream.
4. Dubbed "Bot Dylan" by the newspaper (without approval from the system's creator).
5. Bob L. Sturm, "The 'Horse' Inside: Seeking Causes Behind the Behaviors of Music Content Analysis Systems," *Computers in Entertainment (CIE)* 14, no. 2 (2016).
6. Ray Kurzweil, *The Age of Spiritual Machines: How We Will Live, Work, and Think in the New Age of Intelligent Machines* (Orion, 1999).
7. Brian Eno, *Generative Music 1*, sleeve notes, 1996.
8. Jay Barmann, "Bay Area Billionaire Vinod Khosla Believes that AI Will Replace Musicians and Songwriters in 10 Years," *SFist*, June 14, 2019, <https://sfist.com/2019/06/14/bay-area-billionaire-vinod-khosla/>.
9. Glenn W. Smith and Frederic Fol Leymarie, "The Machine as Artist: An Introduction," *Arts* 6, no. 1 (2017).
10. To be fair, it should be read as more of a provocation than a prediction. Eno has written widely on generative music and is not as inclined toward predictions as Kurzweil. Eno, *Generative Music 1*.
11. Toivonen and Gross have perhaps the simplest definition of computational creativity: "The goal of computational creativity research is to model, simulate, or enhance creativity by computational means." Yet "enhancing" creativity might be considered too inclusive an activity, admitting all kinds of software that might

speed up or transform a creative process. Hannu Toivonen and Oskar Gross, "Data Mining and Machine Learning in Computational Creativity," *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery* 5, no. 6 (2015).

12. It has been hard to precisely define the scope of this book. My focus is on creative tasks in art and music. Sometimes, for convenience, I will use "art" as a loose catchall term (in the sense of "the creative arts") that includes music, as well as many other things. Another useful catchall term favored by some anthropologists and sociologists is "cultural production," which I introduce in chapter 4. I also occasionally refer to "creative domains," with a similar scope in mind. Lastly, although I include literary work and computer games in my list, this book is primarily about visual art and music. There are many other great texts in these specific subfields.

13. Amílcar Cardoso, Tony Veale, and Geraint A. Wiggins, "Converging on the Divergent: The History (and Future) of the International Joint Workshops in Computational Creativity," *AI Magazine* 30, no. 3 (2009).

14. Cardoso, Veale, and Wiggins, "Converging on the Divergent."

15. We could also describe his work as Inman Harvey has described the field of cognitive robotics research: "philosophy of mind with a screwdriver." Inman Harvey, "Robotics: Philosophy of Mind Using a Screwdriver," *Evolutionary Robotics: From Intelligent Robots to Artificial Life* 3 (2000).

16. Paul Brown, personal communication.

17. Harold Cohen, "Parallel to Perception: Some Notes on the Problem of Machine-Generated Art," *Computer Studies* 4, no. 3/4 (1973).

18. I recommend listening to the more timeless Disklavier piano versions rather than the earlier recordings that used the more of-their-time 1980s MIDI sounds. The use of an acoustic piano helps draw attention away from the computational origin of the performance.

19. David Cope, "An Expert System for Computer-Assisted Composition," *Computer Music Journal* 11, no. 4 (1987); David Cope, "Computational Creativity and Music," in *Computational Creativity Research: Towards Creative Machines*, ed. Tarek R. Besold, Marco Schorlemmer, and Alan Smaill (Atlantis, 2015).

20. David Cope, *Virtual Music: Computer Synthesis of Musical Style* (MIT Press, 2004).

21. Ryan Blitstein, "Triumph of the Cyborg Composer," *Pacific Standard*, February 2010, <https://psmag.com/social-justice/triumph-of-the-cyborg-composer-8507>.

