navigating an intertwingularity

computational ambivalence in experimental music practice

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abstract

This project offers a provisional, practitioner-oriented notion of 'computational ambivalence' in experimental music, addressing how many musicians sensitive to the non-neutrality of music technologies resist adopting a single overarching stance towards software, and therefore cannot extricate their technological questioning from music making itself.

Computational ambivalence is established in relation to three idiosyncratically-defined 'threads' — *experimental music*, *music computing*, and *critical cultural computing* — and is exhibited in and through a 'field guide', speculative historical case studies on Iannis Xenakis's *Theraps* and James Tenney's *Quintext*, reflections on my own musical practice, and an accompanying portfolio of music and software.

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dalyn, whose friendship permeates the project.

Mom, who foreshadowed this project by several decades, telling a young me to turn off the computer and go get some fresh air.

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I.

[fade in]

1. introduction (fireside chat?)

1.1. arranging the kindling

Along another course of history, we never embalm music through software.[1]

Our communities keep music software vital, never allowing it to consolidate or converge into paradigms. Some among us treat software as a village, to be collectively inhabited and shaped over time; others treat software as a sand mandala, to be painstakingly crafted then given over to nature.

Here, people trade their homemade instruments at the market, many surprising and delightful.[2] Our sound houses have jolly curators, keen to invite neighbors and strangers alike to listen, restore themselves, and share in the history of their craft.[3] People who put sounds together do so humbly, paying a fair tax per decibel-hour.

Our music has genres like "after a particularly satisfying meal" and "under a tree by the river in autumn". Legible by sunlight, filament, and candle alike, a virtual papyrus furnishes

[1] "Composers are now able, as never before, to satisfy the dictates of that inner ear of the imagination. They are also lucky so far in not being hampered by aesthetic codification — at least not yet! But I am afraid it will not be long before some musical mortician begins embalming electronic music in rules." Edgard Varèse and Chou Wen-chung, "The Liberation of Sound", *Perspectives of New Music* 5, no. 1 (1966): 18.

[2] "Before what we think of as media even existed, the majority of our information exchange took place at the bazaar — the market and social space where people gathered to buy and sell goods, meet up with friends and, probably most importantly, learn what was happening in their world." Douglas Rushkoff, *Program or Be Programmed: Ten Commands for a Digital Age* (Soft Skull Press, 2010), 106.

[3] "We have also sound-houses, where we practise and demonstrate all sounds and their generation…" Francis Bacon, *The New Atlantis* (1626; repr., The Colonial Press, 1901), `http://www.constitution.org/bacon/new_atlantis.htm`

friends with newly concocted musical scripts to trial by the fireplace.[4] While software surrounds us, it recedes into the background.[5]

There was no boom, no bust. Nothing is 2.0. It's just artisans here.

1.2. grabbing some matches

Like many so-called 'digital natives',[6] I spent my youth fixated on a rectangle of monochromatic light. Sitting in the amber glow meant solving puzzles, creating and learning from a cryptic textual code. The glow also provided a haven from an overwhelming world. Computing implied privacy, quietude, and flow.

With time, this glow turned multicolored and pictorial, and many of its more cryptic aspects receded. A simulated white-collar office scene, rendered with a cubist eye, replaced the textual scroll. A demonic screech machine, connected to a nearby telephone jack, provided an on-ramp to the 'information superhighway'. The rest is history: people now mount screens to their wrists and tune into an endless broadcast.[7]

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I also grew up immersed in sound. From kora to Kraftwerk, our home hosted a perpetual, eclectic musical backdrop: Harold Budd and Brian Eno coexisted in 'the rotation' alongside Michael Jackson, Nick Drake, and Toumani Diabaté. All the while, I disassembled cassette recorders, built primitive noise-making circuits, and played the piano eagerly and blissfully without mastery. Music meant connections with objects and their vibrations. It also meant sharing with others, in the flesh, in the air.

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4 "Thus a stove used to furnish more than mere warmth. It was a *focus*, a hearth, a place that gathered the work and leisure of a family and gave the house a center." Albert Borgmann, *Technology and the Character of Contemporary Life: A Philosophical Inquiry* (University of Chicago Press, 1984), 42–43.

5 "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." Mark Weiser, "The Computer for the 21st Century", *Scientific American*, 1991, 94–104.

6 to borrow Marc Prensky's term, contrasted with 'digital immigrant'.

7 "Our devices and, by extension, our nervous systems are now attached to the entire online universe, all the time. Is that my phone vibrating?" Rushkoff, *Program or Be Programmed*, 34.

Entering university, I veered towards what the course catalogs called 'Music Composition', hoping its seeming non-definition could excuse my continued musical dabbling. There, I basked in the early stages of projects, with their appealing possibility of never-ending re-definition, reconfiguration, reinvention; I concluded projects infrequently and reluctantly. Eventually, the liberating aspects of this path gave way to professional expectations; in search of a community, I faced a fragmented, territorialized landscape of contemporary music.

1.3. lighting the fire

As these personal tales unfolded, so did three other coming-of-age stories in discursive threads central to this project: *music computing*, *experimental music*, and *critical cultural computing*.

1.3.1. music computing

The earliest 'buzzes and squawks'[8] of music computing emanating from institutional research labs in the 1950s reflected lofty ambitions, among them 'liberating sound', understanding human music making through modeling it, and forging human/machine musical hybrids. Ambitions of this sort helped justify the otherwise tedious activities of early computing and helped fend off the inevitable skepticism of using scarce computing time for musicking.

By the late 1960s, using a computer to make music was no longer an oddity; music software passed from institution to institution by the box of punch cards.[9] In only a matter of decades, cheap integrated circuits and clever signal processing supported a proliferation of

[8] John Pierce, quoted in Paul Doornbusch, "Computer Sound Synthesis in 1951: The Music of CSIRAC", *Computer Music Journal* 28, no. 1 (2004): 17.

