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Live Coding

A User's Manual

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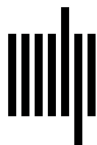
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Notes

Chapter 1

1. For example, users can be exploited through their apparent inclusion, as with the so-called sharing economy. We return to a positive application of the term *user* later in this chapter with reference to artist Olia Lialina's essay "Turing Complete User," 2012, accessed March 11, 2022, in which she argues for the continuing usefulness of the term: <http://contemporary-home-computing.org/turing-complete-user/>.
2. The utility of traditional user manuals for any purpose is problematized in the body of work on *minimal documentation*, which offers complementary evidence for the value of live action and experience as an approach to instruction and learning, rather than reading books. See John M. Carroll, *Minimalism beyond the Nurnberg Funnel* (Cambridge, MA: MIT Press, 1990).
3. See David Ogborn's exposition in chapter 3.
4. The notion of real time is explored further in chapters 5 and 6.
5. Command-line interfaces are essentially live coding interfaces, presented in Douglas Engelbart's 1968 "Mother of All Demos" as a form of augmented intelligence, that are still present in modern operating systems.
6. Of course, live coding also references a variety of alternative practices, including hacking, prototyping, code bending and demo-ing, that are already recognized or understood to some degree. For example, see Iias Bergström and Alan F. Blackwell, "The Practices of Programming" (paper presented at IEEE Visual Languages and Human-Centric Computing (VL/HCC) 2016, Cambridge), https://www.researchgate.net/publication/308540044_The_Practices_of_Programming.
7. See Sarah Groff Hennigh-Palermo's exposition in chapter 3; see also her "Seven Points for a Computer Critical Computer Art," n.d., <http://art.sarahghp.com/seven-points/>.
8. The term *defamiliarization* was introduced by Viktor Shklovsky in his (1917) essay "Art as Device" (sometimes translated as "Art as Technique") in *Theory of Prose* (1925; repr., Elmwood Park, IL: Dalkey Archive Press, 1990). For more on this concept and Russian formalism, see, for instance, Fredric Jameson, *The Prison-House of Language: A Critical Account of Structuralism and Russian Formalism*, vol. 332 (Princeton, NJ: Princeton University Press, 1974).

9. In making software strange, we echo the slogan of the ReadMe festival curated by Olga Goriunova and Alexei Shulgin (organized between 2002 and 2005, with events in Moscow, Helsinki, Aarhus, and Dortmund): “People doing strange things with software” (which is itself a reworking of the “doing strange things with electricity” used in Dorkbot events). For more on this, see Read Me, last modified April 11, 2017, <https://monoskop.org/Readme>.
10. By *open work*, we refer to philosopher and semiotician Umberto Eco’s oft-cited *The Open Work* (Cambridge, MA: Harvard University Press, 1989) to emphasize how live coding is open to, and further completed by, the performer, viewer, reader, or audience.
11. To be more specific, interface design becomes experience design under this (not-open) logic, and this has always been a reductive (behaviorist) notion that experience itself can be designed.
12. For example, the European Disappearing Computer research program. See Norbert Streitz and Paddy Nixon, “The Disappearing Computer-Introduction,” special issue, *Communications of the ACM: The Disappearing Computer* 48, no. 3 (2005): 32–35.
13. Lialina, “Turing Complete User.”
14. By Big Tech we refer to the monopolistic practices of the four or five largest and most dominant companies in the information technology industry: Amazon, Apple, Google, Facebook, and Microsoft. Here we also invoke Douglas Rushkoff’s *Program or Be Programmed: Ten Commands for a Digital Age* (Berkeley, CA: Soft Skull Press, 2011) and the more overt notion of *mass deception* in Theodor Adorno and Max Horkheimer, “The Culture Industry: Enlightenment as Mass Deception,” in *Dialectic of Enlightenment* (1944; repr., London: Verso 1997).
15. Writing on human computer interaction, Christine Satchell and Paul Dourish explore “not using computers—ways not to use them, aspects of not using them, what not using them might mean, and what we might learn by examining non-use as seriously as we examine use.” Their point is not simply about “not using” but about exploring the varieties of not-using and how this relates to social relations (e.g., disenfranchisement as it is related to disability, socioeconomic status, geographical factors, and more). It is clear that certain kinds of users tend to remain invisible. See Christine Satchell and Paul Dourish, “Beyond the User: Use and Non-use in HCI,” in *OZCHI ’09—Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group: Design: Open 24/7* (Australian Computer-Human Interaction Special Interest Group) (New York: Association for Computing Machinery), 9–16.
16. Lialina, “Turing Complete User.”
17. Georges Perec, *Life: A User’s Manual*, trans. David Bellos (London: Harvill Press, 1996); originally published in 1978, in French, with the title *La Vie mode d’emploi*.
18. Raymond Queneau, cited in Warren F. Motte Jr., ed., *OuLiPo: A Primer of Potential Literature*, trans. Warren F. Motte (Funks Grove, IL: Dalkey Archive Press, 1998), 38.
19. For example, we have worked alongside each other within the framework of the AHRC Digital Transformation research projects Live Notation: Matters of Performance (2012) and Weaving Codes/Coding Weaves (2014–2016), as well as through many meetings of the International Conference on Live Coding (since 2015 and ongoing).

20. This etymological relation is explored further by Tim Ingold in *Lines: A Brief History* (London: Routledge, 2016).

21. We draw reference here from poet Kenneth Goldsmith, who has argued that writers today are beginning to resemble programmers—working with writing machines to generate and execute texts. See Kenneth Goldsmith, *Uncreative Writing* (New York: Columbia University Press, 2011), 1. In *Uncreative Writing*, Goldsmith makes clear his desire not to produce ever more new texts but instead to manage, organize, and distribute them in divergent ways.

22. Our method was to draw freely on the affordances of technologies to *render* our thoughts and conversation in a written form that is nevertheless embedded in technical infrastructure—of wikis, word processors, and collaborative writing platforms. We endeavored to stay attentive to the literary and technological form as a “writing machine,” as literary critic N. Katherine Hayles has put it. To further clarify, Hayles explains: “When a literary work interrogates the inscription technology that produces it, it mobilizes reflexive loops between its imaginative world and the material apparatus embodying that creation as a physical presence.” N. Katherine Hayles, *Writing Machines* (Cambridge, MA: MIT Press, 2002), 25. An account of some of these writing experiments can be found in Alan Blackwell, Geoff Cox, and Sang Won Lee, “Live Writing the Live Coding Book” (paper presented at the International Conference on Live Coding 2016, McMaster University, Hamilton, Canada). See <http://iclc.toplap.org/2016/papers.html>.

23. Here we align our views with Walter Benjamin’s “The Author as Producer” in saying: “The reader is always prepared to become a writer, in the sense of being one who describes or prescribes. . . . And writing about work makes up part of the skill necessary to perform it. Authority to write is no longer founded in a specialist training but in a polytechnical one, and so becomes common property.” See Walter Benjamin, “The Author as Producer,” 1934, in Vol. 2, *Selected Writings, 1931–1934*, ed. Howard Eiland, Michael W. Jennings, and Gary Smith (Cambridge, MA: Belknap Press of Harvard University Press, 2005), 90.

24. The temporal lag of writing operates as a “strange loop” in this sense. Consider the following example: “The sentence I am now writing is the sentence you are now reading.” The example is from Douglas Hofstadter, *Gödel, Escher, Bach: An Eternal Golden Braid* (1979; repr., New York: Basic Books, 2000), 495. See also Douglas Hofstadter, *I Am a Strange Loop* (New York: Basic Books, 2007).

25. Across these two parts of the book, the idea is to gradually expose live coding to be a “critical technical practice.” See Philip E. Agre, “Toward a Critical Technical Practice: Lessons Learned in Trying to Reform AI,” in *Bridging the Great Divide: Social Science, Technical Systems, and Cooperative Work*, ed. Geof Bowker, Les Gasser, Leigh Star, and Bill Turner (Hillsdale, NJ: Erlbaum, 1997), 131–157. In referring to aesthetics in terms of *sensing* and *sensemaking*, across the arts and science and concerning human and nonhuman entities, we invoke Matthew Fuller and Eyal Weizman, “Aesthetics,” in *Investigative Aesthetics: Conflicts and Commons in the Politics of Truth* (London: Verso, 2021), 43–55.

On “aesthetic practice” and “practices of aesthetic thinking,” see also Dieter Mersch, *Epistemologies of Aesthetics* (Zurich: Think Art Diaphanes, 2015) and “Aesthetic Thinking: Art as Theōria,” in *Aesthetic Theory*, ed. Dieter Mersch, Sylvia Sasse, and Sandro Zanetti, trans. Brian Alkire (Zurich: Think Art Diaphanes, 2019), 219–236.

26. See TOPLAP Wiki, “Manifesto Draft,” last modified September 3, 2020, <https://toplap.org/wiki/ManifestoDraft>.

27. For more on TOPLAP, see <https://toplap.org/about/>.

28. See Michael Schwab and Henk Borgdorff, introduction to *The Exposition of Artistic Research: Publishing Art in Academia* (Leiden, the Netherlands: Leiden University Press, 2014), 9–20.

29. Agre, “Toward a Critical Technical Practice,” 131–157.

30. Following Karen Barad, we prefer the term *intra-action*—as opposed to *interaction*—to stress agency as not an inherent property of an individual or human to be exercised but as a dynamism of forces. See Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007), 141.

31. Karen Barad makes a similar point in her preface and acknowledgments to *Meeting the Universe Halfway*: “In an important sense, it is not so much that I have written this book, as that it has written me. Or rather, ‘we’ have ‘intra-actively’ written each other (‘intra-actively’ rather than the usual ‘interactively’ since writing is not a unidirectional practice of creation that flows from author to page, but rather the practice of writing is an iterative and mutually constitutive working out, and reworking, of ‘book’ and ‘author’).” See Barad, *Meeting the Universe Halfway*, ix–x. This is also cited in the acknowledgments of Janneke Adema’s *Living Books* (Cambridge, MA: MIT Press 2021).

32. This is a reference to Michel Foucault’s idea of writing with a “shaky hand,” rejecting the notion of a writer with a solid identity, from his introduction to *The Archaeology of Knowledge and the Discourse of Language* (New York: Pantheon Books, 1972). See Thor Magnusson and Kate Sicchio, “Writing with Shaky Hands,” *International Journal of Performance Art and Digital Media* 12, no. 2 (2016): 99–101, <https://toplap.org/special-issue-on-live-coding-in-ijpdm/>.

33. Our intention is that aspects of this book—specifically chapters 2 and 3—can be added to and amended in the future. In this sense this publication is conceived of not as a final product but rather more like a momentary *snapshot* of live coding as it appears at a particular moment in time.

Chapter 2

1. Rather than being bound to the limitations of historical narrative, things are both historical *and* performative; history thereby is not only heard, as Ernst has characterized it, but, we would add, *live coded*. See Wolfgang Ernst, “Toward a Media Archaeology of Sonic Articulations,” in *Digital Memory and the Archive*, ed. Jussi Parikka, Electronic Mediations no. 39 (Minneapolis: University of Minnesota Press, 2013). See also chapters 5 and 6 in this book.

2. Donna Haraway, “Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective,” *Feminist Studies* 14 (1988): 575–599.

3. To be clear, *live* does not necessarily mean ahistorical, and we might learn from some of the past practices of live coding here. While live coding often privileges live improvisation over recording,

and clearly a recording falls short of the experience of a live event, there have been experiments in combining the two. To be specific, we can benefit here from users of Alberto de Campo's "History" class within the SuperCollider language, which records the code whenever it is executed. The Powerbooks_Unplugged laptop ensemble has recorded a great number of performance sessions in this way. Somewhat in this spirit, it might be said that we offer a "history unplugged" in this chapter.

4. Moreover, we recognize that *all* history is contested. Indeed, the perceived difficulty of writing this chapter is not only in dealing with what might be considered facts but also in writing a history of something that is by its nature "live" and that resists being recorded at all. Our approach perhaps owes more to the oral history tradition than any grand (canonical) narrativizing of significant events and people. We are thinking here of the work of Raphael Samuel and the History Workshop movement that developed "history from below." See "Samuel, Professor Raphael Elkan," Making History, accessed March 12, 2022, https://archives.history.ac.uk/makinghistory/historians/samuel_raphael.html.

5. The interviews themselves, although experimental in format and conduct, followed the social science research convention of the semistructured interview. Our research team (the authors of this volume) initially agreed on a set of questions designed to elicit both historical detail and personal reflection. Each interview included these prepared questions but explored topics in further detail (or ignored them) as determined in collaboration by the interests of both the interviewer and interviewee. These explorations and responses included a range of experiments with the collaborative real-time editor PiratePad, and also drew liberally on other technical media. And yet the history that we report remains (somewhat) conventional in style and falls short of representing the diversity of interpretations among the editors of this volume, let alone the voices of those who were interviewed. A further reflection on the ephemerality and provisionality of live technologies is that PiratePad itself was decommissioned in the course of our work, meaning the "live" record of the interviews (which we had intended to publish as an open and editable dynamic text) has disappeared. This fate, although disappointing, is unremarkable when considered in the context of other live-coded performances.

6. Note that the British Nick Collins (b. 1975), known as a pioneering figure in live coding, is not the same person as the American (b. 1954) Nicolas ("Nic") Collins, electronic music composer and writer.

7. Further reflections on diversity are included later in this chapter, and broader questions of settler-colonialism and the legacies of slavery that have resulted in racialized oppression, and in minority status for ethnic groups within technologized society, are addressed and explored in chapter 8.

8. Named in honor of Max Mathews, who in 1957, when working at Bell Labs, developed the original MUSIC program (later called MUSIC-1) that commenced the MUSIC-N series.

9. The sound engine of Pure Data was later incorporated into the Max software written by Puckette years earlier, which became Max/MSP, with *MSP* standing for "Miller S. Puckette."

10. Several interviewees reported the influence of techno/dance music, especially Aphex Twin and Autechre.

11. The VJ, or video jockey, is responsible for assembling and mixing projected video material, usually alongside a DJ.
12. Although this is broadly true, it is also the case that many practitioners have embraced the creative constraints of the eight-bit era.
13. The situation has not fully changed. As DO said, “I think we’re still orienting youth towards the boring computing of the present rather than the fantastic utopian monstrous computing of the near future.”
14. Our use of the term *geek* is very deliberate here to point to creative expression outside of the artistic frame. See Matthew Fuller’s *How to Be a Geek: Essays on the Culture of Software* (Cambridge: Polity Press, 2017). The Read_me festival was set up on similar principles in that creativity is not simply the privilege of the creative class and has become distributed to other fields of nonarts practice. See the Read_me festival, curated by Olga Goriunova and Alexei Shulgin, Moscow, Helsinki, Aarhus, and Dortmund, 2002–2005, at “ReadMe,” Monoskop, last modified April 11, 2017, <https://monoskop.org/Readme>. For more on geek cultures, see, for instance, Ellen Ullman’s *Close to the Machine: Technophilia and Its Discontents* (London: Picador, 2012).
15. Some entered the creative sector, in sound engineering or the nascent video game industry. The less fortunate faced mundane futures: AM headed toward a practical career studying programming with a “bog-standard” computing diploma and degree, where he wasn’t allowed to use the fancy Macs on the media arts course, while SA was frustrated by the boring assignments for his computer science degree, as he already knew more programming than they taught. Some did try to follow both interests. AA registered for a double major in music and computing, but on the first day she was advised to keep the music (which she loved) and drop the computing (assumed to have been her father’s idea). DO started to learn both music and programming at the age of seven, but it was years before he realized they could be combined in “computer music.”
16. This project predates AW’s later and well-known Auto-Illustrator, which similarly parodied Adobe’s commercial software. AW also produced numerous generative sound experiments, released through his company Signwave, exploring the performativity of code. This led to the development of his live coding. See Adrian Ward, Wikipedia, last modified January 21, 2022, [https://en.wikipedia.org/wiki/Adrian_Ward_\(artist\)](https://en.wikipedia.org/wiki/Adrian_Ward_(artist)).
17. See <https://transmediale.de/content/auto-illustrator> and <https://transmediale.de/content/forkbombpl>, respectively. Both works also featured as part of the 2002 touring exhibition *Generator*, curated by Geoff Cox and Tom Trevor, <https://web.archive.org/web/20190220044143/http://generative.net/generator/>.
18. The name *slub* signaled the meeting point of McLean’s slab.org and Ward’s stub.org websites.
19. See NTK Now, June 16, 2000, <http://www.ntk.net/2000/06/16/?l=120#l>.
20. See Public Life, last modified 2019, <http://www.publiclife.org/text1.htm>.
21. See Read_Me 2004 report, August 2004, http://www.m-cult.org/read_me/report.htm.

22. The fourth and final Read_me was held in Dortmund in 2005; see <http://readme.runme.org/>.
23. Ge Wang and Perry R. Cook, "On-the-Fly Programming: Using Code as an Expressive Musical Instrument," in *Proceedings of New Interfaces for Musical Expression*, Hamamatsu Shizuoka, Japan June 3-5, 2004, 138–143. Singapore: National University of Singapore, 2004.
24. See Labomedia Ressources, February 2004. Accessed March 23, 2022: <https://raw.githubusercontent.com/yaxu/unravelling/master/livecodemlarchive.txt>.
25. Hence the elaborate cautions that we presented at the start of this chapter with regard to the problems of taking a historical stance in relation to an avowedly ephemeral endeavor.
26. For a view on the development of the TOPLAP manifesto, see Christopher Haworth, "Algorithmic Music and the Social," in *The Oxford Handbook of Algorithmic Music*, ed. Alex McLean and Roger Dean (Oxford: Oxford University Press, 2018), 557–581.
27. See "Manifesto Draft," TOPLAP, last modified September 3, 2020, <http://toplap.org/wiki/ManifestoDraft>.
28. "Show Us Your Screens" is also the title of a short documentary film made by Louis McCallum and Davy Smith, 2011. See <https://vimeo.com/20241649>.
29. Aside from the various manifestos associated with the modernist period, such as those of surrealism and Dada, numerous other examples point to the belief that art and technology might facilitate radical change. *The Futurist Manifesto* written by F. T. Marinetti in 1909 famously espouses the glorification of war, speed, and misogyny. More in keeping with our views, we would point to its reworking in Franco Bifo Berardi's *Post-Futurist Manifesto* of 2009, which argues that the aspirations of the avant-garde and the dominant order they hoped to overthrow have collapsed into what has become known as the *creative economy*. See *The Post-Futurist Manifesto* by Franco Bifo Berardi, February 2009, http://www.generation-online.org/p/fp_bifo5.htm. There is more to be said about live coding as a counterpoint to the creative and knowledge economies, and we return to this in chapter 8.
30. Author Blackwell recalls creating a real-time executive for machine control in Forth as his undergraduate dissertation at the University of Auckland in 1982. (His original plan to create a sampling synthesizer was considered infeasible because the department could not afford to buy that much RAM!)
31. Douglas J. Collinge, "MOXIE: A Language for Computer Music Performance," in *Proceedings of the International Conference on Computer Music*, Institut de Recherche et Coordination Acoustique/Musique (IRCAM) Paris, France, October 19–23, 1984, 217–220. San Francisco, CA: International Computer Music Association, 1984, <https://quod.lib.umich.edu/cgi/p/pod/dod-idx/moxie-a-language-for-computer-music-performance.pdf?c=icmc;idno=bbp2372.1984.030;format=pdf>.
32. Roger B. Dannenberg, "Software Design for Interactive Multimedia Performance," *Interface—Journal of New Music Research* 22, no. 3 (August 1993): 213–228.
33. Scott Wilson, David Cottle, and Nick Collins, *The SuperCollider Book* (Cambridge, MA: MIT Press, 2011).