22. Cope, *Virtual Music*.

23. Cope, *Virtual Music*.

24. Cope, *Virtual Music*.
25. It is also worth noting that these pioneers are all male, reflecting the gender inequality in opportunities and role models of that time, which persists to a somewhat lesser extent today.
26. Pamela McCorduck, *Machines Who Think* (Peters, 2004).
27. Toby Walsh, "What AI Can (and Can't) Do," 2017, <https://www.youtube.com/watch?v=79O903oGmmU>.
28. For example, see this discussion of shifting nomenclature around the terms machine learning (ML) and AI, <http://approximatelycorrect.com/2018/06/05/ai-ml-ai-swirling-nomenclature-slurried-thought/>.
29. Peter Stone et al., "Artificial Intelligence and Life in 2030," *One Hundred Year Study on Artificial Intelligence: Report of the 2015–2016 Study Panel*, Stanford University, 2016.
30. Stone et al., "Artificial Intelligence and Life in 2030."
31. In 1951, a piece of music was played on a computer, the CSIRAC in Melbourne, Australia, for the first time. This was a rendering of precomposed music, not generative in any way, but this in itself would have presumably drawn attention from different communities to join the frenzy of activity that was about to take place in the space of computer-generated music. Paul Doornbusch, "The Music of CSIRAC, Some Untold Stories," in *Proceedings of the 19th International Symposium of Electronic Art*, ed. K. Cleland, L. Fisher, and R. Harley, ISEA2013, Sydney, 2013.
32. Lejaren A. Hiller Jr. and Leonard M. Isaacson, "Musical Composition with a High Speed Digital Computer," *Audio Engineering Society Convention 9, 1957*.
33. Cope, "An Expert System for Computer-Assisted Composition."
34. Tina Hesman Saey, "Computers Compose Personalized Music," *PopMatters*, June 2007, <http://www.popmatters.com/article/computers-compose-personalized-music/>.
35. Hesman Saey, "Computers Compose Personalized Music." What calculation and confidence was involved in coming up with this figure is worthy of some cynical scrutiny. If, by this measure, Marcel Duchamp would score 1 percent for his creative contribution to the work *Fountain*, then where does this leave us? I hope not to have to answer this question.
36. Philip Ball, "Iamus, Classical Music's Computer Composer, Live from Malaga," *Guardian*, July 1, 2012, <https://www.theguardian.com/music/2012/jul/01/iamus-computer-composes-classical-music>.
37. Olivia Goldhill, "The First Pop Song Ever Written by Artificial Intelligence Is Pretty Good, Actually," *Quartz*, September 24, 2016, <https://qz.com/790523/daddys-car-the-first-song-ever-written-by-artificial-intelligence-is-actually-pretty-good/>.

38. Alex Marshall, "Is This the World's First Good Robot Album?," BBC, January 2018, <https://www.bbc.com/culture/article/20180112-is-this-the-worlds-first-good-robot-album>.
39. Simon Colton et al., "The *Beyond the Fence* Musical and *Computer Says Show* Documentary," *Proceedings of the International Conference on Computational Creativity*, 2016.
40. Guardian Music, "Warner Music Signs First Ever Record Deal with an Algorithm," *Guardian*, March 2019, <https://www.theguardian.com/music/2019/mar/22/algorithm-endeel-signs-warner-music-first-ever-record-deal>.
41. Joel Lehman et al., "The Surprising Creativity of Digital Evolution: A Collection of Anecdotes from the Evolutionary Computation and Artificial Life Research Communities," *arXiv:1803.03453* (2018).
42. <https://www.nexttrembrandt.com/>.
43. Lara O'Reilly, "A Japanese Ad Agency Invented an AI Creative Director—and Ad Execs Preferred Its Ad to a Human's," *Business Insider*, March 2017, <http://www.businessinsider.com/mccann-japans-ai-creative-director-creates-better-ads-than-a-human-2017-3>.
44. Henry Bruce-Jones, "Holly Herndon on AI: Technology 'Should Allow Us to Be More Human,'" *FACT Magazine*, November 2019, <https://www.factmag.com/2019/11/27/holly-herndon-grimes-zola-jesus-artificial-intelligence-interdependent-music/>.
45. Hesman Saey, "Computers Compose Personalized Music."
46. Blitstein, "Triumph of the Cyborg Composer."
47. Ball, "Iamus, Classical Music's Computer Composer, Live from Malaga."
48. More ambiguously, researchers themselves may also appeal to indirect markers of success. When a Japanese data company purchased a work by the AI painting system the Painting Fool to hang in its office, this was presented by its authors as "one of the first instances in Computational Creativity research where creative software has been commissioned directly." Simon Colton et al., "The Painting Fool Sees! New Projects with the Automated Painter," *Proceedings of the International Conference on Computational Creativity*, 2015. Likewise some researchers contributing to the *Beyond the Fence* musical used audience numbers as a proxy for the success of their generative systems.
49. Ball, "Iamus, Classical Music's Computer Composer, Live from Malaga."
50. Smith and Leymarie, "The Machine as Artist."
51. Smith and Leymarie, "The Machine as Artist."
52. François Pachet, "Beyond the Cybernetic Jam Fantasy: The Continuator," *IEEE Computer Graphics and Applications* 24, no. 1 (2004).