[9] F. Richard Moore, "Dreams of Computer Music: Then and Now", *Computer Music Journal* 20, no. 1 (1996): 33.

real-time digital synthesizers, and industry-wide protocols allowed for their interconnection. From there, music computing "jumped out of the laboratory and into the fire".[10]

The current landscape of music computing is vibrant, thriving, and multidisciplinary, with countless communities surrounding venues, events, publications, institutions, products, and more. With music computing now the norm, not the exception, one might safely reopen one of its fundamental questions: what might computing and music offer each other?

1.3.2. experimental music

Originating with the first-hand accounts of individual artists and researchers in the 1950s, who used the adjective 'experimental' to describe their practices, came the label 'Experimental Music'. Wrapped up in this seemingly innocuous term were — and remain — a broad variety of meanings and intentions, disjoint in nature. By the arrival of 'state of the field' writings in the 1970s, a small subset of these practices had become identified as an Experimental Music tradition, increasingly subject to collection and typologization. These writings reflect, for instance, a then-common tendency to divide the European 'avant-garde' from the anglophone 'experimental', despite many underlying commonalities.

More recently, critical writings challenge the centrality of this narrative, dispelling the origin myths and the hagiographic treatment of 'mavericks' in favor of documenting real musical encounters, captured in their inevitable complexity — an 'actually existing experimentalism'.[11] These writings expand the 'experimental' through addressing conspicuous gaps in its narrative, especially surrounding gender and race, but also patronage, performance practice, and improvisation. Other approaches broaden the field of study by incorporating perspectives on experimentalism from outside of music, and through treating experimentalism as a tendency or aspect rather than as a tradition.

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10 Ibid., 40.

11 Benjamin Piekut, *Experimentalism Otherwise: The New York Avant-Garde and Its Limits* (University of California Press, 2011), 8.

1.3.3. critical cultural computing

Finally, the rapid proliferation of personal computers in the 1980s further complicated theorizing technology in the human lifeworld, a task already thick with perspectives and methodologies.

While "philosophical reflection on technology is about as old as philosophy itself",[12] reflection on the technological impacts of the Industrial Revolution and World War II brought a new sense of urgency and public relevance to these discussions. 'Classical' perspectives within the humanities philosophy of technology,[13] for instance, address a well-deserved post-war skepticism towards technology, speaking in polarizing terms of technology's supposed essence and its implications for human agency and self-governance.

By the mid-1980s, philosophy of technology shifted from defining and debating 'Technology' generally to studying specific 'technologies' in their production and use — 'actually existing technology', in a sense. These new accounts, arising from an 'empirical turn', looked to sites of technological use and design to understand how artifacts and culture co-produce. This shift also embraced neighboring disciplines: science and technology studies, anthropology of technology, technoscience, feminist technology studies, and many more.

Each of these fields brought new methods and insights for studying technological artifacts, processes, and their relationship to society, but with only scarce treatment of computing, despite its undeniable pervasiveness. This gap drove the creation of a software studies discourse, and now the early stages of a philosophy of software discourse, both approaching software with a critical, holistic eye towards its significance as a cultural phenomenon.

12 https://plato.stanford.edu/entries/technology/#Gre

13 here following Carl Mitcham's lead in separating a 'humanities' philosophy of technology from an 'engineering' philosophy of technology… see Carl Mitcham, *Thinking Through Technology: The Path Between Engineering and Philosophy* (University of Chicago Press, 1994), 14.

1.4. watching it smolder

Considering all of these recent developments, a questioning musician now faces a baffling context for situating their work, full of questions and potential traps, and having no real guidebook to speak of. This confluence of fresh technologies, ideologies, and aesthetics recalls the situation facing artists in the 'long 1960s',[14] where the theoretical promises of engaging with a new medium met the anxieties and frustrations of actually working with it. Music, as always, ends up articulating far more than sound: it carries in its pressure waves the dreams, dirt, and dread of any human utterance.

By way of a response, this project extends into musical practice Andrew Feenberg's notion of the 'ambivalence of technology' — in which technology serves as a 'scene of struggle', rather than as a utopian or dystopian 'destiny'.[15] This approach emphasizes the immense influence wielded by individuals in shaping technologies; when their technological encounters are understood as both *situated within* and *coproductive of* a surrounding culture, these encounters tell both a personal and collective story, interwoven.

This is no less relevant to 'the ambivalent computer',[16] which finds its way into music making in an impressive variety of capacities and contexts. As used here, 'computational ambivalence' focuses specifically on those scenes in which music and software collide, incorporating both an *ambivalence towards* music computing, experienced by musicians, listeners, and programmers, and the broader *ambivalence of* music computing, through which music software takes shape.

Since this notion extends well beyond the purview of any individual, it is worth questioning my role and motives in introducing it; such a label could too easily imply claims of ownership, exclusivity, or universality. My intentions here are altogether more humble. What began from a deeply personal need — to better situate my own musical stance

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14 Hannah B. Higgins and Douglas Kahn, eds., *Mainframe Experimentalism: Early Computing and the Foundations of the Digital Arts* (University of California Press, 2012), 1.

15 Andrew Feenberg, *Transforming Technology: A Critical Theory Revisited* (Oxford University Press, 2002), 15.

16 Ibid., 91.

within a world that so easily humbles claims made on behalf of technology — gradually shifted towards understanding this stance within a broader social context. So, beyond simply rationalizing my own musical choices, the project began to account for the profound alienation I feel in those musical communities purportedly closest to my interests. In the process, 'computational ambivalence' became identified with my search for other similarly attuned signs of life, in part through using my own experiences as a beacon.

For fellow musicians navigating this intertwingularity,[17] I hope 'computational ambivalence' might serve as a rhetorical site of gathering — where critiques of music software can be shared, considered, and transformed into intentional action. This could prove especially vital to those of us seeking alternatives to the offerings and orthodoxies of mainstream music computing; a collective critical literature provides essential "if we are to learn *how not to reproduce what we inherit*".[18]

1.5. sweeping up

In support of a provisional, practitioner-oriented notion of 'computational ambivalence' in experimental music, this project gathers a collection of disparate exhibits from my musical life.