34. Smalltalk is an object-oriented, dynamically typed reflective programming language designed and created in part for educational use at the Learning Research Group of Xerox PARC by Alan Kay, Dan Ingalls, Adele Goldberg, Ted Kaehler, Diana Merry, Scott Wallace, and others during the 1970s. Connections to the software-engineering industry, including Smalltalk, are discussed further in chapter 7. Some discussion of the research questions related to language design can be found in Brian Burg, Adrian Kuhn, and Chris Parnin, “1st International Workshop on Live Programming (LIVE 2013),” in *35th International Conference on Software Engineering* (Piscataway, NJ: Institute of Electrical and Electronics Engineers, 2013), 1529–1530; and Juraj Kubelka, Romain Robbes, and Alexandre Bergel, “The Road to Live Programming: Insights from the Practice,” in *2018 IEEE/ACM 40th International Conference on Software Engineering* (Piscataway, NJ: Institute of Electrical and Electronics Engineers, 2013), 1090–1101.

35. As noted earlier, Fabrice Mogini, Nick Collins, and John Eacott had a band called 3play around 2002 whose performances involved live coding.

36. Powerbooks_UnPlugged members have included Alberto de Campo, Echo Ho, Hannes Hoelzl, Jan-Kees van Kampen, Julian Rohrerhuber, and Renate Wieser. See <https://pbup.net/>, accessed March 12, 2022.

37. See, for example, Seminaris Sonors, 2011, <https://web.archive.org/web/20180218022134/https://lullcec.org/2011/workshops/seminaris-sonors-2011/>.

38. Alan F. Blackwell, “Patterns of User Experience in Performance Programming,” in *Proceedings of the First International Conference on Live Coding (ICLC)*, University of Leeds, UK, July 13–15, 2015, Geneva, Switzerland: Zenodo/CERN, <http://doi.org/10.5281/zenodo.19315>.

39. Featuring JR, Oliver Wittchow (cf. nanoloop), Raffaello Minuzzi, and the Hamburg artist Sebastian Burdach (d. 2021).

40. See Georgina Born and Kyle Devine, “Music Technology, Gender, and Class: Digitization, Educational and Social Change in Britain,” *Twentieth-Century Music* 12, no. 2 (August 2015): 135–172; and Joanne Armitage, “Spaces to Fail In: Negotiating Gender, Community and Technology in Algorave,” in *Dancecult: Journal of Electronic Dance Music Culture* 10, no. 1 (2018), <https://dj.dancecult.net/index.php/dancecult/article/view/1032>. Armitage refers to research that has explored issues of gender and participation in these fields, including Tami Gadir, “Resistance or Reiteration? Rethinking Gender in DJ Cultures,” *Contemporary Music Review* 35, no. 1 (2016): 115–129, <http://dx.doi.org/10.1080/07494467.2016.1176767>; and Anna Vitores and Adriana Gil-Juárez, “The Trouble with ‘Women in Computing’: A Critical Examination of the Deployment of Research on the Gender Gap in Computer Science,” *Journal of Gender Studies* 25, no. 6 (2015): 1–15, <http://dx.doi.org/10.1080/09589236.2015.1087309>.

41. JA reports an interview with a female live coder who said, “It is the reactions of some men that will create an invisible barrier that says to women ‘you don’t belong here in the way that I do.’” Armitage, “Spaces to Fail In,” 41.

42. JA states that “despite the promises of both the community and the technology, the performative nature of live coding and performing algorave events deeply genders their experiences.” Armitage, “Spaces to Fail In,” 33.

43. See, for example, Freida Abtan, “Where Is She? Finding the Women in Electronic Music Culture,” *Contemporary Music Review* 35, no. 1 (2016): 53–60.
44. Georgina Born and Kyle Devine, “Gender, Creativity and Education in Digital Musics and Sound Art,” *Contemporary Music Review* 35, no. 1 (2016): 1–20, <http://doi.org/10.1080/07494467.2016.1177255>.
45. See workshop for Yorkshire Sound Women Network (YWSN), December 2015, presented by Joanne Armitage and Shelly Knotts. Accessed March 23, 2022, <https://www.youtube.com/watch?v=PboSZGllzU>; also <https://yorkshiresoundwomen.com/>.
46. See Northern Sound Collective, “Automation and Me: Living an Algorithmic Life,” May 8–9, 2019. Accessed March 23, 2022, <https://northernsc.wordpress.com/open-call/>.
47. Armitage, “Spaces to Fail In,” 39.
48. Armitage, “Spaces to Fail In,” 40. More broadly, it is worth adding a further layer of critique here in the work of the Feminist Software Foundation. See, for instance, their C+= manifesto: “Booleans are banned for imposing a binary view of true and false. C+= operates paralogically and transcends the trappings of Patriarchal binary logic.” “C-Plus Equality,” Feminist Software Foundation, accessed April 13, 2018, <https://github.com/ErisBlastar/cplusequality/blob/master/README.md>.
49. See <https://livecode.slack.com>. JA notes that this chat forum has recently moved from Slack to <https://talk.lurk.org/home>, accessed May 8, 2018.
50. Armitage, “Spaces to Fail In,” 42.
51. Algorave guidelines, 2022: <https://github.com/Algorave/guidelines>.
52. Diversity has also been addressed through the common practice of artists engaging with underserved communities—for example, Melody Loveless working with young people with learning difficulties, as she relates in her exposition in chapter 3.
53. See (Algo|Afro) futures, April–June 2021. Accessed March 23, 2022, <https://algo-afro-futures.lurk.org/artists/>.
54. Amy Alexander, “At the Margins: A Look at Marginal Approaches to Coding, Art and Performance” (paper presented at the International Conference of Live Coding, Hamilton, Canada, October 12–15, 2016). The event also included the panel “Equity, Inclusion and the Growth of the Live Coding Community.” See <http://iclc.toplap.org/2016/>.
55. Hakan Erdogmus, Nenad Medvidović, and Frances Paulisch, “0 Years of Software Engineering,” *IEEE Software* 35, no. 5 (2018): 20–24.
56. For example, see both the introduction and contents of Born and Devine, “Gender, Creativity and Education in Digital Musics and Sound Art,” 1–20.
57. Quoted from a Facebook post in Michelle Knotts (“Shelly”—interviewee SK), “Social Systems for Improvisation in Live Computer Music” (PhD diss., Durham University, UK, 2018), 54.
58. Armitage, “Spaces to Fail In.”

59. See Sadie Plant, “The Future Looms: Weaving Women and Cybernetics,” *Body and Society* 1, no. 3–4 (1995): 46. Several recent projects have drawn *threads* between the work of Bauhaus weaver Anni Albers (1899–1994) and coding—for example, Conductive Coding, an etextiles weaving workshop led by Emilie Giles and Sarah Wiseman at Tate Modern (2019) in response to Albers’s retrospective of the same year. See also Anni Albers, *On Weaving* (Middletown, CT: Wesleyan University Press, 1965). A metaphorical connection between the performance practice of live coding and weaving was made by Emma Cocker during the AHRC-funded Live Notation project (led by Hester Reeve and Alex McLean). See Emma Cocker, “Live Notation: Reflections on a Kairotic Practice,” *Performance Research Journal: On Writing and Digital Media* 18, no. 5 (2013): 69–76.

60. This project is discussed elsewhere in chapters 4, 5, and 7 in relation to embodied knowledge and notation; on *loom-thinking*, see Janis Jeffries, “Textiles: What Can She Know?,” in *Feminist Visual Culture*, ed. Fiona Carson and Claire Pajczkowska (New York: Routledge, 2001), 189–207.

61. The Neokhipukamayoq manifesto was launched by Paola Torres Núñez del Prado at Ars Electronica 2021 with Patricia Cavidad through a live performance titled *Khipumancy*, using augmented *Khipu* as interfaces for sound. The manifesto is available at <https://khipumantes.github.io/> (2021). Accessed March 23, 2022.

62. Michelle Boulous Walker reflects on how instituting moments eventually become instituted structures (for her, in relation to philosophy) in *Slow Philosophy: Reading against the Institution* (London: Bloomsbury, 2017).

63. Alan F. Blackwell, Alex McLean, James Noble, and Julian Rohrhuber, eds., in collaboration with Jochen Arne Otto, “Collaboration and Learning through Live Coding,” *Dagstuhl Reports* 3, no. 9 (2014): 130–168, <http://drops.dagstuhl.de/opus/volltexte/2014/4420/>.

64. Following Leeds in 2015, the conference was hosted at McMaster University, Canada, in 2016; in Morelia, Mexico, in 2017; in Madrid, Spain, in 2019; in Limerick, Ireland, in 2020; and in Chile in 2021.

65. The First International Workshop on Live Programming was held in conjunction with the International Conference on Software Engineering (ICSE 2013), a second workshop at the European Conference on Object-Oriented Programming (ECOOP 2016), and four times subsequently at the ACM SIGPLAN Conference on Systems, Programming, Languages, and Applications: Software for Humanity (SPLASH). A series archive is maintained at <http://liveprog.org> (2013–2021). Accessed March 23, 2022.

66. For the current list of TOPLAP nodes, see TOPLAP site, (2004–2021). Accessed March 23, 2022, <https://toplap.org/nodes/>.

67. Tom Cheshire, “Hacking Meets Clubbing with the ‘Algorave,’” *Wired*, September 2013, <https://www.wired.co.uk/article/algorave>.

68. It’s amusing to note that since live coding emerged in 2000, *Wired* magazine published pieces dubbing it the future of electronic music in 2006 (“Real DJs Code Live”), 2013 (“Hacking Meets Clubbing with the ‘Algorave’”), and 2019 (“DJs of the Future Don’t Spin Records, They Write Code”). We anticipate the next prediction in 2025.

69. See Algorave, 2022. Accessed March 23, 2022, <https://algorave.com/>; and also Algorave guidelines, <https://github.com/Algorave/guidelines>.

70. Thor Magnusson, “Herding Cats: Observing Live Coding in the Wild,” *Computer Music Journal* 38, no. 1 (2014): 8–16.

71. The most complete list of live coding links currently shows around fifty live coding environments (<https://github.com/toplap/awesome-livecoding>), with thirty geographically centered communities adding themselves to the list of TOPLAP nodes: <https://toplap.org/nodes/>.

72. New live coders are constantly arriving. There are undoubtedly some whom we should have invited and did not and others who were invited but not able to respond. We plan to maintain this part of the book as an open online resource for continued development and expansion after the published manuscript is complete.

73. We take the term *exposition* from the context of artistic research: Henk Borgdorff and Michael Schwab, eds., *The Exposition of Artistic Research: Publishing in Academia* (Leiden: Leiden University Press, 2014).

Chapter 3

1. <https://youtu.be/hMdkb8pvA8g>; accessed April 12, 2022.

2. <https://www.instagram.com/mariaaristya/>; see Abhinay Khoparzi’s exposition in this chapter.

3. Open Source Shakespeare, accessed March 12, 2022, https://www.opensource-shakespeare.org/views/plays/play_view.php?WorkID=henry6p2&Act=4&Scene=7&Scope=scene&LineHighlight=2721#2721.

4. July 27, 2012, <https://vimeo.com/195936508>.

5. TOPLAP, last modified May 28, 2009, https://toplap.org/wiki/Some_thoughts.

6. Stack Exchange, accessed March 12, 2022, <https://english.stackexchange.com/questions/196489/did-sir-arthur-conan-doyle-coin-the-proverb-a-change-is-as-good-as-a-rest>.

7. <https://composerprogrammer.com/research/collectedrewritings.pdf> t.

8. In *The Language of the New Media* (Cambridge, MA: MIT Press, 2000), Lev Manovich offers the first rigorous and systematic theory of new media, framing it in the history of the media and visual cultures of the last centuries.

9. P is for Personal, Private, Popular, Poetic, Pretty, Playful, Pleasant, Peaceful, Primary, Proto, Post, Potential, Pseudo, Portable, Programming, Physical, Paper . . .

10. “Live coding is not about tools. Algorithms are thoughts.” TOPLAP manifesto draft.

11. Ramos Ana, “The Anarchive: A Language Nomadism, the Way of the Anarchive,” unpublished manuscript, 2018.

12. Nahuatl is a Uto-Aztecan language spoken by approximately 1.5 million people in Mexico. Most speakers live in central Mexico, including in Puebla, Veracruz, Hidalgo, San Luis Potosí, Guerrero, Mexico City (Distrito Federal), Tlaxcala, Morelos, and Oaxaca. There are fewer speakers of Nahuatl in the rest of Mexico, in El Salvador, and in parts of the United States.

13. <http://sro.sussex.ac.uk/id/eprint/46861/1/Magnusson.pdf>; accessed April 12, 2022.

Chapter 4

1. The Live Notation project was funded by the Arts and Humanities Research Council and led by coinvestigators Hester Reeve and Alex McLean, working in dialogue with an international network of artists, coders, and theorists, including Sam Aaron, Maria Chatzichristodoulou, Geoff Cox, Yuen Fong Ling, Dave Griffiths, Thor Magnusson, Brigid McLeer, Kate Sicchio, Andre Stitt, and Wrongheaded, who collectively composed the Live Notation Unit. Emma Cocker observed as an interlocutor, leading to the published outcome: Emma Cocker, “Live Notation—Reflections on a Kairotic Practice,” *Performance Research Journal* 18, no. 5 (January 2014): 69–76.

2. On July 27, 2012, at the Live Notation Unit, the project participants staged a symposium and a series of performances at Arnolfini (an international arts center) in Bristol, UK, to test and question what the phrase *live notation* signifies. More details of the presentations at Arnolfini in July 2012 can be found at <http://livenotation.lurk.org/>. See also Alex McLean and Hester Reeve, “Live Notation: Acoustic Resonance?,” Paper presented at the *International Computer Music Conference* (ICMC), Ljubljana, Slovenia, September 9–14, 2012.

3. See Cocker, “Live Notation.”

4. John Hall, *13 Ways of Talking about Performance Writing* (Plymouth, UK: Plymouth College of Art Press, 2007).

5. See Geoff Cox and Alex McLean, *Speaking Code, Coding as Aesthetic and Political Expression* (Cambridge, MA: MIT Press, 2013). They refer to Florian Cramer’s “Concepts, Notations, Software, Art,” *Netzliteratur*, March 23, 2002, https://www.netzliteratur.net/cramer/concepts_notations_software_art.html.

6. Weaving Codes, Coding Weaves (2014–2016) was an interdisciplinary research project funded by an Arts and Humanities Research Council Digital Transformations Amplification Award, led by principal investigator Alex McLean and international coinvestigator Ellen Harlizius-Klück, with collaborative developer Dave Griffiths and coinvestigator Kia Ng. See Weaving codes – coding weaves, <http://kairotic.org/>, accessed April 16, 2022. See also Ellen Harlizius-Klück, in collaboration with Alex McLean, eds., “Weaving Codes, Coding Weaves,” special issue, *Textile: Journal of Cloth and Culture* 15 (2017). For a project account, see Alex McLean, Ellen Harlizius-Klück, and Janis Jefferies, “Introduction: Weaving Codes, Coding Weaves,” 118–123 and Emma Cocker, “Weaving Codes/Coding Weaves: Penelopean Mêtis and the Weaver-Coder’s Kairos,” 124–141. Concrete examples of exploring weave and code include Julian Rohrhuber and David Griffiths, “Coding with Knots,” 142–157, which explores pre-Colombian *Khípus* using both visual and sonic interpretations, and David Griffiths and Alex McLean, “Textility of Code: A Catalogue of

Errors,” 198–214. This collaboration has continued through the European Research Council–funded PENELOPE project (2016–2021).

7. See Simone Boria et al., eds., *On Turtles and Dragons and the Dangerous Quest for a Media Art Notation System* (Linz: Times Up Press, 2012), 7.

8. Boria et al., *On Turtles and Dragons*, 9.

9. Boria et al., *On Turtles and Dragons*, 9.

10. Boria et al., *On Turtles and Dragons*, 16–25.

11. He also invented two other systems that are relevant to live coding: a system for algorithmic composition, in which consonants are given pitch values according to generative rules, and the Guidonian hand, an improvisational conducting system that a conductor operates by pointing to parts of their hand, thus defining the next note. This can be used in live composition and serves well as a methodological predecessor to what we today call *soundpainting*, which live coder Julio D'Esquivan uses to live code musical ensembles. Thor Magnusson, *Sonic Writing: Technologies of Material, Symbolic and Signal Inscriptions* (London: Bloomsbury, 2019).

12. Documentation of *Code Music Notation*, including video of the performance with Greta Eacott, is available at <https://github.com/thormagnusson/cmn>, accessed April 16, 2022.