53. Christine McLeavey Payne, "Musenet," *OpenAI*, April 2019, <https://openai.com/blog/musenet/>.
54. Sturm, "The 'Horse' Inside."
55. Alexandre Papadopoulos, Pierre Roy, and François Pachet, "Avoiding Plagiarism in Markov Sequence Generation," *Twenty-Eighth AAAI Conference on Artificial Intelligence, 2014*.
56. McLeavey Payne, "Musenet."
57. Aaron Hertzmann, "Can Computers Create Art?," *Arts 7*, no. 2 (2018).
58. Hertzmann, "Can Computers Create Art?"
59. P. M. Todd and G. Werner, "Frankensteinian Methods for Evolutionary Music Composition," in *Musical Networks: Parallel Distributed Perception and Performance*, ed. Niall Griffith and Peter M. Todd (MIT Press/Bradford Books, 1999).
60. More generally, evolutionary computing methods are part of a family of population-based metaheuristic search methods.
61. Gregory S. Hornby, Al Globus, Derek S. Linden, and Jason D. Lohn, "Automated Antenna Design with Evolutionary Algorithms," *Space 2006*, September 19, 2006, [https://ti.arc.nasa.gov/m/pub-archive/1244h/1244%20\(Hornby\).pdf](https://ti.arc.nasa.gov/m/pub-archive/1244h/1244%20(Hornby).pdf).
62. Philip Galanter, "What Is Generative Art? Complexity Theory as a Context for Art Theory," *GA2003—6th Generative Art Conference, 2003*.
63. Kate Compton and Michael Mateas, "Casual Creators," *Proceedings of the International Conference on Computational Creativity, 2015*.
64. Kate Compton, GalaxyKate, <http://www.galaxykate.com/>.
65. Andy Lomas, "On Hybrid Creativity," *Arts 7*, no. 3 (2018).
66. Mitchell Whitelaw, "System Stories and Model Worlds: A Critical Approach to Generative Art," February 2006, <http://mtchl.net/system-stories-model-worlds/>. Whitelaw is also known for the term "metacreation," from his book of that name, which is used prominently in discussions of generative art, particularly that inspired by artificial life. Mitchell Whitelaw, *Metacreation: Art and Artificial Life* (MIT Press, 2004).
67. For a very thorough discussion of current issues relating to the embrace of creative AI, see Blaise Agüera y Arcas, "Art in the Age of Machine Intelligence," *Arts 6*, no. 4 (2017).
68. Karen Hao, "These Awful AI Song Lyrics Show Us How Hard Language Is for Machines," *MIT Technology Review*, November 13, 2018, <https://www.technologyreview.com/f/612412/these-awful-ai-song-lyrics-show-us-how-hard-language-is-for-machines/>. Curiously, the article claims this is evidence of how far we have to go,

but it makes no sense to cherry-pick one example of bad AI output to use as evidence that all AI output is bad. There are some very good language models out there.

69. Cardoso, Veale, and Wiggins, “Converging on the Divergent.”

70. Cardoso, Veale, and Wiggins, “Converging on the Divergent.”

71. The focus on crockpot recipes was in order to limit the search to ingredient combinations, the broad assumption being that for all such recipes, the instructions are to mix the ingredients together in a pot. This is a nice example of simplifying a problem space in computational creativity. It will no doubt offend some crockpot connoisseurs, but as ever, we have to start somewhere. Dan Ventura, “The Computational Creativity Complex,” in *Computational Creativity Research: Towards Creative Machines*, ed. Tarek R. Besold, Marco Schorlemmer, and Alan Smaill (Atlantis, 2015).