I begin by revisiting the three threads described above, which outline areas of long-term concern within my work. Through their idiosyncratic definitions, these threads overlap and conflict in ways that challenge any straightforward practice-wide resolution. Instead, they offer a structure for *dwelling on* these overlaps and conflicts, deferring their resolution until it can occur in context of individual projects.

Next, I assemble a 'field guide' that contains a few of the 'scenes of struggle' I encountered during the course of the project. These are recounted as short fantasias, interweaving

17 Theodor H. Nelson, "Computer Lib / Dream Machines" 1974, 45 (DM).

18 Sara Ahmed, *On Being Included: Racism and Diversity in Institutional Life* (Duke University Press, 2012), 182.

various sources from the three threads, and subjecting them to the musings of an irreverent, sometimes unreliable narrator. This offers a representative sample of the chattery internal monologues characteristic of my working process, essential to understanding its results.

In two subsequent sections, I present speculative case studies on historical works — Iannis Xenakis's *Theraps* and James Tenney's *Quintext* — both of which explicitly subordinate the technological means of their construction to their specific musical ends. In both cases, I describe how my anxieties around adopting the role of 'analyst' led to the creation of various supporting software, including a domain-specific language for encoding *Theraps*.

Finally, I introduce some of my own music, contained within the accompanying portfolio. I follow two strands of my work, which bear surface similarities to the works of the case studies, but otherwise diverge, each work finding its own particular, momentary resolutions to the concerns raised throughout the document.

2. three threads

The three 'threads' considered within this project — *music computing*, *experimental music*, and *critical cultural computing* — each extrapolate outward from an aspect of my practice to an open collection of relevant discourses, communities, and perspectives.

These threads take on an idiosyncratic form, intentionally subsuming or eliding existing disciplinary definitions in favor of finding 'patterns which connect'.[19] So, with no claims to exhaustiveness, individual selections reflect a self-conscious balancing between representing sources and arguments in their originating contexts and acknowledging their participation in the construction of my own 'personal micro-culture'.[20]

The following sections introduce each of the threads, then highlight some mutual affinities that support their juxtaposition in the 'field guide' that follows.

2.1. music computing

As used here, 'music computing' evokes the endless variety of possible entanglements of software and computing with productive musical practice.[21]

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19 "The *pattern which connects is a metapattern*. It is a pattern of patterns. It is that metapattern which defines the vast generalization that, indeed, *it is patterns which connect*." Gregory Bateson, *Mind and Nature: A Necessary Unity* (E. P. Dutton, 1979), 11.

20 to borrow William Gibson's term.

21 'productive' here is used in sympathy with László Moholy-Nagy (1922), as contrasted with 'reproductive'. This usage is intended without evaluative connotations (linking productive to good) or implied efficiency (productivity).

2.1.1. from the garage to the mainstream

Music computing naturally includes the use and development of software for expressly musical purposes ('music software'), from the fleeting and fledgling projects of individuals to the large and long-lived products of corporations.

At its most widespread, music software adopts a small number of recognizable approaches ('paradigms') refined and popularized through large commercial and open source applications: digital audio workstations, notation packages, wave editors, trackers, etc. An incredible amount of music now passes through these programs at one stage or another its production.[22] With many orders of magnitude more 'end users' than developers, the teams who develop such software often follow formalized product design processes[23] to ensure that their work supports specific musical activities ('use cases') for specific musicians ('users') by modeling desirable interactions ('workflows') and their manipulation of reified software models ('representations').

Beyond this mainstream, several prominent music research communities produce music software for electroacoustic and computer music, algorithmic and computer-assisted composition, new musical interfaces, signal processing and audio effects, etc. As with their mainstream counterparts, these communities actively develop and use music software, though here typically favoring use by specialists over a general public, informal design methods over formal ones, and discursive contribution over commercial viability.

Finally, in the hands of individuals, music software undergoes a constant forging and recasting towards addressing one's own needs, exemplified by 'do-it-yourself', 'assemble-it-yourself', 'hobbyist', and 'maker' communities. Working with comparatively small self-made programs, more easily and quickly changed, individuals not only construct bespoke

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22 "I think it's safe to say that there is virtually no contemporary music that does not make use of some kind of electronic technology, whether or not listeners can discern it." Timothy D. Taylor, *Strange Sounds: Music, Technology, and Culture* (Routledge, 2001), 139.

23 for instance 'User-Centered Design', as popularized by Donald Norman, *The Design of Everyday Things* (Basic Books, 1988), and 'Design Thinking'.

software, but also an 'extended self', formed dialogically between a programmer-musician and their creations.

2.1.2. from the idealized to the typical

The approaches mentioned so far share an underlying premise that computerization might ease or reinforce music making. Just as often, though, a musician's intentions fail to map cleanly to those established for a general audience. For many musicians, these moments of mismatch form as much a part of the music computing experience as the idealized use cases and workflows: their needs manifest as 'edge cases', their activities as 'workarounds'.

Alongside these daily frictions, countless other activities contribute to a holistic view of music computing, outside of development or use. For instance: the deliberate avoidance or negotiation of software-afforded musical decisions, pursuit of musical results from software 'failures', appropriation and reapplication of software from non-musical domains, presentation of computing signifiers, metaphors, and processes in otherwise digitally-unmediated contexts, and deferral of agency to non-human subjects. It's truly a wild world.

2.1.3. from the local to the global

Similarly, music computing involves expanded networks of participants beyond the individual. Such networks might include, at the least, musical and technical communities of interest and practice, companies, industries, and governments, each active in shaping music and its related software.