13. John Eacott has produced staff notation on the fly for instrumental ensembles to play using his live notation system, although it was produced by generative processes working on live tide data rather than directly live coded. John Eacott, “Instant Music? Just Add Water,” *AI and Society* 27, no. 2 (May 2012): 287–288, <https://doi.org/10.1007/s00146-011-0350-6>.

14. In conversation, Mark Fell and Rian Treanor offer a controversial comparison between algorithmic and score-based music. Mark Fell and Rian Treanor, “The Musical Score Is the Worst Thing in the History of Music,” *Wire* magazine, January 2021, <https://www.thewire.co.uk/in-writing/interviews/the-musical-score-is-the-worst-thing-that-ever-happened-in-the-history-of-music-mark-fell->

15. Thomas W. Patteson, “Player Piano,” *Oxford Handbooks Online*, November 2014, 10.1093/oxfordhb/9780199935321.013.16.

16. Rebecca Wolf, *Spielen und bedienen: Das selbstspielende Klavier als virtuose Maschine. Spiel (mit) der Maschine: Musikalische Medienpraxis in der Frühzeit von Phonographie, Selbstspielklavier, Film und Radio* (Bielefeld, Germany: Transcript Verlag, 2016).

17. We should note the influence of Conlon Nancarrow’s experimental compositions for player piano on algorithmic music. For a continuation of his ideas in the live coding community, see Diego Villaseñor de Cortina and Alejandro Franco Briones, “Nanc-in-a-Can Canon Generator: SuperCollider Code Capable of Generating and Visualizing Temporal Canons Critically and Algorithmically,” in *Proceedings of the Fourth International Conference on Live Coding* (Madrid: Medialab Prado/Madrid Destino, 2019), <https://doi.org/10.5281/zenodo.3946192>.

18. This dance is still performed by Caroline Radcliffe (as taught to her by Pat Tracey as part of the Camden Clog dance group), who in collaboration with composer Sarah Angliss relates

it to the sounds of call centers as the modern-day equivalent to the mills of the industrial era. See Caroline Radcliffe and Sarah Angliss, “Revolution: Challenging the Automaton: Repetitive Labour and Dance in the Industrial Workspace,” *Performance Research* 17, no. 6 (December 2012): 40–47, <https://doi.org/10.1080/13528165.2013.775758>.

19. These are commonly known as *Mozart’s dice games*, although none are believed to have been published in his name. See also George Brecht, John Cage, and La Monte Young, *An Anthology of Chance Operations, Concept Art, Anti-art, Indeterminacy, Improvisation, Meaningless Work, Natural Disasters* (Munich: Heiner Friedrich, 1970).

20. Luigi Russolo, *The Art of Noise (Futurist Manifesto, 1913)*, trans. Robert Filliou, A Great Bear Pamphlet (New York: Something Else Press, 1967), http://www.artype.de/Sammlung/pdf/russolo_noise.pdf.

21. Theresa Sauer, *Notations 21* (New York: Mark Batty, 2009).

22. Sol LeWitt, “Paragraphs on Conceptual Art,” *Artforum* 5, no. 10 (1967): 79–83.

23. Twenty-four code-based implementations of “Draw a straight line and follow it” are archived at <https://web.archive.org/web/20080825030910/http://instructionset.org/instruction/4/>, accessed April 16, 2022.

24. <http://www.geocities.ws/lasaltersjr/anthonybraxtoninterviews.htm>, accessed April 16, 2022.

25. Live coding is often associated with grid-based music, but this does not always apply. Sound synthesis is often free-flowing, and the TidalCycles system has a rational representation of time focused on metric cycles rather than discrete beat units. Alex McLean, “Making Programming Languages to Dance To: Live Coding with Tidal,” in *Proceedings of the 2nd ACM SIGPLAN International Workshop on Functional Art, Music, Modeling and Design* (New York: Association for Computing Machinery, 2014), <https://doi.org/10.1145/2633638.2633647>.

26. Kate Sicchio, Zeshan Wang, and Marissa Forbes, “Live Coding Tools for Choreography: Creating Terpsicode,” in *Proceedings of the 2020 International Conference on Live Coding* (Limerick, Ireland: University of Limerick), <https://doi.org/10.5281/zenodo.3939135>.

27. We compare different conceptions of time embedded in different live coding systems in chapter 6.

28. Clive is an environment for live coding in the C language and is impressive for the timbral and musical complexity of its short programs, at least in the hands of its creator Claude Heiland-Allen. See, accessed March 15, 2022, <https://mathr.co.uk/clive/>.

29. Mark Fell discusses the tendency of algorithmic musicians to define their own tight constraints in an article in the *Wire*, January 2013, <https://www.thewire.co.uk/in-writing/essays/collateral-damage-mark-fell>.

30. Chris Kiefer and Thor Magnusson, “Live Coding Machine Learning and Machine Listening: A Survey on the Design of Languages and Environments for Live Coding,” in *Proceedings of the Fourth International Conference on Live Coding* (Madrid: Medialab Prado/Madrid Destino, 2019).

31. Steve Tanimoto's ideas about levels of liveness are discussed in chapter 5.
32. The title "Future of Programming" is ironic in that the video addresses ideas from the past that have not yet been realized, including the early work of Douglas Engelbart. See Bret Victor, "Future of Programming," July 2013, <https://vimeo.com/71278954>.
33. Kay's accomplishments include Smalltalk, briefly introduced in chapter 2 and further described in chapters 6 and 7.
34. Thor Magnusson and Alex McLean, "Performing with Patterns of Time," in *Oxford Handbook of Algorithmic Music*, ed. Roger T. Dean and Alex McLean (Oxford: Oxford University Press, 2018), <https://doi.org/10.5281/zenodo.1193251>.
35. Computer music can be represented as data, which pattern operations are applied to, or as functions, where pattern operations are directly combined into more complex behaviors. See Alex McLean, "Algorithmic Pattern," in *Proceedings of the 20th Conference on New Interfaces for Musical Expression* (Birmingham UK, 2020), Geneva, Switzerland: Zenodo/CERN, <https://zenodo.org/record/4299661>.
36. Laurie Spiegel, "Manipulations of Musical Patterns," in *Proceedings of the Symposium on Small Computers and the Arts* (Los Alamitos: IEEE Computer Society Press, 1981), 19–22.
37. David Griffiths, "Computation Is Woven," January 28, 2021, Zenodo, <http://doi.org/10.5281/zenodo.4476811>.
38. In an unpublished 2018 talk in IRCAM (Institut de Recherche et Coordination Acoustique/Musique), Andrew Hugill notes the very different responses that mathematicians, designers, and composers have to pattern, recounted in his blog *Shifting Meanings: The Fate of Words in Transdisciplinary Academia*, January 2020, <http://www.andrewhugill.com/blog/?p=3159>; private emails with Laurie Spiegel reveal that her mother was a keen weaver, suggesting her own conception of pattern could owe as much to her exposure to textiles as her experience as a foundational composer, music technologist, and software developer.
39. Spiegel, "Manipulations of Musical Patterns," 19–22.
40. Bernard Bel, "Rationalizing Musical Time: Syntactic and Symbolic-Numeric Approaches," in *The Ratio Book*, ed. Clarence Barlow, Feedback Papers 43 (Cologne: Feedback Studio, 2001), 86–101.
41. Joanne Armitage, "Spaces to Fail In: Negotiating Gender, Community and Technology in Algorave," *Dancecult: Journal of Electronic Dance Music Culture* 10 (November 2018): 31–45, <https://doi.org/10.12801/1947-5403.2018.10.01.02>.
42. Tanimoto's levels of liveness are explored further in relation to notions of liveness in chapter 5. Cf. Steven Tanimoto, "A Perspective on the Evolution of Live Programming," *LIVE '13, Proceedings of the 1st International Workshop on Live Programming* (Los Alamitos: IEEE Computer Society, 2013), 31–34.
43. Alex McLean, "Improvising with Synthesised Vocables, with Analysis towards Computational Creativity" (Master's thesis, Goldsmiths College, University of London, 2007).

44. McLean, “Making Programming Languages to Dance To.”
45. Jeremy Stewart, Shawn Lawson, Mike Hodnick, and Ben Gold, “Cibo v2: Realtime Livecoding A.I. Agent,” in *Proceedings of the 2020 International Conference on Live Coding* (Limerick, Ireland: University of Limerick), <https://doi.org/10.5281/zenodo.3939174>.
46. Simon Hickinbotham and Susan Stepney, “Augmenting Live Coding with Evolved Patterns,” in *Evolutionary and Biologically Inspired Music, Sound, Art and Design*, ed. Colin Johnson, Vic Ciesielski, João Correia, and Penousal Machado, 31–46, Lecture Notes in Computer Science (Cham, Switzerland: Springer International, 2016), https://doi.org/10.1007/978-3-319-31008-4_3.
47. Francisco Bernardo, Chris Kiefer, and Thor Magnusson, “Designing for a Pluralist and User-Friendly Live Code Language Ecosystem with Sema,” in *Proceedings of the 2020 International Conference on Live Coding* (Limerick, Ireland: University of Limerick), 41–58.
48. We discuss this relation in terms of the “map” and “territory” later in this chapter.
49. C. Pair, “Programming, Programming Languages and Programming Methods,” in *Psychology of Programming*, ed. J.-M. Hoc, T. R. G. Green, R. Samurçay, and D. J. Gilmore (Cambridge, MA: Academic Press, 1990), 11.
50. Ryan Kirkbride, “Troop: A Collaborative Tool for Live Coding” (paper presented at the 14th Sound and Music Computing Conference, Espoo, Finland, July 5–8, 2017), <https://doi.org/10.5281/zenodo.1401895>; FeedForward is a custom live coding editor for TidalCycles created by Alex McLean—see <https://github.com/yaxu/feedforward/>.
51. As mentioned previously, we also experimented with this approach in writing this book. See Alan Blackwell, Geoff Cox, and Sang Won Lee, “Live Writing the Live Coding Book” (paper presented at the International Conference on Live Coding 2016, McMaster University, Hamilton, Canada), <http://iclc.toplap.org/2016/papers.html>.
52. Mark Fisher, *K-PUNK* (blog), May 11, 2015, <http://k-punk.org/abandon-hope-summer-is-coming/>. See Mark Fisher, *K-punk: The Collected and Unpublished Writings of Mark Fisher (2004–2016)*, ed. Darren Ambrose (London: Repeater, 2018).
53. Contesting Derrida’s notion that writing exceeds speech, literary critic N. Katherine Hayles has argued that code exceeds both speech and writing in its address to both humans and machines. See N. Katherine Hayles, *My Mother Was a Computer* (Chicago: University of Chicago Press, 2005), 40.
54. This difficulty of “printing out” live code has been a challenge for this book, and we encourage the reader to explore the videos on our accompanying website.
55. Kofi Agawu, “Structural Analysis or Cultural Analysis? Competing Perspectives on the ‘Standard Pattern’ of West African Rhythm,” *Journal of the American Musicological Society* 59, no. 1 (April 2006): 1–46, <https://doi.org/10.1525/jams.2006.59.1.1>.
56. This tension between code that looks good but may do something unexpected (or even crash!) in practice brings exciting moments often celebrated by audiences.

57. Godfried Toussaint, "The Euclidean Algorithm Generates Traditional Musical Rhythms," in *Proceedings of BRIDGES:Mathematical Connections in Art, Music and Science* (Banff, Alberta: Banff Centre, 2005), 47–56, <http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.62.231>.
58. Philip Ball explains symmetry breaking with the example of heating oil in a pan, causing the perfect symmetry of a circle to be broken and replaced with a new pattern with hexagonal symmetry. Philip Ball, *The Self-Made Tapestry: Pattern Formation in Nature* (Oxford: Oxford University Press, 2001).
59. Alfred Korzybski, *Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics* (International Non-Aristotelian Library, 1933).
60. Transcribed from the Weaving Codes research seminar, October 21, 2014, Leeds, UK.
61. This notion of "following" is expanded in chapter 7 with regard to the way that the live coder as "craftsperson" follows their materials.
62. Paul Klee, *Pedagogical Sketchbook* (New York: Frederick A. Praeger, 1953); emphasis in original.
63. Ursula Franklin, *The Real World of Technology*, 2nd ed. (Toronto: House of Anansi Press, 1999).
64. Thor Magnusson, "Epistemic Tools: The Phenomenology of Digital Musical Instruments" (PhD thesis, University of Sussex, 2009), <http://sro.sussex.ac.uk/id/eprint/83540/>.
65. Roland Barthes, "Death of the Author," in *Image-Music-Text* (New York: Fontana, 1978), 142–148.
66. Atsushi Shimojima, "The Graphic-Linguistic Distinction Exploring Alternatives," *Artificial Intelligence Review* 13, no. 4 (1999): 313–335.
67. For a review of Griffiths's work and other aspects of visualization in live coding environments, see Alex McLean, Dave Griffiths, Nick Collins, and Geraint Wiggins, "Visualisation of Live Code," in *Proceedings of Electronic Visualisation and the Arts London 2010* (Swindon, UK: British Computer Society, 2010), 26–30.
68. Roberts has published an excellent interactive (live codable) demonstration of his work on live code annotations and visualizations at <https://charlieroberts.github.io/annotationsAndVisualizations/>, last modified November 17, 2018. For a more traditional academic paper, see Charles Roberts, Matthew Wright, and JoAnn Kuchera-Morin, "Beyond Editing: Extended Interaction with Textual Code Fragments," in *Proceedings of the International Conference on New Interfaces for Musical Expression* (Baton Rouge: School of Music and the Center for Computation and Technology, Louisiana State University, 2015), 126–131.
69. Thor Magnusson, "Ixi Lang: A SuperCollider Parasite for Live Coding," in *Proceedings of International Computer Music Conference 2011* (Ann Arbor: Michigan Publishing, 2011), 503–506.
70. Nelson Goodman, *Languages of Art: An Approach to a Theory of Symbols* (Indianapolis: Hackett, 1976).
71. This is even so, if we consider the notion of the *post-digital*, in which the distinctions between "old" and "new" media are no longer considered useful. Cramer's examples are the typewriter

and piano keys, notionally analog but in a strictly technical sense both digital systems. See Florian Cramer, "What Is Post-Digital?," *APRJA* 3, no. 1 (2014), <https://doi.org/10.7146/aprja.v3i1.116068>.

72. John Cage, "Art and Technology," in *John Cage: Writer* (New York: Cooper Square Press, 1969).

73. For an account of this dual coding of perception in the context of live coding, see chapter 2 of Alex McLean's "Artist-Programmers and Programming Languages for the Arts" (PhD thesis, Department of Computing, Goldsmiths, University of London, 2011), <https://slab.org/thesis/>.

74. See, for example, Gabriele Brandstetter, *Notationen und Choreographisches Denken* (Freiburg, Germany: Rombach, 2010); Scott deLahunta and Norah Zuniga Shaw, "Constructing Memories: Creation of the Choreographic Resource," *Performance Research* 11, no. 4 (2006): 53–62; and for historic contrast and variety in choreographic notation, Ann Hutchinson Guest, *Choreographics: A Comparison of Dance Notation Systems from the Fifteenth Century to the Present* (London: Routledge, 2014) and Laurence Louppe, *Traces of Dance: Drawings and Notations of Choreographers* (Paris: Editions Dis Voir, 1994). See also Lilia Mestre and Elke Van Campenhout, eds., *Writing Scores in Process* (Brussels: a.pass, 2015); Raphael Gyax and Heike Munder, eds., *Between Zones: On the Representation of the Performative and the Notation of Movement* (Zurich: JRP; Manchester: Ringier, 2010); and Scott deLahunta, Kim Vincs, and Sarah Whatley, eds., "On An/Notations," *Performance Research* 20, no. 6 (2015): 1–2.

75. Jacques Bertin, *Semiology of Graphics: Diagrams, Networks, Maps* (Redlands, CA: ESRI Press, 2010), first published in French in 1968; Yuri Engelhardt, "The Language of Graphics: A Framework for the Analysis of Syntax and Meaning in Maps, Charts and Diagrams: (PhD diss., University of Amsterdam, 2002).

76. For example, the Hybrid Live Coding workshop convened in 2020 explored interdisciplinary perspectives on tactile and haptic interfaces incorporating live coding. See, accessed March 15, 2022, <https://hybrid-livecode.pubpub.org/workshop2020>.

77. Christopher Alexander, *A Pattern Language: Towns, Buildings, Construction* (Oxford: Oxford University Press, 1977).

78. A transcript of Alexander's talk is available at Pattern Language, accessed March 15, 2022, <http://www.patternlanguage.com/archive/ieee.html>.

79. Alan F. Blackwell and Sally Fincher, "PUX: Patterns of User Experience," *Interactions* 17 (2010): 27–31.

80. Thomas R. G. Green, "Cognitive Dimensions of Notations," *People and Computers* 5 (1989): 443–460.

81. Alan F. Blackwell, Thomas R. G. Green, and Douglas J. E. Nunn, "Cognitive Dimensions and Musical Notation Systems," Paper presented at *International Computer Music Conference Workshop on Notation and Music Information Retrieval in the Computer Age*, Berlin Germany, August 27–September 1, 2000.