72. Ventura, “The Computational Creativity Complex.”

73. Pablo Gervás, “A Personal Perspective into the Future for Computational Creativity,” in *Computational Creativity Research: Towards Creative Machines*, ed. Tarek R. Besold, Marco Schorlemmer, and Alan Smaill (Atlantis, 2015).

74. M. T. Pearce, D. Meredith, and G. A. Wiggins, “Motivations and Methodologies for Automation of the Compositional Process,” *Musicae Scientiae* 6, no. 2 (2002).

Chapter 2

1. Quoted in George B. Dyson, *Darwin Among the Machines: The Evolution of Global Intelligence* (Basic Books, 2012).

2. Herman Hesse, *Siddhartha* (New Direction, 1951).

3. Mel Rhodes, “An Analysis of Creativity,” *Phi Delta Kappan* 42, no. 7 (1961).

4. Raymond Williams, *Keywords*, rev. ed. (Fontana Press, 1983).

5. Williams, *Keywords*.

6. Arthur Still and Mark d’Inverno, “A History of Creativity for Future AI Research,” *Proceedings of the 7th Computational Creativity Conference (ICCC 2016)*, Université Pierre et Marie Curie, 2016.

7. Still and d’Inverno, “A History of Creativity for Future AI Research.”

8. Richard Florida, *The Rise of the Creative Class—Revisited* (Basic Books, 2014).

9. Amílcar Cardoso, Tony Veale, and Geraint A. Wiggins, “Converging on the Divergent: The History (and Future) of the International Joint Workshops in Computational Creativity,” *AI Magazine* 30, no. 3 (2009): 15.

10. Geraint A. Wiggins, "A Preliminary Framework for Description, Analysis and Comparison of Creative Systems," *Knowledge-Based Systems* 19, no. 7 (2006).
11. G. Murphy, "Typicality and the Classical View of Categories," *The Big Book of Concepts* (Bradford, 2004).
12. This approach to concepts, also referred to as a cluster concept approach, has roots in the philosophy of Wittgenstein, who argued that there is nothing that unambiguously defines the category of games. Ludwig Wittgenstein, *Philosophical Investigations* (Wiley, 2010).
13. Murphy, "Typicality and the Classical View of Categories."
14. Walter Bryce Gallie, "Essentially Contested Concepts," *Proceedings of the Aristotelian Society, 1955*; Anna Jordanous, "Evaluating Computational Creativity: A Standardised Procedure for Evaluating Creative Systems and its Application" (DPhil thesis, University of Sussex, 2012), http://sro.sussex.ac.uk/id/eprint/44741/1/Jordanous,_Anna_Katerina.pdf.
15. Wiggins, "A Preliminary Framework."
16. Teresa Amabile, *Creativity in Context* (Westview, 1996).
17. One possible hitch here is that if family resemblance is used to identify creativity, then computational creativity that is not very familiar, either in the output itself or the performance of the creative task, might not trigger that association. Indeed, some researchers have seriously examined the possibility of a hypothesized bias against computers as creative producers, as David Cope claimed. This will be discussed in chapter 7.
18. Jared Diamond, "Soft Sciences Are Often Harder than Hard Sciences," *Discover* 8, no. 8 (1987).
19. Rhodes, "An Analysis of Creativity."
20. For most readers it will be an easy sell that the requirement for novelty is also a strict condition of any artistic activity. However, it will be important to take pause to consider the issues with such an assumption when looking cross-culturally, as well as all of the modern Western guises of art making, such as repeat performances. More on this in chapter 4.
21. Amabile, *Creativity in Context*.
22. Dean Keith Simonton, "Creativity and Discovery as Blind Variation: Campbell's (1960) BVS Model after the Half-Century Mark," *Review of General Psychology* 15, no. 2 (2011).
23. Margaret A. Boden, "Creativity and Artificial Intelligence," *Artificial Intelligence* 103, no. 1 (1998).