Musicians often have no shortage of local communities concerned with music computing, from musical ensembles to user groups, artist residencies to technical workshops, student groups to professional organizations, and more. Meanwhile, virtual communities flourish through online forums, social networking sites, and email discussion lists, connecting musicians globally. The exchanges in these communities, lively and varied, focalize specific

practices of music computing. As René T. A. Lysloff argues, while the medium is virtual, these musical communities are very much real — "a community does not come into existence simply because of the physical proximity of its members".[24]

Though less visible, a number of supporting participants are no less essential. Many federal governments, for instance, finance music computing through publicly-funded educational institutions and through allocating research funding to the arts, engineering, and humanities. Such support enables otherwise infeasible work, but also materially guides it, for instance, through associating funding with 'performance indicators', review boards, or trending topics.

Meanwhile, music software lurks in the shadows of several global industries: computing and consumer electronics, music and entertainment, and higher education, at the least. Each of these industries supports music computing through developing enabling technologies, offering financial support, and sometimes through direct participation. These engagements usually embed some expectation of a 'return', either directly, through expected consumption, or indirectly, for instance, by associating a brand or technology with creative activities.[25]

2.2. experimental music

With defining and redefining 'experimental music' now a beloved academic pastime, every attempt to hone the term into univocality instead further compounds its meanings.[26]

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24 René T. A. Lysloff, "Musical Life in Softcity: An Internet Ethnography", in *Music and Technoculture*, ed. René T. A. Lysloff and Leslie C. Gay Jr., Music/Culture (Wesleyan University Press, 2003), 56.

25 'art washing', for instance, describes the practice by large corporations of balancing shady activities with supporting community-level art initiatives.

26 for instance Frank X. Mauceri, "From Experimental Music to Musical Experiment", *Perspectives of New Music* 35, no. 1 (1997): 187–204; Joseph Kudirka, "Extending the Invitation: Composing Notated Experimental Music for Performance" (PhD thesis, University of Huddersfield, 2012), 13; Bob Gilmore, "Five Maps of the Experimental World", in *Artistic Experimentation in Music: An Anthology*, ed. Darla Crispin and Bob Gilmore, Orpheus Institute Series (Leuven University Press, 2014), 23–29; and Philip Thomas, "The Music of Laurence Crane and a Post-Experimental Performance Practice", *Tempo* 70, no. 275 (2016): 5–21.

This project therefore steps back from the ever-receding possibility of a singular 'experimental music', and instead looks at three common contexts where the term gets applied. Instead of seeking to define *what it is*, these consider the term as it confronts practitioners — observing instead *when it is*[27] — in the hope of including musicians and musical practices that might not electively assemble under the same 'what'.

2.2.1. Experimental Music

In one sense, Experimental Music refers to what Experimental Music Studies studies.

Here, experimental music's capital-lettered variant evokes several decades of 'Experimental Music' documentarians, the musicians and musical practices they examine, and their ongoing pursuit of useful concepts and terminology. It embraces, for instance, the stamp collectors' approach taken within anthologies and historical surveys,[28] which strive to assemble living traditions from disparate practices, as well as their critical responses, which highlight unintended consequences of preferring specific stamps over others.[29] It welcomes the attempts by musicians to provisionally define the 'experimental', to classify their activities in or out of it, and to reject such terminology entirely. It also welcomes scholarship that, by way of responding to this discursive mess, documents actual musical encounters in ways that retain the dynamism of moments past.[30]

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27 I credit this pivot to Nelson Goodman's "When is Art?"

28 for instance Michael Nyman, *Experimental Music: Cage and Beyond*, 2nd ed. (1974; repr., Cambridge University Press, 1999); James Saunders, ed., *The Ashgate Research Companion to Experimental Music* (Routledge, 2009); Jennie Gottschalk, *Experimental Music Since 1970* (Bloomsbury, 2016).

29 for instance Barney Childs, "Review: *Experimental Music* by Michael Nyman", *Music Educators Journal* 61, no. 9 (1975): 79–82; Benjamin Piekut, "Book Review: The Ashgate Research Companion to Experimental Music", *Notes* 67, no. 2 (2010): 312–17; Lauren Redhead, "Review: *Experimental Music Since 1970* by Jennie Gottschalk", *Music and Letters* 98, no. 2 (2017): 324–25.

30 for instance Amy C. Beal, *New Music, New Allies: American Experimental Music in West Germany from the Zero Hour to Reunification* (University of California Press, 2006); Georgina Born, *Rationalizing Culture: IRCAM, Boulez, and the Institutionalization of the Musical Avant-Garde* (University of California Press, 1995); George E. Lewis, *A Power Stronger Than Itself: The AACM and American Experimental Music* (University of Chicago Press, 2008); Benjamin Piekut, *Experimentalism Otherwise: The New York Avant-Garde and Its Limits* (University of California Press, 2011); Benjamin Piekut, ed., *Tomorrow Is the Question: New Directions in Experimental Music Studies* (University of Michigan Press, 2014); Dana L. Reason Myers, "The Myth of Absence: Representation, Reception, and the Music of Experimental Women Improvisors" (PhD thesis, University of California, San Diego, 2002).

Presenting these various views on Experimental Music on equal footing should not, however, imply an endorsement of the partisanship contained within some of their pages. In some cases, descriptive categories used to catalog practices might create an illusion of stable genres and genre membership, ready for prescriptive application. When these categories feed back into our real life musical encounters, we then have an opportunity to choose whether to accept their suggested distinctions and exclusions as new orthodoxies, or to refuse them and their implied boundary policing in an effort to keep music weird.[31]

Thwarting any simple definition or taxonomy, Experimental Music manages to hang together somehow — a chaotic constellation of music, individuals, and folklore, connected by inherently messy interrelations, and constituted more by these relations than by notions of membership.[32]

2.2.2. experimental [music]

In another sense, an experimental music manifests *attempt*.