82. Alan F. Blackwell and Thomas R. G. Green, "A Cognitive Dimensions Questionnaire Optimised for Users," in *Proceedings of the Twelfth Annual Meeting of the Psychology of Programming Interest Group*, ed. Alan F. Blackwell and E. Bilotta, (Cosenza, Italy: Edizioni Memoria, 2000), 137–152.
83. Matthew Duignan, James Noble, and Robert Biddle, "Abstraction and Activity in Computer-Mediated Music Production," *Computer Music Journal* 34, no. 4 (2010): 22–33.
84. Tom Hall and Alan F. Blackwell, "Sharing Digital Performance Notation with the Audience," in *Proceedings of the 9th Conference on Interdisciplinary Musicology–CIM14*, Berlin: Staatliches Institut für Musikforschung, 2014.
85. Alan F. Blackwell, "Patterns of User Experience in Performance Programming," in *Proceedings of First International Conference on Live Coding*, 2015, Geneva, Switzerland: Zenodo/CERN, <http://doi.org/10.5281/zenodo.19315>.
86. Theodor W. Adorno, "On the Fetish Character in Music and the Regression of Listening," in *The Culture Industry: Selected Essays on Mass Culture*, ed. J. M. Bernstein (London: Routledge, 1981).
87. Simon Yuill, "All Problems of Notation Will Be Solved by the Masses: Free Open Form Performance, Free/Libre Open Source Software, and Distributive Practice," *Mute* 2, no. 8 (May 2008), <https://www.metamute.org/editorial/articles/all-problems-notation-will-be-solved-masses>. These ideas have also been explored in Geoff Cox and Morten Riis, "(Micro) Politics of Algorithmic Music: Towards a Tactical Media Archaeology," in *The Oxford Handbook on Algorithmic Music*, ed. Alex McLean and Roger Dean (Oxford: Oxford University Press, 2018).
88. In this statement, which also provides the title of Yuill's essay, Cardew is making an explicit political allegiance to Marxism (not least as a founding member of the Revolutionary Communist Party in the UK). Like many other utopian projects, the Scratch Orchestra collapsed, which was explained by Yuill as a consequence of its overreliance on notation as a determining factor for change and the inherent contradiction that in legislating for nonconformity it operated its own form of authoritarianism. This can be further explained, perhaps, by its lack of ability to modify its own notational form on an ongoing basis.
89. Paolo Virno, *A Grammar of the Multitude: For an Analysis of Contemporary Forms of Life* (Los Angeles: Semiotext(e), 2004), 52.
90. Paolo Virno, *When the Word Becomes Flesh: Language and Human Nature* (South Pasadena, CA: Semiotext(e), 2015), 22.
91. Virno, *Grammar of the Multitude*, 66.

Chapter 5

1. This chapter draws on Emma Cocker's articles "Performing Thinking in Action: The Meletē of Live Coding," *International Journal of Performance Arts and Digital Media* 12, no. 2 (2016): 102–116 and "What Now, What Next—Kairotic Coding and the Unfolding Future Seized," in

"Improvisational Creativity," ed. Jon McCormack, Toby Gifford, and Shelly Knotts, special issue, *Journal of Digital Creativity* 29, no. 1 (2018): 82–95.

2. Theorist and philosopher Mark Fisher argues that in music there has been a symptomatic privileging of liveness and a consequent lack of engagement with recorded and sampled forms (such as dub or hip-hop), and the technology through which they are served, as well as the materiality of the sounds themselves. See Mark Fisher, "The Metaphysics of Crackle: Afro-futurism and Hauntology," *Dancecult: Journal of Electronic Dance Music Culture* 5, no. 2 (2013): 42–55.

3. Philip Auslander, *Liveness: Performance in a Mediatized Culture* (London: Routledge, 1999).

4. This point of departure echoes that taken by artist-researcher Winnie Soon in "Executing Liveness: An Examination of the Live Dimension of Code Inter-actions in Software (Art) Practice" (PhD thesis, Aarhus University, Denmark, 2016).

5. See Steven Tanimoto, "VIVA: A Visual Language for Image Processing," *Journal of Visual Languages and Computing* 1, no. 2 (1990): 127–139; Tanimoto, "A Perspective on the Evolution of Live Programming," in *Proceedings of the 1st International Workshop on Live Programming, 2013*, 31–34, <https://liveprogramming.github.io/2013/papers/liveness.pdf>. IEEE Press (Institute of Electrical and Electronics Engineers), San Francisco, California. However, note that Tanimoto writes from a computer science and software-engineering perspective, rather than wishing to characterize the experiences of artistic performance.

6. The notion of *pre-gramming* is discussed in chapter 4. As Thor Magnusson and Kate Sicchio note, "Live coders programme, they write in public (Greek: *pro-graphēin*)—but they also *pre-gramme*, that is, their algorithmic writing is conditioned by a system that has already been designed with careful considerations of expressivity, constraints, interface, and other concerns of human-machine interaction and performer-audience communication." Thor Magnusson and Kate Sicchio, "Writing with Shaky Hands," *International Journal of Performance Arts and Digital Media* 12, no. 2 (2016): 99–101. Indeed, live coding further complicates the relation between *pre-gramming* and *programming* (indeed, between activity *behind the scenes* and *onstage*) since many live coders share (and even livestream) their preparatory practicing and pre-gramming activity, including the making of new functions directly online (for example, by sharing on GitHub) for others to engage with and comment on. See, for example, Tidalcycles, January 2021, <https://club.tidalcycles.org/t/ply-and-chords/2724/11?u=yaxu>.

7. Later in the chapter, we discuss the notion of real-time composition in relation to the increased immediacy enabled by minimizing the technical latency between the writing and the execution of code with reference to Steven Tanimoto's hierarchy of degrees of liveness. However, for choreographer João Fiadeiro, real-time composition (RTC) is a theoretical-practical tool for problematizing the experience of improvisation and composition where the performer is invited to "let go" their role as "creator"—along with the "interference" of habits and patterns of behavior—to become the "facilitator" or "mediator" of "what happens," conceived as a coemergent process. See João Fiadeiro, "If You Don't Know, Why Do You Ask? An Introduction to the Method of Real-Time Composition," in *Knowledge in Motion: Perspectives of Artistic and Scientific Research in Dance*,

ed. Sabine Gehm, Pirkko Husemann, and Katharina von Wilcke (Bielefeld, Germany: Transcript, 2007), 101–110. The notion of real time is further explored in chapter 6.

8. See also Mark J. Butler, *Playing with Something That Runs: Technology, Improvisation and Composition in DJ and Laptop Performance* (Oxford: Oxford University Press, 2014). The repeatability and recording of live coding performances raises complex questions regarding issues of copyright, around which there is currently little consensus within the live coding community.

9. Benoît and the Mandelbrots (Holger Ballweg, Patrick Borgeat, Juan A. Romero, Matthias Schneiderbanger), interview by Emma Cocker, July 11, 2016.

10. See Rangga Aji's exposition in chapter 3.

11. See the ALGOBABEZ (Shelly Knotts and Joanne Armitage) exposition in chapter 3.

12. The blank slate is always bound to be a relative concept. For example, a blank slate using *ixi lang* is impregnated with more musical sounds and patterns than the blank slate of SuperCollider, which in turn is more pregnant than C/C++. This reflects the system's hierarchy of code: *ixi lang* is written in SuperCollider, which is written in C/C++. Live coders have always used their own libraries and convenience classes to make live coding faster and less of an inventing-the-wheel-in-front-of-a-live-audience process. Increasingly, people package these systems as self-standing live coding environments, a unique system derived from that person's coding style. Specific systems such as LOLC, Gibber, Al-Jazari, Scheme Bricks, or Texture are all good examples of constrained and limited systems that explore a particular idea yet provide a wide scope for general musical expression.

13. See Richard Dudas, "Comprovisation: The Various Facets of Composed Improvisation within Interactive Performance Systems," *Leonardo Music Journal* 20 (2010): 29–31, <https://openmusiclibrary.org/article/4662/>.

14. Peggy Phelan, *Unmarked: The Politics of Performance* (London: Routledge, 1993), 146.

15. Auslander, *Liveness*.

16. Auslander, *Liveness*, 11.

17. Auslander, *Liveness*, 5. Auslander refers to Jean Baudrillard's *For a Critique of the Political Economy of the Sign*, trans. Charles Levin (St. Louis: Telos Press, 1981), 175–176.

18. Auslander, *Liveness*, 3.

19. Philip Auslander, "Afterword: So Close and Yet So Far Away, the Proxemics of Liveness," in *Experiencing Liveness in Contemporary Performance: Interdisciplinary Perspectives*, ed. Matthew Reason and Anja Mølle Lindelof, Routledge Advances in Theatre and Performance Studies (London: Routledge, 2017), 296. See also Auslander, "Digital Liveness: A Historic-Philosophical Perspective," *PAJ: A Journal of Performance and Art* 34, no. 3 (2012): 3–11.

20. Nick Couldry, "Liveness, Reality, and the Mediated Habitus from Television to the Mobile Phone," *Communication Review* 7 (2004): 353–361. The experience of technologically mediated

liveness has been unexpectedly foregrounded since 2020 (during the final years of writing this book) as a consequence of the COVID-19 pandemic, with a rise in streamed performances and zoom events. For example, Eulerroom Equinox 2020 (March 2020) was a live discussion by the TOPLAP community, originally planned as a physically situated event, that resulted in a stream of 117 performances. See YouTube video, https://www.youtube.com/watch?v=qcE_a8IXk8o&list=PLMBIpbV-wQLUXxRDiwz5Jholf2CX_uM6.

21. Reason and Lindelof, *Experiencing Liveness in Contemporary Performance*, 6.
22. Reason and Lindelof, *Experiencing Liveness in Contemporary Performance*, 7–8.
23. Reason and Lindelof, *Experiencing Liveness in Contemporary Performance*.
24. See Alan F. Blackwell, “The Dark Side of Metaphor: Fetish in User Interfaces” (paper presented at the Conference on Human Factors in Computing Systems, April 10–15, 2010, Atlanta), <https://www.cl.cam.ac.uk/events/experiencingcriticaltheory/Blackwell-DarkSide.pdf>.
25. See Kenton O’Hara, Richard Harper, Helena Mentis, Abigail Sellen, and Alex Taylor, “On the Naturalness of Touchless: Putting the ‘Interaction’ Back into NUI,” *ACM Transactions on Computer-Human Interaction* 20, no. 1 (April 2013): article 5.
26. Choreographer and philosopher Maxine Sheets-Johnson uses the term *kinesthetic memory* to address the question of “how we do what we do.” Maxine Sheets-Johnson, *The Corporeal Turn: An Interdisciplinary Reader* (Exeter, UK: Imprint Academic, 2009), 11. See also Sheets-Johnson, *The Primacy of Movement* (Amsterdam: John Benjamins, 1999) and Zeynep Çelik Alexander, *Kinaesthetic Knowing* (Chicago: University of Chicago Press, 2017).
27. These categories of “intelligence” are drawn from Howard Gardner’s *Frames of Mind: The Theory of Multiple Intelligences* (New York: Basic Books, 1983). For example, on embodiment see Francisco J. Varela, Evan Thompson, and Eleanor Rosch, *The Embodied Mind* (Cambridge, MA: MIT Press, 1991).
28. James J. Gibson, *The Senses Considered as Perceptual Systems* (Boston: Houghton Mifflin, 1966), 97. See Michael Polyani, “Tacit Knowing: Its Bearing on Some Problems of Philosophy,” *Review of Modern Physics* 34 (1962): 601–616 and Michael Polyani, *The Tacit Dimension* (1966; repr., Gloucester, MA: Peter Smith, 1983).
29. See also Thor Magnusson and Kate Sicchio, eds., “Live Coding in Performance Arts,” special issue, *International Journal of Performance Arts and Digital Media* 12, no. 2 (2016).
30. See André Lepecki, ed., *Dance, Documents of Contemporary Art* (London: Whitechapel; Cambridge, MA: MIT Press, 2012). See also Sheets-Johnson, *Corporeal Turn*; Alva Noë, *Action in Perception* (Cambridge, MA: MIT Press, 2004); Noë, *Varieties of Presence* (Cambridge, MA: Harvard University Press, 2012).
31. See Kate Sicchio’s exposition in chapter 3.
32. See Kate Sicchio’s exposition in chapter 3.
33. See Joana Chicau’s exposition in chapter 3.

34. Daniel Stern, *Forms of Vitality: Exploring Dynamic Experience in Psychology, the Arts, Psychotherapy, and Development* (Oxford: Oxford University Press, 2010), 3. In so doing, he departs from philosopher Henri Bergson's conceptualization of *élan vital*, conceived as a "vital force or impulse," an immanent creative principle continually developing and generating new forms.
35. Stern, *Forms of Vitality*, 9.
36. Stern, *Forms of Vitality*, 45.
37. Stern, *Forms of Vitality*, 8. This distinction connects with the "imperative how vs. declarative what" dichotomy in programming-language design. See C. Pair, "Programming, Programming Languages and Programming Methods," in *Psychology of Programming*, ed. J.-M. Hoc, T. R. G. Green, R. Samurçay, and D. J. Gilmore (London: Academic Press, 1990), 11.
38. Stern, *Forms of Vitality*, 4.
39. Reason and Lindelof use the term *deadliness* in reference to the writing of Brook, *Experiencing Liveness in Contemporary Performance*, 1. See also Peter Brook, *The Empty Stage* (London: Penguin, 1972).
40. Erin Manning, *Always More Than One: Individuation's Dance* (Durham, NC: Duke University Press, 2013), 139.
41. Manning, *Always More Than One*, 147.
42. Manning, *Always More Than One*, 142.
43. See N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature and Informatics* (Chicago: University of Chicago Press, 2010).
44. The notions of *thinking-in-action*, *thought-in-motion*, and *loom-thinking* are explored further in relation to live coding in chapter 7.
45. See Tim Ingold, "The Textility of Making," in *Being Alive: Essays on Movement, Knowledge and Description* (London: Routledge, 2011), 210–219. The epistemological implications of live coding's "textility" is explored further in chapter 7.
46. Mihaly Csikszentmihályi, *Flow: The Classic Work on How to Achieve Happiness* (London: Rider, 2002), 64.
47. See also Chris Nash and Alan F. Blackwell, "Flow of Creative Interaction with Digital Music Notations," in *The Oxford Handbook of Interactive Audio*, ed. K. Collins, B. Kapralos, and H. Tessler (New York: Oxford University Press, 2014), 387–404.
48. Csikszentmihályi, *Flow*, 56.
49. There is no such thing as real time or the present to the computer, only degrees of delay. See Wolfgang Ernst, *Delayed Present: Media-Induced Tempor(e)alities and Techno-Traumatic Irritations of "the Contemporary"*, ed. Geoff Cox and Jacob Lund (Berlin: Sternberg Press, 2017).
50. See also David M. Berry, "Real-Time Streams," in *The Philosophy of Software: Code and Mediation in the Digital Age* (London: Palgrave Macmillan, 2011), 142–169.

51. Tanimoto, "Perspective on the Evolution of Live Programming."
52. Tanimoto, "Perspective on the Evolution of Live Programming."
53. Tanimoto, "Perspective on the Evolution of Live Programming."
54. Tanimoto, "Perspective on the Evolution of Live Programming."
55. Tanimoto, "Perspective on the Evolution of Live Programming."
56. Tanimoto, "Perspective on the Evolution of Live Programming."
57. See Chris Nash, "Supporting Virtuosity and Flow in Computer Music" (PhD thesis, University of Cambridge, 2012), <https://doi.org/10.17863/CAM.16375>.
58. See also Rosa Menkman, *The Glitch Moment(um)* (Amsterdam: Institute of Network Cultures, 2011).
59. Alternatively, for some thinkers *acceleration* has radical critical potential, where certain technosocial processes could in fact be accelerated as a way of generating change. See Robin Mackay and Armen Avanessian, eds., *#Accelerate#: The Accelerationist Reader* (Falmouth, UK: Urbanomic, in association with Merve, 2014).
60. On failure within live coding, see Tom Johnson, *Failing: A Very Difficult Piece for String Bass* (Paris: Editions 75, 1975), and also Nick Collins, "Infinite Length Pieces: A User's Guide," in *Proceedings of MAXIS*, Sheffield, UK: Sheffield Hallam University, April 12–14, 2002, where it is unclear whether the (prototype) software has terminated or just crashed. See also Kim Cascone's "The Aesthetics of Failure: Post-Digital Tendencies in Contemporary Computer Music," *Computer Music Journal* 24, no. 4 (December 2000): 12–18.
61. On the loss of intervals in contemporary culture, see Byung-Chul Han, *The Scent of Time* (Cambridge: Polity Press, 2017).
62. See Elizabeth Wilson's exposition in chapter 3.
63. See Marc Leman, *The Expressive Moment: How Interaction (with Music) Shapes Human Empowerment* (Cambridge, MA: MIT Press, 2016) and Leman, *Embodied Music Cognition and Mediation Technology* (Cambridge, MA: MIT Press, 2007).
64. J. L. Austin, *How to Do Things with Words* (Cambridge, MA: Harvard University Press, 1975).
65. Austin later revised the opposition between constatives and performatives through the introduction of three categories: locutionary (e.g., the performance of an utterance), illocutionary (e.g., the force of the utterance, thus its real, intended meaning, such as a command or promise), and perlocutionary (e.g., its actual effect, whether intended or not).
66. See Geoff Cox and Alex McLean, "Vocable Speech," in *Speaking Code, Coding as Aesthetic and Political Expression* (Cambridge, MA: MIT Press, 2013), 35.
67. Adrian Mackenzie, *Cutting Code: Software and Sociality* (New York: Peter Lang, 2006), 141.

68. Mackenzie, *Cutting Code*, 141.
69. Florian Cramer has written more extensively about this in “Concepts, Notations, Software, Art,” *Netzliteratur*. March 23, 2002, https://www.netzliteratur.net/cramer/concepts_notations_software_art.html.
70. Alexander R. Galloway, “Language Wants to Be Overlooked: On Software and Ideology,” *Journal of Visual Culture* 5, no. 3 (2006): 315–331.
71. Wendy Hui Kyong Chun, *Programmed Visions: Software and Memory* (Cambridge, MA: MIT Press, 2011), 23. We also refer to the agency of live coding in the final chapter of this book and ask what it *wants*.
72. Chun, *Programmed Visions*, 24.
73. Chun, *Programmed Visions*, 24. See also chapter 4 for a discussion of how source code is like a map that you can only read once you know the territory that it generates.
74. In an echo of D. W. Winnicott’s *object relations*, it becomes something through its destruction; see Winnicott, *Playing and Reality* (Abingdon: Taylor and Francis, 2005).
75. Chun, *Programmed Visions*, 25.
76. This phrase invokes Derrida’s concept of *hauntology*. Furthermore, the unreliable separation of the living and dead is made clear by sound recording, according to Jason Stanyek and Benjamin Piekut in “Deadness, Technologies of the Intermundane,” *Drama Review* 54, no. 1 (2010): 14–28.
77. Chun, *Programmed Visions*, xii.
78. Giorgio Agamben, “Notes on Gesture,” in *Means without Ends: Notes on Politics*, trans. Vincenzo Binetti and Cesare Casarino (1992; repr., Minneapolis: University of Minnesota Press, 2000), 57.
79. Agamben, “Notes on Gesture,” 116. He is referring to Aristotle’s distinction between production (*poiesis*, which has an end other than itself) and action (*praxis*, which is itself an end) (56). Gesture disrupts the false distinction and presents means without end. See also Giorgio Agamben, “Language and Historical Categories in Benjamin’s Thought,” in *Potentialities* (Stanford, CA: Stanford University Press, 2007), 48–62, where he refers to Walter Benjamin’s essay “On Language as Such and the Language of Man,” in *One-Way Street, and Other Writings*, trans. Edmund Jephcott and Kingsley Shorter (London: New Left Books, 1979), 107–123. Agamben also draws on Walter Benjamin’s idea of pure language—that is, a language operating beyond a mode of communication between subjects to become one of pure communicability.
80. Paolo Virno, *When the Word Becomes Flesh: Language and Human Nature* (South Pasadena, CA: Semiotext(e), 2015), 35.
81. Dieter Mersch, *Epistemologies of Aesthetics* (Zurich: Think Art Diaphanes, 2015), 118–119.
82. Mersch, *Epistemologies of Aesthetics*, 170.