24. James C. Kaufman and Robert J. Sternberg, *The International Handbook of Creativity* (Cambridge University Press, 2006).
25. Henri Poincaré, *The Foundations of Science: Science and Hypothesis, the Value of Science, Science and Method*, trans. George Bruce Halstead (Science Press, 1913).
26. Albert Rothenberg and Carl R. Hausman, *The Creativity Question* (Duke University Press, 1976).
27. Margaret Boden, *The Creative Mind* (Weidenfeld and Nicholson, 1990); Simon Schaffer, "Making Up Discovery," in *Dimensions of Creativity*, ed. Margaret Boden (MIT Press, 1994).
28. The historian of science Simon Schaffer (Schaffer, "Making Up Discovery") offers an alternative analysis of the social context of such reveries and why they should not be taken too literally. I come to this in chapter 3.
29. Poincaré, *The Foundations of Science*.
30. A. Koestler, *The Ghost in the Machine* (Hutchinson, 1967).
31. Gilles Fauconnier and Mark Turner, *The Way We Think: Conceptual Blending and the Mind's Hidden Complexities* (Basic Books, 2008). Conceptual blending has become a major theme in computational creativity; see, for example, Francisco Câmara Pereira and Amílcar Cardoso, "Conceptual Blending and the Quest for the Holy Creative Process," *Proceedings of the Symposium for Creativity in Arts and Science of AISB 2002*.
32. Gilles Fauconnier and Mark Turner, "Conceptual Blending, Form and Meaning," *Recherches en communication* 19, no. 19 (2003): 57–86, <http://sites.uclouvain.be/rec/index.php/rec/article/viewfile/5191/4921>. An example is the counterfactual. Fauconnier observes that a statement such as "In France, Watergate would not have hurt Nixon" is easy for most humans to process and understand, yet provides quite a remarkable and powerful thinking mechanism, in this case comparing US and French political systems.
33. Silvano Arieti, *Creativity: The Magic Synthesis* (Basic Books, 1976).
34. Amabile, *Creativity in Context*.
35. Sam Glucksberg, "The Influence of Strength of Drive on Functional Fixedness and Perceptual Recognition," *Journal of Experimental Psychology* 63, no. 1 (1962).
36. E. Paul Torrance, "The Nature of Creativity as Manifest in Its Testing," in *The Nature of Creativity: Contemporary Psychological Perspectives*, ed. R. J. Sternberg (Cambridge University Press, 1988).
37. G. Polya, *How to Solve It* (Princeton University Press, 1957).
38. Alex F. Osborn, *Applied Imagination* (Charles Scribner, 1953).

39. Simonton, "Creativity and Discovery as Blind Variation."
40. In an article on improvisation in the creative process, Keith Sawyer elaborates on one of Picasso's creative sessions, as seen in Henri Georges Clouzot's film *The Mystery of Picasso*. The description supports Simonton's position: "In his studio, Picasso is painting free-form, without preconceived image or composition; he is experimenting with colors, forms, and moods. He starts with a figure of a reclining nude—but then loses interest, and the curve of the woman's leg reminds him of a matador's leg as he flies through the air after being gored by a bull—so he paints over the nude and creates an image of a bull and matador. But this leads him to yet another idea; he paints over the bullfight image and begins work on a Mediterranean harbor. ... Five hours later, Picasso stops and declares that he will have to discard the canvas. ... But the time was not wasted—he has discovered some new ideas that he can use in his next painting." R. Keith Sawyer, "Improvisation and the Creative Process: Dewey, Collingwood, and the Aesthetics of Spontaneity," *Journal of Aesthetics and Art Criticism* 58, no. 2 (2000).
41. Robert J. Sternberg, "The Nature of Creativity," *Creativity Research Journal* 18, no. 1 (2006).
42. Jacob W. Getzels and Mihaly Csikszentmihalyi, *The Creative Vision: A Longitudinal Study of Problem Finding in Art* (Wiley, 1976).
43. Simonton, "Creativity and Discovery as Blind Variation."
44. Boden, *The Creative Mind*.
45. G. A. Wiggins, "Towards a More Precise Characterisation of Creativity in AI," *Case-Based Reasoning: Papers from the Workshop Program at ICCBR'01*, Washington, DC, Naval Research Laboratory, Navy Center for Applied Research in Artificial Intelligence, 2001.
46. Geraint A. Wiggins, "Searching for Computational Creativity," *New Generation Computing* 24, no. 3 (2006).
47. Peter Gärdenfors, *Conceptual Spaces: The Geometry of Thought* (MIT Press, 2004).
48. Patricia D. Stokes and Danielle Fisher, "Selection, Constraints, and Creativity Case Studies: Max Beckmann and Philip Guston," *Creativity Research Journal* 17, nos. 2–3 (2005).
49. Stokes and Fisher, "Selection, Constraints, and Creativity Case Studies."
50. Stokes and Fisher, "Selection, Constraints, and Creativity Case Studies."
51. W. Ross Ashby Digital Archive, <http://www.rossashby.info/aphorisms.html>.
52. Emile Durkheim, *Selected Writings*, ed. Anthony Giddens (Cambridge University Press, 1972).