In this adjectival form, the 'experimental' emphasizes those commonplace acts of striving that coalesce into culture.[33] These attempts adhere to no discursive or disciplinary boundaries, uniting molecular gastronomy, parkour, 'free improvisation', *ars subtilior*, and Oulipo, but also the scientific method, self-improvement, and political action. At every turn, someone is attempting something.

When paired with the equally slippery term 'music', a generative question emerges: what might it mean to attempt in relation to 'music'? Words have few advantages, if any, for ad-

31 thinking of "Keep Austin Weird".

32 "I like to imagine LAG, the Livermore Action Group, as a kind of cyborg society, dedicated to realistically converting the laboratories that most fiercely embody and spew out the tools of technological apocalypse, and committed to building a political form that actually manages to hold together witches, engineers, elders, perverts, Christians, mothers and Leninists long enough to disarm the state." Donna J. Haraway, "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century", in *Sex/Machine: Readings in Culture, Gender, and Technology*, ed. Patrick D. Hopkins, Indiana Series in the Philosophy of Technology (Indiana University Press, 1991), 439.

33 This approach has sympathy with the broad approach to musical experimentation taken within the Orpheus Instituut publications, and extends it to remove any need for clarity.

dressing such a question. Only through practice, through making and sharing, do we gain access to each others' approaches, experiencing through all of our senses the differences of opinion we hold around what constitutes a meaningful 'attempt' and a desirable 'music'. For some, this might suggest a cultural boundary questioning, evoked by Brian Eno when he speaks of a "continual re-asking of the question 'what also could music be?'"[34] For others, though, it might mean joining a pickup orchestra,[35] building musical instruments out of fresh produce,[36] or trying out a new scale or tuning system.[37]

Considering 'experimental' in this way might bring together those individuals engaging in attempt and those who come to encounter their activities and artifacts. A mindset of curious inquiry in such encounters, rather than of cataloging or validation, supports a reciprocal appreciation involving attention, participation, comprehension, and response.

2.2.3. 'experimental music'

In a final sense, 'experimental music' simply stands as a floating signifier, an unambiguous *mention* fated to ambiguous *use*.

It is this formulation that labels the dusty record bin in the shop's back corner, or serves as a courteous non-reply to the question "what sort of music do you make?". It sits enigmatically at the bottom of a negative cascade of genre: 'experimental music' classifies all that isn't classified otherwise.

While failing to clarify any specific *musical* intent, the words nevertheless call attention to a *social* one: they mark an intent to differentiate, often (but not exclusively) from a perceived mainstream. They situate the attempt of the 'experimental' in the realm of our interactions,

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34 Nyman, *Experimental Music*, xii.

35 how different, really, is the Portsmouth Sinfonia from your local community or school orchestra?

36 for instance, the 'banana piano' (https://www.youtube.com/watch?v=rfQqh7iCcOU&t=62) or 'carrot clarinet' (https://www.youtube.com/watch?v=BISrGwN-yH4).

37 a couple thousand scales, for a rainy day: http://www.huygens-fokker.org/scala/downloads.html#scales

acting as a shibboleth to separate the curious from the mathophobic.[38] To state "I make 'experimental music'" might indicate little more than a projection of identification with an unexplained difference.

2.3. critical cultural computing

Collected under the label 'critical cultural computing' are various approaches to questioning how humans relate to computing technologies, from philosophical reflections on technology in general to the concrete experiences of computing pioneers.[39] These perspectives span from the mundane to the mythological, the optimistic to the cynical, and the activist to the resigned.

2.3.1. philosophy of/and technology

To the extent that one can approach computers as technology generally, insights from philosophical literature on technology prove useful. Many relevant authors and texts assemble around 'Philosophy of Technology',[40] the Society for Philosophy and Technology, its journal *Techné*, and a few notable book series.[41] As with Experimental Music, this work proceeds without a consensus view (or need thereof), but nevertheless features a number of key attempts at synthesis.

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38 'Mathophobic' is used here to evoke Seymour Papert, who uses it to refer not only to a fear of math, but also to a fear of learning more generally. See Seymour Papert, *Mindstorms: Children, Computers, and Powerful Ideas* (Basic Books, 1980), 38.

39 This term is a hopeless amalgamation of existing terms, adding 'critical' to Lev Manovich's 'cultural computing'. 'Critical Computing', while less cumbersome, has been used to mean either: 1) computing for 'mission-critical systems' like life support and urban infrastructure, or, 2) the application of computational paradigms to critical studies (digital humanities). 'Critical Digital Studies', also close, overemphasizes the relevance of the 'digital' within software. Finally, 'New Media' orients itself optimistically, and has that new word smell (see: 'new math', 'new coke', 'new music').

40 also 'Philosophy *and* Technology'. See Paul Durbin, "Philosophy of Technology: In Search of Discourse Synthesis", *Techné* 10, no. 2 (2006) for an impressive overview of three decades worth of arguments and controversies.

41 for instance, the Indiana Series in the Philosophy of Technology, University of Chicago Press, Kluwer Academic Publishers, etc.

Carl Mitcham's *Thinking Through Technology* (1994),[42] for instance, distinguishes between an Engineering Philosophy of Technology, concerned with "analyses of technology from within",[43] therefore presuming a technological presence, and a Humanities Philosophy of Technology, concerned with "bring[ing] non- or transtechnological perspectives to bear on interpreting the meaning of technology". Mitcham weighs these in favor of the humanities approach,[44] and addresses technology through four primary lenses: as object, knowledge, activity, and volition.

Mitcham's text, through its extensive referencing, calls attention to the overwhelming volume of perspectives in the then relatively young field. This abundance further intensified in the following decade, leading participants to lament the absence of canonical texts[45] and confront the field's 'paradox of continual beginning', in which authors reference each others' works, but seldom carry out "systematic elaborations and assessments".[46]

Taking up both of these challenges, *Technology and the Good Life?* (2000), edited by Eric Higgs, Andrew Light, and David Strong,[47] subjects the work of Albert Borgmann to the critique of more than a dozen noteworthy contributors.[48] Borgmann's theories lend themselves particularly well to such an elaboration and assessment, since they raise broad philosophical issues of everyday significance: 'character', morality, nostalgia, 'values', and so on. Each contributor proceeds from some aspect of his work — most often, his 'device paradigm'[49] — and offers their own responses, many of which situate Borgmann's work within broader philosophical controversies.