83. Mersch, *Epistemologies of Aesthetics*, 52.
84. See Erika Fischer-Lichte, "Explaining Concepts," in *The Transformative Power of Performance: A New Aesthetics* (London: Routledge, 2008).
85. The notion of autopoiesis here draws on the work of Humberto Maturana and Francisco Varela—e.g., *Autopoiesis and Cognition: The Realization of the Living* (1980). See also Andy Clark and David J. Chalmers, "The Extended Mind: A Dynamical Systems Perspective," *Analysis* 58 (1998): 7–19.
86. Marvin Carlson, introduction to Fischer-Lichte, *Transformative Power of Performance*, 7.
87. Fischer-Lichte, *Transformative Power of Performance*, 39. See also Umberto Eco, *The Open Work* (Cambridge, MA: Harvard University Press, 1989).
88. Fischer-Lichte, *Transformative Power of Performance*, 68.
89. For example, see Thor Magnusson's *ixi lang* "shuffle," referred to in Jason Freeman and Akito Van Troyer, "Collaborative Textual Improvisation in a Laptop Ensemble," *Computer Music Journal* 35, no. 2 (Summer 2011): 8–21. Also, see the self-modifying live code editor `feedback.pl`, described in Adrian Ward et al., "Live Algorithm Programming and a Temporary Organisation for Its Promotion," in *Read_me: Software Art and Cultures*, ed. Olga Goriunova and Alexei Shulgin (Århus, Denmark: Digital Aesthetics Research Centre, University of Aarhus, 2004).
90. See Donna J. Haraway, *Staying with the Trouble: Making Kin in the Chthulucene*, Experimental Futures (Durham, NC: Duke University Press, 2016) and Donna J. Haraway, "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin," *Environmental Humanities* 6, no. 1 (2015): 159–165, 160.
91. See Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005). In *Vibrant Matter*, Jane Bennett explores the "capacity of things . . . not only to impede or block the will and designs of humans but also to act as quasi agents or forces with trajectories, propensities, or tendencies of their own." See Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham, NC: Duke University Press, 2010), viii.
92. Karen Barad, "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter," new issue, *Signs: Gender and Science* 28, no. 3 (Spring 2003), 808. See also Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007).
93. Barad, "Posthumanist Performativity," 827.
94. As mentioned earlier, this geographical displacement has become even more foregrounded since 2020 as a consequence of the COVID-19 pandemic.
95. Fischer-Lichte, *Transformative Power of Performance*, 50.
96. Paulo Freire, *Pedagogy of the Oppressed* (New York: Seabury Press, 1968).
97. Reason and Lindelof, *Experiencing Liveness*, 2. See Martin Buber, *Between Man and Man* (London: Routledge, 2002), 241.

98. Martin Howse, Earthcodes Project, September 17, 2014, <http://www.1010.co.uk/org/earthcode.html>.

99. See also Martin Howse, "Dark Interpreter," *The Dark Interpreter*, September 6, 2015, <http://www.1010.co.uk/org/darkint.html>.

100. See Fischer-Lichte, *Transformative Power of Performance*, 51–60.

101. Miwon Kwon, *One Place after Another: Site-Specific Art and Locational Identity* (Cambridge, MA: MIT Press, 2004), 126. See also Irit Rogoff, "WE: Collectivities, Mutualities, Participations," in *I Promise Its Political: Performativität in der Kunst*, ed. Dorothea Von Hantelmann and Marjorie Jongbloed (Cologne: Museum Ludwig, 2002).

102. Kwon, *One Place after Another*, 7.

103. Christopher Kelty, "Geeks and Recursive Publics," in *Two Bits: The Cultural Significance of Free Software* (Durham, NC: Duke University Press, 2008), 28.

104. Kelty, "Geeks and Recursive Publics," 29.

105. Kelty, "Geeks and Recursive Publics," 29.

106. Kelty, "Geeks and Recursive Publics," 62.

107. See Iris Saladino's exposition in chapter 3.

108. Simon Yuill, "All Problems of Notation Will Be Solved by the Masses: Free Open Form Performance, Free/Libre Open Source Software, and Distributive Practice," *Mute* 2, no. 8 (May 2008): 67, <https://www.metamute.org/editorial/articles/all-problems-notation-will-be-solved-masses>. Yuill provides the example of drumming circle performances in which "anyone can join in with their own algorithms and code, constructing and developing a collective rhythmic work, as well as performances that start from one piece of code that is rewritten by successive performers."

109. See Abhinay Khoparzi's exposition in chapter 3.

110. Yuill, "All Problems of Notation," 77.

111. Yuill, "All Problems of Notation," 67. To Yuill, live coding enacts many of the principles of free software development:

Of all the artforms supported and enabled through FLOSS . . . "livecoding" has emerged as the one which most directly embodies the key principles of FLOSS production into the creation and experience of the work itself. . . . Livecoding emphasises the FLOSS principle of code-based production as a form of production that is itself "live" and living, that enables the possibility of production by others for their own purposes. (Yuill, "All Problems of Notation," 65)

112. Stephen Ramsay, *Algorithms Are Thoughts, Chainsaws Are Tools*, video, 2016, <https://vimeo.com/699880166>. Accessed 15 May 2016, in Cocker, "Performing Thinking in Action," 109.

113. For an analysis of the difference between frontstage and backstage performance in everyday life, see Irving Goffman, *The Presentation of Self in Everyday Life* (Woodstock, NY: Overlook, 1973).

114. Yuill, “All Problems of Notation,” 66.

115. For a key historical touchstone text on “aura” and its relation to technology, see Walter Benjamin, “The Work of Art in the Age of Mechanical Reproduction,” in *Illuminations*, ed. Hannah Arendt, trans. Harry Zohn (New York: Schocken Books, 1969).

116. The notion of virtuosity is addressed in chapter 4, where it is rescued from its association with the cult of the performer and recuperated as political action through the prism of Paolo Virno’s writing.

117. Catherine Wood, *Yvonne Rainer: The Mind Is a Muscle* (London: Afterall, 2007), 27. Wood is specifically referring to Yvonne Rainer’s choreographic performances from the 1960s onward. See also Rainer’s *No Manifesto* (1965), which explicitly refuses virtuosity in the commonplace understanding.

118. Yuill, “All Problems of Notation,” 67.

Chapter 6

1. A formal definition of the phrase *time critical* in a technical context, by analogy to systems properties such as *safety critical*, would refer to systems where the correctness of the program execution depended not only on the value of the outputs but also on the time at which those outputs were produced. A computer science response to this research question might involve mathematically verified guarantees that a particular event will occur at a particular moment in time—a proof procedure that can itself be applied to the programming languages used in live coding, as in Sam Aaron, Dominic Orchard, and Alan F. Blackwell, “Temporal Semantics for a Live Coding Language,” in *Proceedings of the 2nd ACM SIGPLAN International Workshop on Functional Art, Music, Modeling and Design* (New York: Association for Computing Machinery, 2014), 37–47.

2. We paraphrase this from Peter Osborne, *Anywhere or Not at All: Philosophy of Contemporary Art* (London: Verso, 2013), 17.

3. Irit Rogoff describes a shift from criticism to critique to what she describes as “criticality.” See Irit Rogoff, “From Criticism to Critique to Criticality,” *Transversal*, January 2003, <https://transversal.at/transversal/0806/rogoff1/en>.

4. Here we paraphrase Geoff Cox and Jacob Lund’s *The Contemporary Condition: Initial Thoughts on Contemporaneity and Contemporary Art* (Berlin: Sternberg Press, 2016), 9. The book is the first in an edited series related to the research project the Contemporary Condition at Aarhus University, led by Jacob Lund and Geoff Cox and funded by the Danish Council for Independent Research. See “The Contemporary Condition,” Aarhus University, last modified May 10, 2021, <http://contemporaneity.au.dk/>.

5. Osborne, *Anywhere or Not at All*, 17.

6. Giorgio Agamben, “What Is the Contemporary?,” in *What Is an Apparatus? and Other Essays* (Palo Alto, CA: Stanford Press, 2009), 39–55.

7. In Agamben's words:

Those who are truly contemporary, who belong to their time, are those who neither perfectly coincide with it nor adjust themselves to its demands. . . . But precisely because of this condition, precisely through this disconnection and this anachronism, they are more capable than others of perceiving and grasping their own time. ("What Is the Contemporary?," 40)

8. See Jack Burnham's "Systems Esthetics," *Artforum* 7, no. 1 (September 1968): 30–35 and "Real Time Systems," *Artforum* 8, no. 1 (September 1969): 49–55.

9. See Wolfgang Ernst's *Delayed Present* (Berlin: Sternberg Press, 2017). For instance, a stream of data produces differences due to the influence of all things that are executing and running in real time, making the stream decidedly unpredictable. The alternative phrase *near real time* is commonly used in technical circles to describe this delay between the occurrence of an event and the use of the processed data, exemplified by the buffering effects when streaming heavy audio or video data from the internet.

10. Rogoff, "From Criticism to Critique to Criticality."

11. Alex McLean, Dave Griffiths, Nick Collins, and Geraint Wiggins, "Visualisation of Live Code," in *Proceedings of Electronic Visualisation and the Arts*, London, 2010. Swindon, BCS Learning & Development Ltd., 2010: 26–30.

12. Scratch also has some features that are less conventional in contemporary terms, such as a message-passing model that has only relatively recently been supplemented with support for conventional named procedures.

13. See also Andrew Sorensen and Henry J. Gardner, "Programming with Time: Cyber-Physical Programming with Impromptu." In *Proceedings of the 25th Annual ACM SIGPLAN Conference on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA)*, Reno/Tahoe, Nevada, October 17–21, 2010 (New York: Association for Computing Machinery, 2010): 822–834.

14. Julian Rohrer, "Algorithmic Complementarity, or the Impossibility of 'Live' Coding," *Collaboration and Learning through Live Coding (Dagstuhl Seminar 13382)* 3, no. 9 (2014): 140–142, <http://dx.doi.org/10.4230/DagRep.3.9.130>.

15. Olivia Jack, "Hydra: Live Coding Networked Visuals," in *Proceedings of the Fourth International Conference on Live Coding*, Medialab Prado / Madrid Destino, Madrid, Spain, 16–18 January 2019. Geneva, Switzerland: Zenodo/CERN, 353–354. <https://doi.org/10.5281/zenodo.3946269>. See also <https://hydra.ojack.xyz/>.

16. The aforementioned Scratch does not account for logical time, so although it has functionality to make sound and introduce pauses to create rhythm, timing inaccuracies lead to any music produced with it having a pronounced shuffling feel.

17. Depending on the system's sample rate but in terms of digital sound, a *moment* often lasts for 1/44,100th of a second, with 44.1 kilohertz the standard sample rate used by audio compact discs.

18. To adopt a phrase also repeated by poststructuralist thinkers such as Gilles Deleuze (in *Difference and Repetition*) and Jacques Derrida (in *Spectres of Marx*) to indicate how lived time is

experienced as a kind of illusion. See Jack Reynolds, *Understanding Existentialism* (London: Routledge, 2014), 101.

19. Jon May and Nigel Thrift, eds., *Timespace: Geographies of Temporality* (London: Routledge, 2007), 4–5.

20. Stuart Grant, Jodie McNeilly, and Maeva Veerapen, eds., *Performance and Temporalisation: Time Happens* (Basingstoke, UK: Palgrave Macmillan, 2014), 1, 3.

21. See also Julian Rohrerhuber, “Algorithmic Music and the Philosophy of Time,” in *The Oxford Handbook of Algorithmic Music*, ed. Alex McLean and Roger T. Dean (Oxford: Oxford University Press, 2018), <https://zenodo.org/record/2596675#.YBFtRpP7QW4>.

22. Zygmunt Bauman, *Liquid Times: Living in an Age of Uncertainty* (Cambridge: Polity Press, 2007), 1.

23. Michael Hardt and Antonio Negri go even further in their account of globally networked late capitalism, in which they claim that “all *times* have been subsumed in a general *non-place*,” which could also arguably be conceived as a general non-time. Michael Hardt and Antonio Negri, *Empire* (Cambridge, MA: Harvard University Press, 2000), 353.

24. Amelia Groom, ed., *Time, Documents of Contemporary Art* (London: Whitechapel; Cambridge, MA: MIT Press, 2013), 13.

25. See Jonathan Crary, *24/7: Late Capitalism and the Ends of Sleep* (London: Verso, 2013) for a more detailed account of these conditions.

26. Michael Hardt and Antonio Negri would conceive of this as “total subsumption” to the logic of capital or empire. See Hardt and Negri, *Empire*, 2000.

27. Zygmunt Bauman, *Liquid Life* (Cambridge: Polity Press, 2005).

28. Indeed, conceived in these terms one could argue as the political philosopher Alain Badiou does: “It is better to do nothing than to contribute to the invention of formal ways of rendering visible that which Empire already recognises as existent.” Alain Badiou, “Fifteen Theses on Contemporary Art,” in *Performance Research* (London: Routledge, 2004).

29. Jodie McNeilly, “Temporalising Digital Performance,” in Grant, McNeilly, and Veerapen, *Performance and Temporalisation*, 153.

30. Within music theory, meter is conceived as ground, and rhythm is the figure. In music tradition, time may be notated within discrete symbols, such as Western staff notation or Indian *Bol* syllables, but performed with subtle phrasing over continuous time.

31. The temporality of latency is discussed by Kristen Veel through its etymological roots (from the Latin *latentum*, meaning “hidden,” “lurking,” “concealing”), including how it prompts further thinking around invisibility and uncertainty. See Kristen Veel, “Latency,” in *Uncertain Archives: Critical Keywords for Big Data*, ed. Nanna Bonde Thylstrup, Daniela Agostinho, Annie Ring, Catherine D’Ignazio, and Kristin Veel (Cambridge, MA: MIT Press, 2021), 313–319.

32. See Alex McLean, "Forkbomb.pl," July 4, 2001, <https://slab.org/forkbomb-pl/>, a short section of code that when executed gradually disables a computer system. Similarly, glitch is a musical genre in its own right in which musical instruments are pushed to their limits as a way to give audibility to things you are not *meant* to hear in conventional musical terms. See Rosa Menkman, *The Glitch Moment(um)* (Amsterdam: Institute of Network Cultures, 2011).
33. McNeilly, "Temporalising Digital Performance," 153.
34. Grant, McNeilly, and Veerapen, *Performance and Temporalisation*, 3.
35. Elizabeth Grosz, ed. *Becomings: Exploration in Time, Memory and Futures* (Ithaca, NY: Cornell University Press, 1999).
36. Grosz, *Becomings*, 4.
37. Grant, McNeilly, and Veerapen, *Performance and Temporalisation*, 6.
38. Grosz, *Becomings*, 18–19.
39. Henri Bergson, *Matter and Memory* (London: Dover, 1991), 137.
40. Bergson, *Matter and Memory*, 138.
41. Grosz, *Becomings*, 25.
42. Daniel Stern, *The Present Moment in Psychotherapy and Everyday Life* (New York: W. W. Norton, 2004), 27.
43. Stern, *Present Moment in Psychotherapy and Everyday Life*, 27. Here, perhaps, this future-of-the-present moment could be considered in relation to Erin Manning's writing on *preacceleration*. See Erin Manning, *Relationescapes: Movement, Art, Philosophy* (Cambridge, MA: MIT Press, 2009).
44. Martin Heidegger, *Being and Time* (1953; repr., Albany: State University of New York Press, 2010). The Greek word *ekstasis* (standing outside oneself) is used by Heidegger to indicate how Dasein (the experience of being) stands out from the past and projects itself toward a future by way of the present.
45. Heidegger, *Being and Time*, 334.
46. McNeilly, "Temporalising Digital Performance," 156.
47. Alfred Schutz, "Making Music Together: A Study in Social Relationship," in vol. 2, *A. Schutz, Collected Papers* (The Hague: Martinus Nijhoff, 1976), 159–179.
48. But, of course, it is important to recognize that the way in which words like *promise* are employed may or may not closely resemble human uses of the same word. For a discussion of this, see Alan F. Blackwell, "Metaphors We Program By: Space, Action and Society in Java," in *Proceedings of the 18th Annual Workshop of the Psychology of Programming Interest Group*, 7–21. Brighton, UK: University of Sussex, 2006.
49. A further example could be taken from a technical paper discussing the formal logic of temporality implemented in Sonic Pi. See Sam Aaron, Dominic Orchard, and Alan F. Blackwell, "Temporal Semantics for a Live Coding Language," 37–47.

50. See Thor Magnusson, “The Threnoscope: A Musical Work for Live Coding Performance” (paper presented at the First International Workshop on Live Programming in Conjunction with the 35th International Conference on Software Engineering, 2013, May 18–26, 2013, San Francisco).

51. Martin Clayton, *Time in Indian Music: Rhythm, Metre, and Form in North Indian Rāg Performance* (Oxford: Oxford University Press, 2000), 16.

52. Bernard Bel, “Rationalizing Musical Time: Syntactic and Symbolic-Numeric Approaches,” in *The Ratio Book*, ed. Clarence Barlow, Feedback Papers 43 (Cologne: Feedback Studio, 2001), 86–101.

53. Here we paraphrase Agamben’s notion of the contemporary once more, as an experience of disconnection in order to establish a disjunctive relationship with one’s own time. See Agamben, “What Is the Contemporary?,” 40.