53. Dyson, *Darwin among the Machines*.
54. Alan M. Turing, "Computing Machinery and Intelligence," *Mind* 59, no. 236 (1950).
55. Turing, "Computing Machinery and Intelligence."
56. Turing, "Computing Machinery and Intelligence."
57. Norbert Wiener, *Cybernetics or Control and Communication in the Animal and the Machine*, vol. 25 (MIT Press, 1961).
58. Charles Darwin, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (John Murray, 1859).
59. Robert Epstein, Gary Roberts, and Grace Beber, eds., *Parsing the Turing Test* (Springer, 2009).
60. Comment in an email discussion forum, archived at <https://www.southampton.ac.uk/~harnad/Hypermail/Explaining.Mind96/0069.html>.
61. Selmer Bringsjord, Paul Bello, and David Ferrucci, "Creativity, the Turing Test, and the (Better) Lovelace Test," in *The Turing Test: The Elusive Standard of Artificial Intelligence*, ed. James H. Moor (Springer, 2003).
62. Martin Mumford and Dan Ventura, "The Man Behind the Curtain: Overcoming Skepticism About Creative Computing," *Proceedings of the Sixth International Conference on Computational Creativity, June 2015*.
63. Mumford and Ventura, "The Man Behind the Curtain."
64. This is not exactly how Turing described the test, but it is well known as a simpler but equivalent version.
65. Robert M. French, "The Turing Test: The First 50 Years," *Trends in Cognitive Sciences* 4, no. 3 (2000).
66. Blay Whitby, "The Turing Test: AI's Biggest Blind Alley?," in *Machines and Thought: The Legacy of Alan Turing*, ed. Peter Millican and Andy Clark (Oxford University Press, 1996).
67. Whitby, "The Turing Test: AI's Biggest Blind Alley?"
68. Coventry University, "Turing Test Transcript Reveal How Chatbot 'Eugene' Duped the Judges," June 2015, <https://www.coventry.ac.uk/primary-news/turing-test-transcripts-reveal-how-chatbot-eugene-duped-the-judges/>.
69. Ian Sample and Alex Hern, "Scientists Dispute Whether Computer 'Eugene Goostman' Passed Turing Test," *Guardian*, June 2014, <https://www.theguardian.com/technology/2014/jun/09/scientists-disagree-over-whether-turing-test-has-been-passed>.

70. Alec Radford et al., “Language models are unsupervised multitask learners,” *OpenAI Blog* 1, no. 8 (2019), citing B. McCann, N. S. Keskar, C. Xiong, and R. Socher, “The Natural Language Decathlon: Multitask Learning as Question Answering,” *arXiv preprint arXiv:1806.08730* (2018).

71. Auerbach, David, “A Computer Program Finally Passed the Turing Test? Not So Fast,” *Slate Magazine*, June 2014, <https://slate.com/technology/2014/06/turing-test-reading-university-did-eugene-goostman-finally-make-the-grade.html>.

72. French, “The Turing Test: The First 50 Years.”

73. Oliver Bown, “Generative and Adaptive Creativity: A Unified Approach to Creativity in Nature, Humans and Machines,” in *Computers and Creativity*, pp. 361–381 (Springer, 2012).

Chapter 3

1. W. Ross Ashby Digital Archive, <http://www.rossashby.info/aphorisms.html>.

2. This saying is widely credited to Thompson, for example by Daniel Dennett in an Edge.org article (<https://www.edge.org/conversation/the-evolution-of-culture>), but without citation.

3. John Steinbeck, *East of Eden* (Viking, 1952).

4. Sami Abuhamdeh and Mihaly Csikszentmihalyi, “The Artistic Personality: A Systems Perspective,” in Csikszentmihalyi, *The Systems Model of Creativity* (Springer, 2015).