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42 Carl Mitcham, *Thinking Through Technology: The Path Between Engineering and Philosophy* (University of Chicago Press, 1994).

43 Ibid., 39.

44 Ibid., 89.

45 Eric Higgs, Andrew Light, and David Strong, eds., *Technology and the Good Life?* (University of Chicago Press, 2000), 4.

46 Quoting Elisabeth Stöker (1983), ibid., 5.

47 Higgs, Light, and Strong, *Technology and the Good Life?*

48 "Certainly there are many views now on the social effects of technology and how we are to evaluate those effects, but the field nonetheless lacks a critical discussion of those competing views of the kind that characterizes most philosophical subfields." ibid., 5.

49 Albert Borgmann, *Technology and the Character of Contemporary Life: A Philosophical Inquiry* (University of Chicago Press, 1984), 40.

Finally, *American Philosophy of Technology: The Empirical Turn*, edited by Hans Achterhuis (2001),[50] gives concise introductions to six American figures of philosophy of technology: Borgmann, Herbert Dreyfus, Don Ihde, Andrew Feenberg, Donna Haraway, and Langdon Winner. These thinkers serve as representatives of an 'empirical turn' in philosophy of technology in the 1980s and 1990s, which, in contrast to a predominantly European 'classical' philosophy of technology,[51] "started to focus on concrete technologies and issues, attempted to develop contextual, less deterministic theories of technology or started borrowing them from STS, and started to assume a less dystopian, more pragmatic and balanced attitude towards modern technology".[52]

2.3.2. social constructivism and technology

This 'empirical turn' in philosophy of technology reflected the growing influence of outside disciplines, many of which were developing contemporaneously around the 'Strong Programme' within Sociology of Scientific Knowledge. The Strong Programme, originating in Edinburgh (Barry Barnes, David Bloor) and Bath (Harry Collins), considers knowledge claims as inextricably contingent on their surrounding social context. David Bloor distinguishes the program through four tenets: causality, impartiality, symmetry, and reflexivity.[53] The impartiality and symmetry tenets in particular, which approach knowledge claims equally, irrespective of their perceived 'truth' or 'rationality', have proven useful for studying how sociotechnical systems develop — a project taken up by numerous subfields of Science and Technology Studies.

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50 Hans Achterhuis, ed., *American Philosophy of Technology: The Empirical Turn*, trans. Robert P. Crease, Indiana Series in the Philosophy of Technology (Indiana University Press, 2001).

51 "The traditional corpus in philosophy of technology, if one may call it that, is constituted by the works of a rather diverse company of authors, such as Jacques Ellul, Martin Heidegger, Lewis Mumford, Ivan Illich, Karl Marx, and various members of the Frankfurt School (Marcuse, Adorno, Horkheimer, Habermas)." Philip Brey, "Philosophy of Technology: A Time for Maturation", *Metascience* 6, no. 1 (1997): 92.

52 Philip Brey, "Philosophy of Technology After the Empirical Turn", *Techné* 14, no. 1 (2010): 39.

53 David Bloor, *Knowledge and Social Imagery*, 2nd ed. (1976; repr., University of Chicago Press, 1991), 7.

The Social Construction of Technology program, outlined by Pinch and Bijker,[54] applies Collins' 'Empirical Program of Relativism' to understanding how technologies move from 'interpretative flexibility' to 'closure' in relation to relevant social groups. Meanwhile, MacKenzie and Wajcman relax the symmetry principle in *The Social Shaping of Technology*[55] to allow artifacts to again have 'properties' and 'effects'.[56] Actor-Network Theory (Latour, Callon, Law), generalizes the principle of symmetry to encompass non-human agents and agency — but not, crucially, intentionality — within heterogeneous networks of material-symbolic actors. This invited disciplinary controversy, especially acute in the 'Epistemological Chicken' debate, which addresses the limits of reflexivity and agency.[57] At a distance from this fray, but nevertheless informed by it, Andrew Pickering's *Mangle of Practice* considers the 'real-time' practices of doing science, addressing how scientists form knowledge in relationship to instruments with 'material agency'.[58]

2.3.3. theorizing software and culture

Approaching software through a general technological frame ultimately grants only a partial understanding, since computing resists treatment as a monolithic artifact, medium, or movement, and carries its own distinct cultural history. Further, since computing concepts and metaphors now permeate everyday life, an analyst's task of teasing apart causes and effects proves especially challenging. A growing number of humanities scholars bring their extensive engineering experience to assessing claims made on behalf of software.[59]

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54 Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (1987; repr., MIT Press, 2012).

55 Donald MacKenzie and Judy Wajcman, eds., *The Social Shaping of Technology* (Open University Press, 1987).

56 Philip Brey, "Social Constructivism for Philosophers of Technology: A Shopper's Guide", *Techné* 2, nos. 3 – 4 (1997): 7.

57 for more, see Andrew Pickering, ed., *Science as Practice and Culture* (University of Chicago Press, 1992); David Bloor, "Anti-Latour", *Studies in History and Philosophy of Science* 30, no. 1 (1999): 81–112; Langdon Winner, "Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology", *Science, Technology, & Human Values* 18, no. 3 (1993).

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

59 see David M. Berry, *The Philosophy of Software: Code and Mediation in the Digital Age* (Palgrave Macmillan, 2011), 4–5 for one overview of the landscape.