54. Victor Turner, *From Ritual to Theatre: The Human Seriousness of Play* (New York: PAJ, 1982), 44.

55. See also Julian Rohrhuber, “Live Coding and the Self Alienation of Time,” keynote lecture at the First International Conference on Live Coding, 2015, University of Leeds, UK.

56. Catherine Clément, *Syncope: The Philosophy of Rapture*, trans. Sally O’Driscoll and Deirdre M. Mahoney (Minneapolis: University of Minnesota Press, 1994), 1.

57. Clément, *Syncope*, 5.

58. Clément, *Syncope*, 254. The original reference is from Jean-Jacques Rousseau’s article on syncope in *A Complete Dictionary of Music*, trans. William Waring (1779; repr., New York: AMS Press, 1975), 390–391. Significantly, in the original the word *time* was used instead of *beat* but has been changed in keeping with Clément’s usage.

59. More specifically, she draws on Bergson’s writing on the *syncopathic* figure of the *renunçiant* who leaves the village for the forest. Her argument is that Bergson uses the duality to point to a deeper division between time and duration: “In the village, time is homogenous and divisible. . . . In the forest, duration is heterogeneous and indivisible, is in continuous mutation.” Clément, *Syncope*, 173.

60. Reflecting on the concept of *futurity*, writer Jean-Paul Martinon turns to the French language and identifies two different words for the future: *le futur* and *l’avenir*. The first, *le futur*, he states, “refers to something distant or remote, possible, or probable. . . . *Le futur* supposes in fact the possibility of projection, predictions, and prophecies.” While *le futur* is concerned with “what will or might be,” *l’avenir*, as Martinon notes, is usually translated as “what is ‘yet-to-come.’” He differentiates the two modes thus: “One focuses on what the future does or what we do with the future [*l’avenir*] and the other concentrates on what the future *is* or *holds* [*le futur*].” Though different, both models refer to the future as a linear continuation of time. Against this logic, he positions the radical potential of a third term: *à-venir* (the expression of the “to-come”), which represents an “unhinging,” a “spacing (and) temporizing” that “interrupts the present,” “breaking up . . . the measurable linearity of space and time.” Moreover, he asserts, “*À-venir* does not stem from the future, but *from itself*, from a ‘self’ that ‘lies’ between radical impossibility (‘what has not yet streamed’) and a future historically determined in advance.” According to Martinon, “*À-venir*

surges between the foreseeable, 'projectable,' 'plannable,' and programmable *future present* and the radical future, that is . . . that which exceeds or is more than this future possibility." Jean-Paul Martinon, *On Futurity, Malabou, Nancy and Derrida* (London: Palgrave Macmillan, 2007), 1, 4–5, 7.

61. See Emma Cocker, "Live Notation: Reflections on a Kairotic Practice," *Performance Research* 18, no. 5 (2013): 69–76, where the concept of kairotic coding is coined to address the specific mode of timing and timeliness operating within the diverse live coding practices specifically encountered by Cocker within the Arts and Humanities Research Council–funded project Live Notation: Transforming Matters of Performance (2012), as previously discussed.

62. Eric Charles White, *Kaironomia: On the Will to Invent* (Ithaca, NY: Cornell University Press, 1987), 14.

63. White, *Kaironomia*, 54–55.

64. As White notes, *kairos* has its origins in two different sources: archery, where it describes "an opening . . . through which the archer's arrow has to pass" and weaving, where there is "a 'critical time' when the weaver must draw the yarn through a gap that momentarily opens in the warp of the cloth being woven." White, *Kaironomia*, 13.

65. Stern, *Present Moment in Psychotherapy and Everyday Life*, 7.

66. Stern, *Present Moment in Psychotherapy and Everyday Life*, 7.

67. Antonio Negri, *Time for Revolution* (New York: Continuum, 2003), 152.

68. Antonio Negri, *Negri on Negri: Antonio Negri in Conversation with Anne Dufourmantelle* (London: Routledge, 2004), 104.

69. Simon O'Sullivan, *Art Encounters: Deleuze and Guattari, Thought beyond Representation* (London: Palgrave, 2006), 119.

70. O'Sullivan, *Art Encounters*, 122.

71. For an introduction to symmetry breaking, see Ian Stewart, *Fearful Symmetry: Is God a Geometer?* (Mineola, NY: Dover, 2010).

72. Grosz, *Becomings*, 3.

73. Grosz, *Becomings*, 11.

74. See François Hartog, *Regimes of Historicity: Presentism and Experiences of Time* (New York: Columbia University Press, 2015).

75. O'Sullivan, *Art Encounters*, 37.

76. See Emma Cocker, "What Now, What Next—Kairotic Coding and the Unfolding Future Seized," in "Improvisational Creativity," special issue, *Digital Creativity* 29, no. 1 (2018): 82–95.

77. See Tom Hall, "Towards a Slow Code Manifesto," *Ludions*, April 2007, <http://www.ludions.com/texts/2007a/>. Tom Hall, Julian Rohrer, and Renate Wieser initially promoted slow

code ideals as members of the Elementary Music Ensemble and later the Slow Code Library for SuperCollider.

78. As Adrian Heathfield states, where “duration nearly always involves the collapse of objective measure. Whether it is long or short in ‘clock time,’ its passage will be marked by a sense of the warping of time.” Adrian Heathfield, *Out of Time: The Lifeworks of Tehching Hsieh* (Cambridge, MA: MIT Press, 2009), 22.

79. Wolfgang Ernst, *Chronopoetics: The Temporal Being and Operativity of Technological Media* (London: Rowman and Littlefield, 2016), 63–95.

80. Ernst, *Chronopoetics*, 63.

81. Cf. our earlier comment on *temporal semantics*, fn. 42.

82. Ernst, *Chronopoetics*, 89.

83. See Bernard Stiegler, *La technique et le temps*, 3 vols. (Paris: Éditions Galilée, 1994–2001).

84. For Ernst, the critical difference is that media do not produce (discursive) cultural signs but rather (nondiscursive) technical signals, and in this way media can be understood as active “archaeologists” of knowledge. It is important to explain that Ernst takes his cue from the writings of Michel Foucault and his *Archaeology of Knowledge* (1969; repr., London: Routledge 2002) and from the various strands of German media theory associated with Friedrich Kittler, who developed a critique of Foucault for not taking seriously enough the ways in which media produce knowledge. That Ernst was trained as a historian is important for an appreciation of his particular take on media archaeology and his preference for Foucauldian epistemic ruptures: “As an alternative way of writing—or rather not writing—media history.” Anthony Enns, “Foreword: *Media History versus Media Archeology: German Media Theory and Wolfgang Ernst’s Chronopoetics*,” in Ernst, *Chronopoetics*, xviii.

85. Wolfgang Ernst, “Media Archaeography: Method and Machine versus History and Narrative of Media,” in *Media Archaeology: Approaches, Applications and Implications*, ed. Erkki Hutamo and Jussi Parikka (Berkeley: University of California Press, 2011), 239.

86. Ernst’s example is Fourier analysis in which the machine can be considered to be a better cultural analyst (or archaeologist) than the human. This knowledge can then be presented back to humans to enhance their understanding. When processing signals, such as sound waves, Fourier analysis can isolate narrowband components of a compound waveform, concentrating them for easier detection or removal.

87. Wolfgang Ernst, “. . . Else Loop Forever’: The Untimeliness of Media” (paper presented at Humboldt University, Berlin, 2009, <https://www.medientheorien.hu-berlin.de/de/medienwissenschaft/medientheorien/ernst-in-english/pdfs/medzeit-urbin-eng-ready.pdf>). Here, we also refer to Winnie Soon and Geoff Cox, “Infinite Loops,” in *Aesthetic Programming* (London: Open Humanities Press, 2020), 94–95.

88. Alan M. Turing, “On Computable Numbers, with an Application to the Entscheidungsproblem,” *Proceedings of the London Mathematical Society* 42 (1936/1937): 230–265.

89. “The end of history” is a concept that supposes that a particular political, economic, or social system may develop that would constitute the end point of human evolution and the final form of government. Among other references to Hegel and Marx, it is commonly associated with Francis Fukuyama’s *The End of History and the Last Man* (New York: Free Press, 1992), which argued for the triumph of Western liberal democracy, and as such the end of history, after 1989 (marking the fall of communism). Like Ernst, we happily contest this on technological and political grounds.

90. Rohrerhuber, “Algorithmic Music and the Philosophy of Time.”

91. Ernst, “Else Loop Forever.”

92. Ernst, “Else Loop Forever.”

93. Alan C. Kay, “The Early History of Smalltalk” (New York: Association for Computing Machinery, 1993), <http://gagne.homedns.org/~tgagne/contrib/EarlyHistoryST.html>. Publicly released in 1980 and developed through numerous iterations since 1971 by Alan Kay, Dan Ingalls, Adele Goldberg, Ted Kaehler, Diana Merry, Scott Wallace, Peter Deutsch, and Xerox PARC, in the context of ARPA (Advanced Research Projects Agency) in the US, Smalltalk has since informed the development of many other popular languages, such as Java, Python, and Ruby.

94. Although see, for example, the section on algorithmic pattern in chapter 4 for a more nuanced treatment of the algorithm.

95. Shintaro Miyazaki, “Algorhythmics: Understanding Micro-temporality in Computational Cultures,” *Computational Culture 2* (2012), <http://computationalculture.net/article/algorhythmics-understanding-micro-temporality-in-computational-cultures>.

96. Rogoff, “From Criticism to Critique to Criticality.” A key reference to the political potential of this can also be found in Walter Benjamin’s “On the Concept of History,” in vol. 4, *Selected Writings, 1938–1940*, ed. Howard Eiland and Michael W. Jennings (Cambridge, MA: Belknap Press, 1992).

97. Thus, to Fisher, we realize that we are listening not only to a “phonographic revenant, but also by introducing the technical frame, the material pre-condition of the recording, on the level of the content.” Fisher, “The Metaphysics of Crackle,” 49. Additionally, of course, this affords creative possibilities of working with the aesthetics of the crackle as a parallel to what we broadly argue is the case with live coding. The connection to temporality, or more specifically *contemporaneity*, has been developed in Geoff Cox, Ryan Nolan, and Andrew Prior, “The Crackle of Contemporaneity,” in *Futures of the Contemporary: Contemporaneity, Untimeliness, and Artistic Research*, ed. Paulo de Assis and Michael Schwab (Leuven, Belgium: Orpheus Institute Series-Leuven University Press, 2019), 97–114.

Chapter 7

1. In “Nicomachean Ethics” Aristotle outlines different types of thought including *technē* (productive knowledge, craft, art), *epistēmē* (theoretical or scientific knowledge), and *phronēsis* (prudence, practical wisdom), associating them, respectively, with the faculties of *poiesis* (making),

theoria (contemplation), and *praxis* (action). See “Nicomachean Ethics,” book 6, in *Western Philosophy: An Anthology*, ed. and trans. John Cottingham (Oxford: Blackwell, 3rd Edition, 2021). Of course, the words in the previous parentheses are only the closest denominators for the ancient Greek terms; there is no one-to-one mapping because what we understand as craft, art, or scientific knowledge today had a different meaning twenty-five hundred years ago. It is from the term *technē* that we get the words *technical*, *technique*, and *technology*. Although tracing the philosophical lineage of contested terms such as *technē* is beyond the scope of this book, some specific references are offered that help to consider the term *technē* in relation to live coding. Thor Magnusson questions the historical division between *technē* and *episteme* through exploration of the relation of technology and knowledge in *Sonic Writing: Technologies of Material, Symbolic and Signal Inscriptions* (London: Bloomsbury, 2019). Emma Cocker explores *technē* as a subversive, tactical knowledge in relation to live coding in “Weaving Codes/Coding Weaves: Penelopean Mētis and the Weaver-Coder’s Kairos,” 140. Cocker refers specifically to the work rhetoric scholar Janet Atwill, who draws on Aristotelian thought to explore *technē* as a particular mode of “knowing” or art capable of responding to situations that are contingent, shifting, or unpredictable in order to effect a change of balance or power by steering the direction of events through wily means rather than through force. See Janet Atwill, *Rhetoric Reclaimed: Aristotle and the Liberal Arts Tradition* (Ithaca, NY: Cornell University Press, 1998). See also Ben Spatz, *What a Body Can Do: Technique as Knowledge, Practice as Research* (London: Routledge, 2015), especially the section “A Selective Genealogy of Technique” (26–28), for an exploration of *technē* and technique.

2. See Elizabeth Fisher and Rebecca Forthum, *On Not Knowing: How Artists Think* (London: Black Dog, 2013).

3. For more on this, see M. Beatrice Fazi, *Contingent Computation: Abstraction, Experience, and Indeterminacy in Computational Aesthetics* (Lanham, MD: Rowman and Littlefield, 2018).

4. This echoes the argument in chapter 6 that technologies are not simply tools that shape meaning; rather, they are constitutive of meaning, rather like philosopher Bernard Stiegler’s point that our relation to time is constituted, or “mediated,” by the technical means through which it is apprehended. See Bernard Stiegler, *La technique et le temps*, 3 vols. (Paris: Éditions Galilée, 1994–2001).

5. Karen Barad states: “To be entangled is not simply to be intertwined with another, as in the joining of separate entities, but to lack an independent, self-contained existence. Existence is not an individual affair. Individuals do not preexist their interactions; rather, individuals emerge through and as part of their entangled intra-relating.” Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007), ix.

6. Philip E. Agre, “Toward a Critical Technical Practice: Lessons Learned in Trying to Reform AI,” in *Bridging the Great Divide: Social Science, Technical Systems, and Cooperative Work*, ed. Geof Bowker, Les Gasser, Leigh Star, and Bill Turner (Hillsdale, NJ: Erlbaum, 1997), 131–157.

7. For more on the relation between Agre and music technology, see Alan F. Blackwell, “Too Cool to Boogie: Craft, Culture and Critique in Computing,” in *Sound Work: Composition as Critical*

Technical Practice, ed. Jonathan Impett (Leuven, Belgium: Orpheus Institute Series—Leuven University Press, 2021), 15-33 and Georgina Born, “Diversifying MIR: Knowledge and Real-World Challenges, and New Interdisciplinary Futures,” *Transactions of the International Society for Music Information Retrieval* 3, no. 1 (2020): 193–204, <https://doi.org/10.5334/tismir.5>.

8. For instance, Herman Heine Goldstine and John Von Neumann, “Planning and Coding of Problems for an Electronic Computing Instrument” (Princeton, NJ: Institute for Advanced Study, 1947).

9. There are exceptions, of course; for example, Larry Cuba borrowed the Jet Propulsion Laboratory mainframe computer during the night when creating the computer graphic movie *First Fig* (1974). Cuba’s methods were in many ways live coding practice, where code could be written in real-time with real-time results.

10. Michael A. Cusumano, “The Software Factory: A Historical Interpretation,” *IEEE Software* 6, no. 2 (1989): 23–30, <http://doi.org/10.1109/MS.1989.10017>.

11. W. S. Humphrey, *Characterizing the Software Process: A Maturity Framework*. CMU/SEI-87-TR-11 (Pittsburgh: Carnegie Mellon University, Software Engineering Institute, 1987).

12. This disposability is indeed something that should be questioned in relation to the very large numbers of Raspberry Pi computers that were purchased out of enthusiasm for this UK success story but never used.

13. John Markoff, *What the Dormouse Said: How the 60s Counterculture Shaped the Personal Computer Industry* (London: Penguin, 2005). Markoff relates the work done in this lab to drug culture, psychedelic rock, and alternative spirituality. The title of Markoff’s book is a reference to a Jefferson Airplane lyric: “Remember what the Dormouse said Feed your head Feed your head.”

14. Alan C. Kay, “A Personal Computer for Children of All Ages,” in vol. 1, *Proceedings of the ACM Annual Conference* (New York: Association for Computing Machinery, 1972).

15. As noted in chapter 2, Smalltalk was a key inspiration in the evolution of the SuperCollider language involved in many live coding environments for music, as was the Simula language that inspired Smalltalk itself. In Smalltalk, “everything is an object,” including numbers, characters, or any other data types (e.g., musical notes or dance steps), and new methods can be created for any of these.

16. For the claimed invention of the icon, see David C. Smith, *Pygmalion: A Computer Program to Model and Stimulate Creative Thought* (Basel, Switzerland: Birkhauser, 1977). However, alternative claims have been made: see Alan F. Blackwell, “The Reification of Metaphor as a Design Tool,” *ACM Transactions on Computer-Human Interaction* 13, no. 4 (2006): 490–530.

17. See DynamicLand Foundation narrative, accessed March 15, 2022, <https://dynamicland.org/dynamicland-501c3-narrative.pdf>.

18. Ben Shneiderman, “Direct Manipulation: A Step beyond Programming Languages,” *Computer* 8 (1983): 57–69.

19. An illustrative example is the everyday use of wildcards in the IBM PC-DOS command line language. Most PC users were familiar with syntax such as “DEL *.BAK” to quickly remove large numbers of backup files—a quick and easy operation that otherwise requires tedious clicking and dragging to achieve the same effect in a GUI.
20. Douglas K. Smith and Robert C. Alexander, *Fumbling the Future: How Xerox Invented, Then Ignored, the First Personal Computer* (New York: William Morrow, 1988).
21. See chapter 4 for an account of the evolution of these various practices.
22. Kent Beck et al., *Manifesto for Agile Software Development*, 2001, <http://www.agilemanifesto.org>.
23. In fact, wiki was used in the early stages of live writing this book. See Alan Blackwell, Geoff Cox, and Sang Won Lee, “Live Writing the Live Coding Book” (paper presented at the International Conference on Live Coding 2016, McMaster University, Hamilton, Canada), <http://iclc.toplap.org/2016/papers.html>.
24. Bo Leuf and Ward Cunningham, *The Wiki Way: Quick Collaboration on the Web* (Boston: Addison-Wesley, 2001).
25. Christopher Alexander, *A Pattern Language: Towns, Buildings, Construction* (Oxford: Oxford University Press, 1977).
26. Alan F. Blackwell and Sally Fincher, “PUX: Patterns of User Experience,” *Interactions* 17 (2010): 27–31.
27. Free Software Foundation (website), accessed March 12, 2022, <https://www.fsf.org>.
28. Performing music using the Linux bash shell was indeed a topic at the Changing Grammars symposium where TOPLAP was founded, as described in chapter 2.
29. Eric Raymond, “The Cathedral and the Bazaar,” *Knowledge, Technology and Policy* 12 (1999): 23–49. Raymond refers to changes within the open-source movement, in which the “Cathedral” practitioners were the first generation of open-source campaigners, reflecting academic and institutional authority rather than what we now recognize as self-organizing online communities.
30. See LIVE: Workshop on Live programming, accessed March 15, 2022, <http://liveprog.org> and <http://liveprogramming.github.io/2013/>, for the series of workshops that followed an initial meeting in 2013.
31. Daniel Cardoso Llach, “Software Comes to Matter: Toward a Material History of Computational Design,” *Design Issues* 31 (2015): 41–54.
32. Kate Crawford, *Atlas of AI* (New Haven, CT: Yale University Press, 2021); Kate Crawford and Vladan Joler, *Anatomy of an AI System: The Amazon Echo as an Anatomical Map of Human Labor, Data and Planetary Resources*, AI Now Institute and Share Lab, September 7, 2018, <https://anatomyof.ai>.
33. See chapter 2 for details on the TOPLAP manifesto (2004).
34. Alex McLean notes that this particular statement is likely to have been written by Julian Rohrhuber, following his contribution to the discussion around the drafting of the manifesto:

"I would suggest not to use tools at all, or not to see algorithms as tools at least." Julian Rohrhuber, TOPLAP mailing list, February 24, 2004, <https://toplap.org/archive/livecode.txt>.