5. Mihaly Csikszentmihalyi, *The Systems Model of Creativity: The Collected Works of Mihaly Csikszentmihalyi* (Springer, 2015).

6. Andrew Pickering, “The Politics of Theory: Producing Another World, with Some Thoughts on Latour,” *Journal of Cultural Economy* 2, nos. 1–2 (2009).

7. Pickering, “The Politics of Theory.”

8. Alfred Gell, *Art and Agency: An Anthropological Theory* (Clarendon, 1998).

9. Mihaly Csikszentmihalyi, “Society, Culture, and Person: A Systems View of Creativity,” in Csikszentmihalyi, *The Systems Model of Creativity* (Springer, 2015).

10. Dean Keith Simonton, “Scientific Creativity as Constrained Stochastic Behavior: The Integration of Product, Person, and Process Perspectives,” *Psychological Bulletin* 129, no. 4 (2003).

11. That said, Simonton later accepts that the equal-odds rule applies less in the arts, where there is more potential for manipulating the reception of the work.

12. Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 3rd ed. (University of Chicago Press, 1996).
13. Csikszentmihalyi, "Society, Culture, and Person."
14. Csikszentmihalyi, "Society, Culture, and Person."
15. Robert J. Sternberg and Todd I. Lubart, "An investment theory of creativity and its development," *Human development* 34, no. 1 (1991).
16. Malcolm Gladwell, "Blowing Up," *New Yorker*, April 22, 2002.
17. David N. Perkins, "Creativity: Beyond the Darwinian Paradigm," in *Dimensions of Creativity*, ed. Margaret Boden (MIT Press, 1996).
18. Keynote, *Proceedings of the International Conference on Computational Creativity*, 2016.
19. Kenneth O. Stanley and Joel Lehman, *Why Greatness Cannot Be Planned: The Myth of the Objective* (Springer, 2015).
20. Dava Sobel, *Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time* (Penguin, 1996).
21. Sobel's book lists a number of wonderfully crackpot proposals.
22. Charles Landry, *The Creative City: A Toolkit for Urban Innovators* (Earthscan, 2012).
23. Ilkka Kakko and Sam Inkinen, "Homo Creativus: Creativity and Serendipity Management in Third Generation Science and Technology Parks," *Science and Public Policy* 36, no. 7 (2009).
24. Richard Florida, *The Rise of the Creative Class—Revisited* (Basic Books, 2012).
25. Csikszentmihalyi, "Society, Culture, and Person."
26. Harold Cohen was also enthusiastic about making this point: "To what extent could we reasonably maintain that the human mind initiates? Concepts are formed on the basis of prior concepts, decisions are made on the basis of feedback from the environment and from the results of previous decisions. The probability is that, if one could identify the starting point for an artist's whole life's work, one would find a set of concepts completely formulated if not completely digested, given to him and not initiated by him." Cohen, "Parallel to Perception: Some Notes on the Problem of Machine-Generated Art," *Computer Studies* 4, no. 3/4 (1973).
27. Csikszentmihalyi, *The Systems Model of Creativity*.
28. Simon Schaffer, "Making Up Discovery," in *Dimensions of Creativity*, ed. Margaret Boden (MIT Press, 1996).
29. Simon Schaffer, "Making Up Discovery," quoting Paul David, "The Hero and the Herd in Technological History: Reflections on Thomas Edison and the Battle of

the Systems,” in *Favorites to Fortune*, ed. L. R. Patrice, David S. Higonnet, and Henry Rosovsky Landes (Harvard University Press, 1991), 72–119.

30. Ernst Kris and Otto Kurz, *Legend, Myth, and Magic in the Image of the Artist: A Historical Experiment* (Yale University Press, 1981).

31. Margot F. Breerton, David M. Cannon, Ade Mabogunje, and Larry J. Leifer, “Collaboration in Design Teams: How Social Interaction Shapes the Product,” in *Analyzing Design Activity*, ed. Nigel Cross, Kees Dorst, and Henri Christiaans (Wiley, 1996), 319–341.

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Chapter 4

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Chapter 5

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Chapter 8

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