David Golumbia, for instance, notes in *The Cultural Logic of Computation*[60] that despite the utopian rhetoric often surrounding computers, they "too often […] aid institutions in centralizing, demarcating and concentrating power".[61] He draws on the notion of 'computationalism'[62] to describe a pervasive and deceptive tendency to explain human social experience through computational processes,[63] which he illustrates through examples from computational linguistics to enterprise resource planning. David Berry's *Philosophy of Software* and *Critical Theory and the Digital* approach computing as an ontotheology (after Heidegger), needing to be understood both " 'ontologically', from the inside out', and 'theologically' from the outside in".[64]

Here, the paradox of continual beginning strikes again: the literature theorizing software and culture increases at a pace well beyond the ability to track, let alone meaningfully synthesize. From the muddle, three of the more stable configurations are worth highlighting: Software Studies, exemplified by Matthew Fuller's *Software Studies: A Lexicon*,[65] Lev Manovich's *Software Takes Command*,[66] and *Speaking Code* by Geoff Cox and Alex McLean;[67] New Media, as exemplified by Manovich's *The Language of New Media*[68] and the *New Media Reader* by Noah Wardrip-Fruin and Nick Montfort;[69] and historical studies on the gendering of computing, exemplified by Janet Abbate's *Recoding Gender*[70] and Marie Hicks's *Programmed Inequality*.[71]

60 David Golumbia, *The Cultural Logic of Computation* (Harvard University Press, 2009).
61 Ibid., 4.
62 Golumbia describes this as "a successor term to 'functionalism' " within analytic philosophy. "In its received (sometimes called its 'classical') form, computationalism is the view that not just human minds are computers but that *mind itself* must be a computer". ibid., 7.
63 Ibid., 8.
64 Berry, *The Philosophy of Software*, 27.
65 Matthew Fuller, ed., *Software Studies: A Lexicon* (MIT Press, 2008).
66 Lev Manovich, *Software Take Command*, International Texts in Critical Media Aesthetics (Bloomsbury, 2013).
67 Geoff Cox and Alex McLean, *Speaking Code: Coding as Aesthetic and Political Expression*, Computer software Studies (MIT Press, 2012).
68 Lev Manovich, *The Language of New Media* (MIT Press, 2001).
69 Noah Wardrip-Fruin and Nick Montfort, eds., *The New Media Reader* (MIT Press, 2003).
70 Janet Abbate, *Recoding Gender: Women's Changing Participation in Computing*, History of Computing (MIT Press, 2012).
71 Marie Hicks, *Programmed Inequality: How Britain Discarded Women Technologists and Lost Its Edge in Computing*, History of Computing (MIT Press, 2018).

For a broader audience, notable texts by Jaron Lanier,[72] Larry Lessig,[73] Evgeny Morozov, Douglas Rushkoff,[74] and Sherry Turkle[75] encourage critical thought around the social and political dimensions of computing.

2.3.4. historical accounts of computing pioneers

Finally, from the accounts of individuals involved in dreaming, designing, and developing the precursors to today's personal computers, we can see the rocky path these took from interpretative flexibility to closure.

Vannevar Bush, in his 1945 essay "As We May Think",[76] articulates a vision of how American scientists, recently freed from their wartime obligations, might "implement the ways in which man produces, stores, and consults the record of the race". He proposes a number of possibilities, including the 'memex', a desk-sized microfiche with a number of curious and useful capabilities. As if this were too practical, he also proposes bypassing the indirect interfaces towards directly intercepting and inducing the body's electrical signals. Woven throughout his otherwise reserved and optimistic text are markers of war weariness, culminating in a devastatingly bipolar conclusion.

This essay inspired J. C. R. Licklider, and later Doug Engelbart, who both dedicated themselves to using computers to augment human intellect after spending time on military technologies. Licklider suggests in "Man-Computer Symbiosis" that much of his time spent on technical problems "can be performed more effectively by machines than by men";[77] he imagines a future in which a person poses questions, provides surrounding context, and generally guides 'information-processing equipment', which formulates tests and dynamic models useful for problem solving. Concrete examples, where they occur,

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72 Jaron Lanier, *You Are Not a Gadget* (2010; repr., Penguin Books, 2011).

73 Lawrence Lessig, *Code: And Other Laws of Cyberspace, Version 2.0*, 2nd ed. (Basic Books, 2006).

74 Douglas Rushkoff, *Program or Be Programmed: Ten Commands for a Digital Age* (Soft Skull Press, 2010).

75 Sherry Turkle, *The Second Self: Computers and the Human Spirit* (1984; repr., MIT Press, 2005).

76 Vannevar Bush, "As We May Think", *The Atlantic Monthly* 176, no. 1 (1945): 101–8.

77 J. C. R. Licklider, "Man-Computer Symbiosis", *IRE Transactions on Human Factors in Electronics* 1 (1960): 4–11.

show intended military, laboratory, and library uses.[78] Engelbart, meanwhile, addresses the everyday problem solver — in "Augmenting Human Intellect: a Conceptual Framework", he describes a scenario involving Joe, an augmented intellectual worker, who deftly manipulates text and symbols. This would develop into the "Mother of all Demos" only a few years later.[79]

Ted Nelson captured the enthusiasm and sense of endless possibility for computing in his *Computer Lib / Dream Machines*,[80] but also how jargon and technical misunderstanding could be used to take advantage of normal people, not just by 'the computer priesthood' but by salesmen and professionals of all sorts ("DOWN WITH CYBERCRUD!"[81]). Nelson's later *Possiplex* and video series "Computers for Cynics"[82] recount a vivid, irreverent computing history, full of the political constraints that held computing back from the possible.