35. Mikael Wiberg, "Methodology for Materiality: Interaction Design Research through a Material Lens," *Personal and Ubiquitous Computing* 18 (2013): 1–12.

36. In the form of cardiac pacemakers and cochlear implants. Many other devices are likely to follow.

37. For example, the dog microchip registration scheme mandated by the UK government.

38. Alan F. Blackwell et al., "Tangible User Interfaces in Context and Theory," In *CHI '07 Extended Abstracts on Human Factors in Computing Systems (CHI EA '07)*. (New York: Association for Computing Machinery, 2007), 2817–2820.

39. Nicolai B. Hansen, Rikke Toft Nørgård, and Kim Halskov, "Crafting Code at the Demo-Scene," in *Proceedings of the ACM Conference on Designing Interactive Systems* (New York: Association for Computing Machinery, 2014), 35–38.

40. Donald A. Schön, *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1983).

41. Shad Gross, Jeffrey Bardzell, and Shaowen Bardzell, "Structures, Forms, and Stuff: The Materiality and Medium of Interaction," *Personal and Ubiquitous Computing* 18, no. 3 (2014): 637–649. It can also be seen in relation to a wider material turn within the social sciences and humanities, reflected in the discourse of new materialism, object-oriented ontology, and speculative realism, for example, in the work of thinkers such as Tim Ingold ("Materials against Materiality," *Archaeological Dialogues* 14, no. 1 (2007): 1–16; Bruno Latour (actor-network theory); Jane Bennett (*Vibrant Matter: A Political Ecology of Things*, 2009), Graham Harman (*Object-Oriented Ontology: A New Theory of Everything*, 2018; *Speculative Realism: An Introduction*, 2018). See also Diana Coole and Samantha Frost, eds., *New Materialisms: Ontology, Agency, and Politics* (Durham, NC: Duke University Press, 2010).

42. Alan F. Blackwell, Marian Petre, and Luke Church, "Fifty Years of the Psychology of Programming," *International Journal of Human-Computer Studies* 131 (2019): 52–63.

43. Schön, *Reflective Practitioner*.

44. Andrew Pickering, *The Mangle of Practice: Time, Agency and Science* (Chicago: University of Chicago Press, 1995).

45. Malcolm McCullough, *Abstracting Craft: The Practiced Digital Hand* (Cambridge, MA: MIT Press, 1998).

46. Gross, Bardzell, and Bardzell, "Structures, Forms, and Stuff."

47. See also Graham Harman, *Immaterialism: Objects and Social Theory* (Cambridge: Polity Press, 2016).

48. Richard Sennett, *The Craftsman* (New Haven, CT: Yale University Press, 2008).

49. See Software Carpentry, home page, accessed March 12, 2022, <https://software-carpentry.org>. This is a reference to the Software Craftsmanship Manifesto, 2009, <http://manifesto.softwarecraftsmanship.org>.
50. The demoscene and live coding communities have had surprisingly little overlap despite the former holding closely related activities of live coding “shader” competitions onstage and in front of very large audiences. A recent exception is the Parisian Cookie Collective, well known in the demoscene and actively hosting algoraves, although their events focus on live coding of video rather than music.
51. Hansen, Nørgård, and Halskov, “Crafting Code at the Demo-Scene,” 35–38. Note that members of the community prefer the typography *demoscene*, and despite the title of the publication by Hansen et al., the text of that paper uses both forms. Here we use the form preferred by the community itself.
52. Tim Ingold, “The Textility of Making,” *Cambridge Journal of Econometrics* 34 (2010): 91–102.
53. Tim Ingold, *Making: Anthropology, Archaeology, Art and Architecture* (London: Routledge, 2013).
54. Ingold, *Making*, 6
55. Ingold, *Making*, 6–7.
56. Deleuze and Guattari state,
 A distinction must be made between two types of science, or scientific-procedures: one consists in “reproducing,” the other in “following.” The first involves reproduction, iteration and reiteration; the other, involving iteration, is the sum of the itinerant, ambulant sciences. Iteration is too readily reduced to a modality of technology, or of the application and verification of science. But this is not the case: following is no, at all the same thing as reproducing, and one never follows in order to reproduce. (“Treatise on Nomadology—the War Machine,” in *A Thousand Plateaus: Capitalism and Schizophrenia*, trans. Brian Massumi (New York: Continuum, 1987), 372.
57. Ingold’s notion of textility is also referred to in chapter 4.
58. See Ingold, “Materials against Materiality,” 1–16. See also Alfred Gell, *Art and Agency: An Anthropological Theory* (Oxford: Oxford University Press, 1998).
59. Paul Klee, *Pedagogical Sketchbook* (New York: Frederick A. Praeger, 1953).
60. To Florian Cramer, La Monte Young’s *Composition* (1961) provides an example of (noncomputer) software art in which the instruction is unambiguous enough to be executed by a machine. See Cramer’s “Concepts, Notations, Software, Art,” *Netzliteratur*, March 23, 2002, https://www.netzliteratur.net/cramer/concepts_notations_software_art.html. A number of 2008 code-based implementations of this work, including by early live coders Amy Alexander and Dave Griffiths, are archived under <https://web.archive.org/web/20080825030910/http://instructionset.org/instruction/4/>.
61. Rikard Lindell, “Crafting Interaction: The Epistemology of Modern Programming,” *Personal and Ubiquitous Computing* 18 (2014): 613–624.
62. Simon Schaffer, “Babbage’s Intelligence: Calculating Engines and the Factory System,” *Critical Inquiry* 21, no. 1 (1994): 203–227.

63. Tony (C. A. R.) Hoare and Charles Antony Richard, "An Axiomatic Basis for Computer Programming," *Communications of the ACM* 12, no. 10 (1969): 576–580.
64. Edsger W. Dijkstra, "Programming: From Craft to Scientific Discipline," in *Proceedings of the International Computing Symposium*, 23–30 (Liege, Belgium, 1977). Amsterdam; New York: North-Holland, 1977.
65. See Lucy Suchman, *Human-Machine Reconfigurations: Plans and Situated Actions* (Cambridge: Cambridge University Press, 2007), as well as Paul Dourish, *Where the Action Is: The Foundations of Embodied Interaction* (Cambridge, MA: MIT Press, 2004).
66. Ursula Franklin, *The Real World of Technology*, 2nd ed. (Toronto: House of Anansi Press, 1999).
67. Lindell, "Crafting Interaction."
68. Perhaps this is completely appropriate in an information economy and media society where so many products and commodities have also become insubstantial—for example, audio streams, image files, and electronic books—and email has replaced records, photographs, books, and letters.
69. As discussed in chapter 4 in the section on "Dynamics of Machine Notations." See also Alan F. Blackwell, "Patterns of User Experience in Performance Programming," in *Proceedings of the First International Conference on Live Coding*, 2015, Geneva, Switzerland: Zenodo/CERN, <http://doi.org/10.5281/zenodo.19315>.
70. Ilias Bergström and Alan F. Blackwell, "The Practices of Programming," in *Proceedings of IEEE Visual Languages and Human-Centric Computing* (Piscataway, NJ: Institute of Electrical and Electronics Engineers), 190–198, https://www.researchgate.net/publication/308540044_The_Practices_of_Programming
71. See Bengt Molander, *The Practice of Knowing and Knowing in Practices* (Frankfurt: Peter Lang, 2015).
72. The difference between "knowing that" and "knowing how" is explored by Gilbert Ryle in *The Concept of the Mind* (1949; repr., Harmondsworth, UK: Penguin 1973), which was in turn preceded by Ryle's "Knowing How and Knowing That: The Presidential Address," in *Proceedings of the Aristotelian Society* (Oxford: Oxford University Press, 1945–1946). Ryle's formulation is re-evaluated, debated, and contested in John Bengson and Marc A. Moffett, eds., *Knowing How: Essays on Knowledge, Mind and Action* (New York: Oxford University Press, 2011). On "knowing how," see also Bengt Molander, *Practice of Knowing and Knowing in Practices*.
73. See Henk Borgdorff, "The Production of Knowledge in Artistic Research," in *The Conflict of the Faculties: Perspectives on Artistic Research and Academia* (Leiden: Leiden University Press, 2012), 140–173.
74. See Henk Borgdorff, Peter Peters, and Trevor Pinch, eds., *Dialogues between Artistic Research and Science and Technology Studies*, Routledge Advances in Art and Visual Studies (London: Routledge, 2019).
75. Robin Nelson, *Practice as Research in the Arts: Principles, Protocols, Pedagogies, Resistances* (New York: Palgrave Macmillan, 2013), 37.

76. Schön, *Reflective Practitioner*.
77. Michael Polanyi, *The Tacit Dimension* (Gloucester, MA: Peter Smith, 1983).
78. Francisco Varela, Evan Thompson, and Eleanor Rosch, *The Embodied Mind: Cognitive Science and Human Experience* (Cambridge, MA: MIT Press, 1993); Alva Noë, *Action in Perception* (Cambridge, MA: MIT Press, 2004).
79. Nelson, *Practice as Research*, 43.
80. Dorothy Leonard and Sylvia Sensiper, "The Role of Tacit Knowledge in Group Innovation," *California Management Review* 40 (1998): 113, cited in Nelson, *Practice as Research*, 38.
81. Bergström and Blackwell, "Practices of Programming."
82. See Jessica Jacobs, "Intersections in Design Thinking and Art Thinking: Towards Interdisciplinary Innovation," *Creativity: Theories, Research, Applications* 5, no. 1 (2018): 4–25.
83. Emma Cocker, "Weaving Codes/Coding Weaves: Penelopean Mêtis and the Weaver-coder's Kairos," *Textile: Journal of Cloth and Culture* 15, no. 2 (2017): 124–141.
84. Erin Manning and Brian Massumi, *Thought in the Act: Passages in the Ecology of Experience* (Minneapolis: University of Minnesota Press, 2014), 41.
85. Manning and Massumi, *Thought in the Act*, 43–44.
86. Dieter Mersch, *Epistemologies of Aesthetics*, trans. Laura Radosh (Zurich: Think Art Diaphanes, 2015), 52.
87. Mersch, *Epistemologies of Aesthetics*, 53–54.
88. See also chapter 5 for a discussion on how live coding performance has the capacity to inaugurate "temporary communities," to borrow Miwon Kwon's phrase.
89. *Détournement*, meaning "rerouting, hijacking," is a technique developed in the 1950s by the Letterist International and adapted by the Situationist International. The principle of *détournement* or of *détourning* involves appropriating or altering an existing practice or artifact (especially the practices and products of capitalism) to give it a new subversive meaning or revolutionary significance.
90. Sarat Maharaj, "Know-How and No-How: Stopgap Notes on 'Method' in Visual Art as Knowledge Production," *Art and Research* 2, no. 2 (2009), <http://www.artandresearch.org.uk/v2n2/maharaj.html>.
91. Elizabeth Fisher and Rebecca Fortnum, eds., *On Not Knowing: How Artists Think* (London: Black Dog, 2013), 7.
92. Fisher and Fortnum, *On Not Knowing*, 7. See also Emma Cocker, "Tactics for Not Knowing: Preparing for the Unexpected," in Fisher and Fortnum, *On Not Knowing*, 126–135.
93. The epistemological significance of improvisation has indeed been of long interest within many disciplines, especially within both music and choreography, two fields of practice that are

embraced by and have in turn contributed to and informed the development of live coding. See Ann Cooper-Albright and David Gere, eds., *Taken by Surprise: A Dance Improvisation Reader* (Middletown, CT: Wesleyan University Press, 2003) including the section “Improvising Body, Improvising Mind”, 3–40. See also “Improvisational Creativity,” special issue, *Journal of Digital Creativity* 29, no. 1 (2018); Mark J. Butler, *Playing with Something That Runs: Technology, Improvisation and Composition in DJ and Laptop Performance* (Oxford: Oxford University Press, 2014).

94. Roger Caillois, *Man, Play and Culture*, trans. Meyer Barash (1958; repr., Champaign: University of Illinois Press, 2001), 5–6. David Graeber’s analysis of play is further explored in chapter 8. See David Graeber, *The Utopia of Rules: On Technology, Stupidity, and the Secret Joys of Bureaucracy* (Brooklyn, NY: Melville House, 2015).

95. Caillois, *Man, Play and Culture*, 5.

96. Instead of creating and preserving individual works, live coding continually produces new works, sharing them in the same way that love is shared: the more you share love, the more value it holds. Indeed, online live coding events are therefore not carefully curated for consumption but are open celebrations of production en masse. Anyone can perform during streamed events that can last over eighty hours nonstop, crossing the world’s time zones. These events have left behind an archive of thousands of performances that would take many weeks to view, by which time a new event might well have taken place. See Mark Fisher, *K-PUNK* (blog), May 11, 2015, <https://k-punk.org/abandon-hope-summer-is-coming/>

97. Paolo Virno, *When the Word Becomes Flesh: Language and Human Nature* (South Pasadena, CA: Semiotext(e), 2015), 22.

98. Mersch, *Epistemologies of Aesthetics*, 26.

99. Mersch, *Epistemologies of Aesthetics*, 26

100. Dieter Mersch, “Aesthetic Thinking: Art as Theōria,” in *Aesthetic Theory*, ed. Dieter Mersch, Sylvia Sasse, and Sandro Zanetti, trans. Brian Alkire (Zurich: Think Art Diaphanes, 2019), 219–236. See also the research project Practices of Aesthetic Thinking: A Sinergia project of the Swiss National Science Foundation, January 2, 2017–February 28, 2021, <https://sinergia-pat.ch/>. See also Alex Arteaga, “Embodied and Situated Aesthetics,” *Artnodes*, (2017): 20–27, which is a reformulation of his lecture “Understanding: On the Cognitive Function of Aesthetic Practices” at the Questioning Aesthetics symposium, Art Research and Aesthetics, Barcelona, June 20–22, 2017.

101. Mersch, “Aesthetic Thinking,” 219–220.

102. Mara Ambrožič and Angela Vettese, eds., *Art as a Thinking Process: Visual Forms of Knowledge Production* (Berlin: Sternberg Press, 2013), 8.

103. Mersch, *Epistemologies of Aesthetics*, 8.

104. Mersch, *Epistemologies of Aesthetics*, 9.

105. Mersch, *Epistemologies of Aesthetics*, 9–10.

106. Mersch, *Epistemologies of Aesthetics*, 9–10.
107. Mersch, *Epistemologies of Aesthetics*, 11.
108. Mersch, *Epistemologies of Aesthetics*, 11.
109. Mersch, *Epistemologies of Aesthetics*, 52.
110. Manning and Massumi, *Thought in the Act*, vii.
111. Manning and Massumi, *Thought in the Act*.
112. Debra Hawhee, *Bodily Arts: Rhetoric and Athletics in Ancient Greece* (Austin: University of Texas Press, 2004), 75. On *loom-thinking*, see Janis Jeffries, “Textiles: What Can She Know?,” in *Feminist Visual Culture*, ed. Fiona Carson and Claire Pajaczkowska (New York: Routledge, 2001), 189–207. As stated in chapter 4, see Sadie Plant’s statement, “The computer emerges out of the history of weaving. . . . The loom is the vanguard site of software development” and more in “The Future Looms: Weaving Women and Cybernetics,” *Body and Society* 1, no. 3–4 (1995): 46. Several recent projects have drawn “threads” between the work of Bauhaus weaver Anni Albers (1899–1994) and coding—for example, Conductive Coding, an e-textiles weaving workshop led by Emilie Giles and Sarah Wiseman at Tate Modern (2019) in response to the Albers’s retrospective. See also Anni Albers, *On Weaving* (Middletown, CT: Wesleyan University Press, 1965).
113. Cocker, “Weaving Codes/Coding Weaves,” 124–141.
114. For example, see Ellen Harlizius-Klück, “Weaving as Binary Art and the Algebra of Patterns,” in Harlizius-Klück, Ellen, in collaboration with Alex McLean, eds., “Weaving Codes, Coding Weaves,” special issue, *Textile: Journal of Cloth and Culture* 15, no. 2 (2017).
115. Led by Ellen Harlizius-Klück in collaboration with Alex McLean. For the project outline, see “A Study of Weaving as Technical Mode of Existence, Cordis, last modified December 27, 2021, <https://cordis.europa.eu/project/rcn/206885/factsheet/es>.
116. Maharaj, *Know-How and No-How*. See also Sarat Maharaj, “What the Thunder Said: Toward a Scouting Report on ‘Art as a Thinking Process,’” in Ambrožič and Vettese, *Art as a Thinking Process*, 154–160.
117. See Michel Foucault, *Power/Knowledge* (New York: Pantheon, 1980).
118. For an overview of some of these postcognitivist approaches, see Simon Penny, *Making Sense, Cognition, Computing, Art and Embodiment* (Cambridge, MA: MIT Press, 2017).
119. Alan Turing, “On Computable Numbers, with an Application to the Entscheidungs Problem,” *Proceedings of the London Mathematical Society* 2, no. 1 (1937): 230–265.
120. Luciana Parisi, “Reprogramming Decisionism,” *e-flux* 85 (October 2017), <https://www.e-flux.com/journal/85/155472/reprogramming-decisionism/>.
121. Parisi, “Reprogramming Decisionism.”
122. Michel Foucault, *Archaeology of Knowledge* (New York: Pantheon Books, 1972).

123. Wolfgang Ernst, *Digital Memory and the Archive*, ed. Jussi Parikka, Electronic Mediations no. 39 (Minneapolis: University of Minnesota Press, 2011), 239.
124. Geoff Cox, "What Does Live Coding Know?," in *Proceedings of the First International Conference on Live Coding* (Leeds: University of Leeds, 2015).
125. Barad, *Meeting the Universe Halfway*.
126. Foucault indicates that an apparatus (*dispositif* in French) is a network or system of relations between entities, such as "discourses, institutions, architectural forms, regulatory decisions, laws, administrative measures, scientific statements, philosophical, moral, and philanthropic propositions." Michel Foucault, "The Confession of the Flesh," in *Power/Knowledge: Selected Interviews and Other Writings*, ed. Colin Gordon (New York: Pantheon, 1980), 194–228.
127. Barad, *Meeting the Universe Halfway*, 98.
128. See Geoff Cox and Alex McLean, *Speaking Code, Coding as Aesthetic and Political Expression* (Cambridge, MA: MIT Press, 2013), 35.
129. To explain, in brief, Heisenberg's uncertainty principle asserts that one cannot precisely know both position *and* momentum, but position *or* momentum *can* be known.
130. Barad, *Meeting the Universe Halfway*, 19.
131. Barad, *Meeting the Universe Halfway*, 198–199.
132. Barad. *Meeting the Universe Halfway*, 200.
133. Parisi, "Reprogramming Decisionism." We might also refer, as Parisi does, to N. Katherine Hayles's *nonconscious cognition*, which challenges anthropocentrism in favor of a coevolutionary cognitive infrastructure where machines do not passively adapt to data retrieved but instead establish new patterns of meaning by aggregating, matching, and selecting data (they learn). See N. Katherine Hayles, *Unthought: The Power of the Cognitive Nonconscious* (Chicago: University of Chicago Press, 2017).

Chapter 8

1. Here we reference, for instance, Kevin Kelly, *What Technology Wants* (New York: Viking Press, 2010), in which he suggests technology is a living organism, although it is worth saying that artificial life is outside our scope of interest for this book. See also W. J. T. Mitchell, "What Do Pictures 'Really' Want?," *October* 77 (Summer 1996): 71–82.
2. Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007), ix.
3. See chapter 2 on the emergence of algorave; see also Iman Amrani, "Run the Code: Is Algorave the Future of Dance Music?," *Guardian*, November 30, 2017, <https://www.theguardian.com/music/2017/nov/30/is-algorave-the-future-of-dance-music-sheffield-algomech-festival>; and *Resident Advisor's* "Algorave Generation," 2019, <https://ra.co/features/3396>.

4. The term *rave* is associated with the so-called acid movement developed through secret and underground venues and warehouse and street parties, as well as the use of pirate radio stations.
5. For more on the roots of rave, including the queer and Black politics underpinning Chicago house and Detroit techno, see Simon Reynolds, *Energy Flash* (London: Faber and Faber, 2013).
6. Shintaro Miyazaki, "Algorhythmics: Understanding Micro-temporality in Computational Cultures," *Computational Culture* 2 (2012), <http://computationalculture.net/article/algorhythmics-understanding-micro-temporality-in-computational-cultures>.
7. Adrian Mackenzie, "The Production of Prediction: What Does Machine Learning Want?," *European Journal of Cultural Studies* 18, no. 4–5 (2015): 429–445.
8. Here we are reminded of a passage in Marx's *Capital*, in which he asks what commodities would say if they could speak, which would be for them to emphasize their exchange value over use value. See "The Commodity," Marxists Internet Archive, n.d., <https://www.marxists.org/archive/marx/works/1867-c1/commodity.htm>; see also David Cunningham, "If Commodities Could Speak," Fotomuseum Winterthur, September 7, 2016, https://www.fotomuseum.ch/en/explore/still-searching/articles/29094_if_commodities_could_speak.
9. Mackenzie, "Production of Prediction," 431–432.
10. Mackenzie makes a useful intervention with regard to our understanding of the key terms: "We cannot conduct critical enquiry into how calculation will automate future decisions without putting the notions of calculation and automation into question." Adrian Mackenzie, *Machine Learners: Archaeology of a Data Practice* (Cambridge, MA: MIT Press 2017), 8.
11. Alan F. Blackwell, "Objective Functions: (In) Humanity and Inequity in Artificial Intelligence," *HAU: Journal of Ethnographic Theory* 9, no. 1 (2019): 137–146.
12. Mackenzie, "Production of Prediction," 433.
13. Echoing Giorgio Agamben's *Means without Ends: Notes on Politics* (Minneapolis: University of Minnesota Press, 2000). This was previously applied to live coding in Geoff Cox's "Means-End of Software," in *Interface Criticism: Aesthetics beyond Buttons*, ed. Christian Ulrik Andersen and Søren Pold (Aarhus, Denmark: Aarhus University Press, 2011), 145–161.
14. The metaphor of infrastructural undermining as a subversive cultural act might trace speculative connections from the event described in chapter 2, where Alex McLean and Adrian Ward shouted their "Generative Manifesto" over algorithmic beats at London's Institute of Contemporary Arts, to the notorious event at the same venue on January 3, 1984, when post-punk band Einstürzende Neubauten's performance of *Concerto for Voice and Machinery* saw the band drilling through the stage, supposedly to access a system of tunnels heading under the Mall to Buckingham Palace. The otherwise unexplained reference to chainsaws in the TOPLAP manifesto is perhaps an evocation of the destructive capacity that is inherent in powerful tools.
15. Niklaus Wirth's 1975 formulation that "algorithms+data structures=programs" is cited in Paul Dourish, "Algorithms and Their Others: Algorithmic Culture in Context," *Big Data and Society* 3, no. 2 (August 2016), <https://journals.sagepub.com/doi/full/10.1177/2053951716665128>.

16. Andrew Goffey, "Algorithm," in *Software Studies: A Lexicon*, ed. Matthew Fuller (Cambridge, MA: MIT Press, 2008), 21–30.
17. David Graeber, *The Utopia of Rules: On Technology, Stupidity, and the Secret Joys of Bureaucracy* (Brooklyn, NY: Melville House, 2015).
18. A bellwether of this anxiety was the revelation of the personalized political campaigning associated with psychographic services company Cambridge Analytica in its contributions to the Libertarian maneuvering of the Trump election and Brexit campaigns.
19. A newspaper headline that appears to have been bowdlerized from the actual protest chant "Fuck the algorithm," as heard in video from the event uploaded to Twitter, August 16, 2020: <https://twitter.com/i/status/1294985562106015750>.
20. Louise Amoore, "Why 'Ditch the Algorithm' Is the Future of Political Protest," *Guardian*, August 19, 2020, <https://www.theguardian.com/commentisfree/2020/aug/19/ditch-the-algorithm-generation-students-a-levels-politics>.
21. Jacques Attali, *Noise: The Political Economy of Music* (Minneapolis: University of Minnesota Press, 1985).
22. Cargo Collective, accessed March 15, 2022, <http://cargocollective.com/onfcopoe/>; Kate Sicchio, Zeshan Wang, and Marissa Forbes, "Live Coding Tools for Choreography: Creating Terpsicode," in *Proceedings of the 2020 International Conference on Live Coding* (Limerick, Ireland: University of Limerick, 2020), <https://doi.org/10.5281/zenodo.3939135>.
23. See the multiday streams archived at Eulerroom, YouTube video, accessed March 15, 2022, <https://www.youtube.com/c/Eulerroom/playlists> and the muxy software developed to coordinate with them at GitHub, <https://github.com/munshkr/muxy>.
24. Alex Taylor, "Data, (Bio)sensing and (Other-)Worldly Stories from the Cycle Routes of London," in *Quantified: Biosensing in Everyday Life*, ed. Dawn Nafus (Cambridge, MA: MIT Press, 2016).
25. Shoshana Zuboff, *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power* (New York: PublicAffairs, 2019).
26. Matteo Pasquinelli, "Google's PageRank Algorithm: A Diagram of Cognitive Capitalism and the Rentier of the Common Intellect," in *Deep Search*, ed. Konrad Becker and Felix Stalder (London: Transaction, 2009). For more on the politics of search, related to race in particular, see Safiya Umoja Noble, *Algorithms of Oppression: How Search Engines Reinforce Racism* (New York: New York University Press, 2018).
27. See Alan F. Blackwell, "Objective Functions: (In)humanity and Inequity in Artificial Intelligence," *HAU: Journal of Ethnographic Theory* 9, no. 1 (2019): 137–146.
28. Martin Scherzinger, "The Political Economy of Streaming," in *The Cambridge Companion to Music in Digital Culture*, ed. Nicholas Cook, Monique M. Ingalls, and David Trippett (Cambridge: Cambridge University Press, 2019), 274–297.

29. The contemporary interest in the Luddites comes as no surprise given the alienating effects of AI automation. See, for instance, Miriam A. Cherry's "The Future Encyclopedia of Luddism," *MIT Press Reader*, January 19, 2021, <https://thereader.mitpress.mit.edu/the-future-encyclopedia-of-luddism/>.

30. For further discussion of live coding as a Luddite movement, see Alex McLean, Giovanni Fanfani, and Ellen Harlizius-Klück, "Cyclic Patterns of Movement across Weaving, Epiplokē and Live Coding," *Dancecult: Journal of Electronic Dance Music Culture* 10, no. 1 (2018): 5–30, <http://dx.doi.org/10.12801/1947-5403.2018.10.01.01>.

31. Such conversational dynamics between coder and machine reach back to figures as diverse as Gordon Pask, David Tudor, Alan Kay, or Richard Stallman (in his original work on the Emacs editor). The reconfiguration of interactive computing and electronics, as the West emerged from the Cold War era, can be seen as a reaction against the adoption of cybernetic theory in the infrastructure, bureaucracies, and government apparatus of the military industrial complex.

32. See, for example, Jacob Austin et al., "Program Synthesis with Large Language Models," 2021, arXiv:2108.07732. These developing technologies correspond to the liveness levels 5 and 6 proposed by Steve Tanimoto and discussed earlier in chapter 5. See Steven L. Tanimoto, "A Perspective on the Evolution of Live Programming," in *Proceedings of the 1st International Workshop on Live Programming* (New York: Institute for Electrical and Electronics Engineers, 2013), 31–34.

33. See *Sema: A Playground for Livecoding Music and AI*, University of Sussex, 2021–2022, <https://www.sema.codes>.

34. This project was funded as part of the LINK Master's program in Germany during 2021 and 2022 and led by etextile artist and designer Mika Satomi, live coders Elizabeth Wilson and Alex McLean, choreographer Deva Schubert, and performance artist Juan Felipe Amaya Gonzalez, originally instigated with Berit Greinke.

35. Richard Harper, ed., *Inside the Smart Home* (Berlin: Springer, 2006).

36. This is the research focus of Magnusson's Intelligent Instruments research project at *Sonic Writing* (blog), December 9, 2020, <http://www.sonicwriting.org/blog/intent>. See also Intelligent Instruments Lab, Reykjavik, 2021–2022, <http://www.iil.is>.

37. Some of these experiences have been anticipated in configurable software systems such as the Emacs editor, which became notorious for the irritating experience of you sitting at another user's terminal to find that they had installed a "key-binding" configuration file different from your own habits, with the computer becoming unpredictable or even unusable as a result.

38. Lianne Bainbridge, "Ironies of Automation," *Automatica* 19, no. 6 (1983): 775–779.

39. Here we again reference Franklin's dichotomy between prescriptive and holistic technology. Ursula Franklin, *The Real World of Technology*, 2nd ed. (Toronto: House of Anansi Press, 1999).

40. Philip E. Agre, "Toward a Critical Technical Practice: Lessons Learned in Trying to Reform AI," in *Bridging the Great Divide: Social Science, Technical Systems, and Cooperative Work*, ed. Geof Bowker, Les Gasser, Leigh Star, and Bill Turner (Hillsdale, NJ: Erlbaum, 1997), 131–157.

41. This is broadly what Walter D. Mignolo argues in his “Foreword: On Pluriversality and Multipolarity,” in *Constructing the Pluriverse: The Geopolitics of Knowledge*, ed. Bernd Reiter (Durham, NC: Duke University Press, 2018), x: “Together, epistemology and hermeneutics prevent the possibility of pluriversality, with all its internal diversity, and close off ways of thinking and doing that are not grounded in Western cosmology.” We already hinted at this at the end of chapter 7.

42. Christopher M. Kelty, “Culture’s Open Sources: Software, Copyright, and Cultural Critique,” *Anthropological Quarterly* 77, no. 3 (2004): 499–506. European public resistance to the corporate controls being introduced in the US Digital Millennium Copyright Act coalesced in events such as a 2001 conference, convened by the Arts Council of England with the Academia Europaea, on Collaboration and Ownership in the Digital Economy, at which Kelty was joined both by arts activists, such as Florian Cramer and Geert Lovink, alongside legal, policy, and business innovators James Boyle, Richard Stallman, Bruce Perens, and Rishab Ghosh. See Rishab A. Ghosh, ed., *Code: Collaborative Ownership and the Digital Economy* (Cambridge, MA: MIT Press, 2006).

43. Mackenzie, *Machine Learners*, 23, 27. His example is TensorFlow, accessed March 15, 2022, <https://www.tensorflow.org/>, originally developed by researchers and engineers from the Google Brain team within Google’s AI organization, which comes with extensive support and has wide application across multiple domains and disciplines. We would cite examples from the live coding community that also have extensive communities built around them, such as TidalCycles and Sonic Pi.

44. See the paradoxical notion of *inclusive exclusion* in Giorgio Agamben, *Homo Sacer: Sovereign Power and Bare Life* (Stanford, CA: Stanford University Press, 1998).

45. Dawn Nafus, James Leach, and Bernhard Krieger, “Gender: Integrated Report of Findings,” *FLOSSPOOLS, Deliverable D 16* (March 2006), https://www.researchgate.net/publication/264799720_FLOSSPOOLS_Deliverable_D_16_Gender_Integrated_Report_of_Findings.

46. Linda Tuhiwai Smith, *Decolonizing Methodologies: Research and Indigenous Peoples* (London: Zed Books, 2012), 221.

47. Paulin J. Hountondji, “Scientific Dependence in Africa Today,” *Research in African Literatures* 21, no. 3 (1990): 5–15.

48. Pernille Bjørn, Anne-Marie Søderberg, and S. Krishna, “Translocality in Global Software Development: The Dark Side of Global Agile,” *Human-Computer Interaction* 34, no. 2 (2019): 174–203.

49. As so importantly observed in Eve Tuck and K. Wayne Yang, “Decolonization Is Not a Metaphor,” *Decolonization: Indigeneity, Education and Society* 1, no. 1 (2012): 1–40.

50. Cited in Smith, *Decolonizing Methodologies*, 25.

51. Lilly Irani, Janet Vertesi, Paul Dourish, Kavita Philip, and Rebecca E. Grinter, “Postcolonial Computing: A Lens on Design and Development,” in *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI)*, Atlanta, Georgia, April 10–15, 2010, 1311–1320. (New York: Association for Computing Machinery, 2010.)

52. Geoffrey C. Bowker and Susan Leigh Star, *Sorting Things Out: Classification and Its Consequences* (Cambridge, MA: MIT Press), 1999.
53. Kavita Philip, Lilly Irani, and Paul Dourish, "Postcolonial Computing: A Tactical Survey," *Science, Technology and Human Values* 37, no. 1 (2012): 3–29.
54. Kate Crawford and Vladen Joler, "Anatomy of an AI System: The Amazon Echo as an Anatomical Map of Human Labor, Data and Planetary Resources," AI Now Institute and Share Lab, September 7, 2018, <https://anatomyof.ai/>.
55. Kate Crawford, *Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence* (New Haven, CT: Yale University Press, 2021).
56. See Evans Augustt, YouTube channel, 2020–21, <https://www.youtube.com/channel/UCVi-EuhS951316RirfLYwqg>.
57. Danielle Stein and Craig Valters, "Understanding Theory of Change in International Development," JSRP Paper 1 (London: London School of Economics, 2012), <http://eprints.lse.ac.uk/id/eprint/56359>.
58. Georges Perec, *Life: A User's Manual*, trans. David Bellos (London: Harvill Press, 1996); originally published in 1978, in French, with the title *La Vie mode d'emploi*.
59. Lialina, "Turing Complete User."
60. Lialina, "Turing Complete User."
61. Lialina notes that "the notion of the Invisible User is pushed by influential user interface designers, specifically by Don Norman a guru of user friendly design and long time advocate of invisible computing. He can be actually called the father of Invisible Computing."
62. Lialina, "Turing Complete User."
63. Gilles Deleuze, "Postscript on Control Societies," *Negotiations* (New York: Columbia University Press, 1995), 177–182.
64. We again borrow the terms *entanglement* and *intrarelate* from Barad, *Meeting the Universe Halfway*.
65. Michelle Boulous Walker, *Slow Philosophy: Reading against the Institution* (London: Bloomsbury, 2017), xv.
66. "Don't be evil!" is Google's well-known company motto from 2000 and is subsequently in their corporate code of conduct, indicative of the moral confusion between lines of individual and corporate responsibility. See Matthew Fuller and Andrew Goffey, *Evil Media* (Cambridge, MA: MIT Press, 2012) for a (Nietzschean) discussion of media morality beyond good and evil.
67. Again, how might live coding generate something of the "red plenty" that Mark Fisher argues for (as we discuss in chapter 4), which exceeds the pressure of capitalism (which is concerned with necessarily *restricting* wealth rather than creating it) by producing or even accelerating overwhelming plenty? See Mark Fisher, *K-PUNK* (blog), May 11, 2015, <https://k-punk.org/abandon-hope-summer-is-coming/>.

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