Alan Kay and Adele Goldberg, with their team at Xerox PARC's Learning Research Group, also encountered a gulf between their rich conception of computing and its reception. They imagined a future in which children gained new fluency in accessing, remixing, and sharing dynamic simulations of the world's media, using a small portable computer (the 'DynaBook'[83]), and through a concise object-oriented, conversational programming language (Smalltalk). Through a now-legendary turn of events, their work was prematurely atomized; the current state of computing owes much to the work at PARC, but falls short of their vision.[84]

Seymour Papert, among others, shared their desire to make computers a meaningful support for learning, taking issue with the common classroom use of computers to drill 'facts' — "the computer programming the child". In *Mindstorms*,[85] he presents computers as

78 See also J. C. R. Licklider, *Libraries of the Future* (MIT Press, 1965).
79 https://www.youtube.com/watch?v=M5PgQS3ZBWA
80 Theodor H. Nelson, "Computer Lib / Dream Machines" 1974.
81 ibid., 3. More on cybercrud on ibid., 8.
82 https://www.youtube.com/watch?v=KdnGPQaICjk
83 Alan C. Kay, "A Personal Computer for Children of All Ages" (Xerox Palo Alto Research Center, 1972).
84 see Michael Hiltzik's *Dealers of Lightning*.
85 Papert, *Mindstorms*.

powerful partners for Piagetian learning, through a number of LOGO-powered 'microworlds' designed to support 'syntonic' assimilation of mathematical concepts. As computers proliferated in classrooms, LOGO took a dual life, in some circumstances empowering children to explore without agenda, in others, subjecting them to further regulation.

2.4. tangled up pairwise

This section elaborates on a few of the salient pairwise relationships between threads.

2.4.1. music computing & experimental music

In a sense, music computing and experimental music share a longstanding mutual interest, oriented towards discovering how music and computing might relate. This affinity was especially evident during the earliest days of music computing, when computers required immense effort and specialization, and those working with them had few precedents on which to build. The common 'pioneering' metaphor captures the sense of experiment permeating a moment when so few people knew so little about an area of so much promise.

A few experiments, selected from the 'frontier' days of music computing, serve to highlight the comparatively unbound relationship of computing to music at its outset. When CSIRAC allegedly squawked *Twinkle, Twinkle, Little Star* through its 'hooter',[86] or an IBM 7094 'sang' *Daisy Bell*, these triumphs affirmed the tremendous technical efforts needed to synthesize sound.[87] Similarly, when ILLIAC 'composed' a string quartet, this involved ambitious experiments into machine composition and its public perception.[88] Where these projects adopted relatively uncontroversial western music as their subject,

[86] Paul Doornbusch, "Computer Sound Synthesis in 1951: The Music of CSIRAC", *Computer Music Journal* 28, no. 1 (2004): 15.

[87] "Who would have expected that the first musical sounds produced by a multimillion-dollar example of our most advanced technology would sound more like a child's first violin lesson than the pinnacle of musical evolution?" F. Richard Moore, "Dreams of Computer Music: Then and Now", *Computer Music Journal* 20, no. 1 (1996): 29–30.

[88] Lejaren A. Hiller Jr. and Leonard M. Isaacson, *Experimental Music: Composition with an Electronic Computer* (McGraw-Hill Book Company, 1959), ch. 5.

early works of computer music like Tenney's *Analog #1 (Noise Study)* and Brün's *Anepigraphe* took the computer as a point of departure for music idiomatic to this new medium, asking what music could become in its presence.

These differences in approach reveal how questions of musical aesthetics and those of musical representation and domain modeling curiously interrelate. From the outset, music computing went beyond merely applying pre-existing models of music to 'solutions' by machine,[89] it ventured into the value-laden establishment of these models themselves. While some computer musicians focused on making a given musical model computable, many more were active participants in a parallel frontier, where an aesthetic 'land grab' brought a flourishing of alternative models. Decades later, despite a now weighty history of prior precedents, the relationship of technical means to musical ends remains fundamentally and profoundly open. Hearing music computed therefore often means encountering individuals' projections of what 'music' might mean, reduced to a perceived essence, modeled, simulated, and reflected back into the world.

While music computing presumes the involvement of computers from the outset, typically with an optimistic orientation, neither this involvement nor its optimism should be presumed in a wider musical frame. To musicans operating within an expanded musical field, computing may simply supply an additional inherited technosocial system to consider in musical context. As with musical instruments, techniques, notations, and so forth, computing can prove irrelevant in some musical contexts, while remaining essential to others.

2.4.2. critical cultural computing & music computing

Even though music only rarely makes an appearance in the literature of critical cultural computing, the insights from this literature often apply directly and usefully to music

[89] See, for instance, "ILLIAC PROGRAMMING: A guide to the Preparation of Problems for Solution by the University of Illinois Digital Computer".

computing. Musicians can therefore harvest from this exemplary surrounding literature for their theorization of music computing from 'within'.

Meanwhile, the musical use of computers can extend these critical approaches by offering a challenging domain for critical study. Especially pertinent are the many 'limit cases' encountered by musicians in their practical work. On one level, the computer reveals through its mediations aspects of music making that might otherwise be concealed or presumed, for instance: embodiment, expression, reactivity, stability, agency, and creativity. Music computing offers a seemingly endless supply of Heideggerian 'breakdowns', which, when investigated, offer insights about music making and computing generally.

But these breakdowns, encountered by a presumed subject, already assume a higher level of access to (and participation in) music computing than should be taken for granted. Some of the more controversial aspects of music computing, concerned with privilege, participation, and power, benefit from the deeper structural understandings provided by the critical writings.

2.4.3. experimental music & critical cultural computing

When experimental musicians engage in the questioning of 'music', they share a critical, inquisitive mindset with those who similarly question 'technology' and 'computing'. This impulse, philosophical in inclination (but typically not in method), strives to "understand how things in the broadest possible sense of the term hang together in the broadest possible sense of the term".[90] This mindset progressively differentiates experiences in and of the world, constructing distinctions from apparent unities as a matter of course. That much of the vocabulary within this project proves uselessly polysemic — 'experimental', 'music', and 'technology', each problematic — reflects this tendency, understood here as a productive failure of the world's heterogeneity to reduce under the pressure of language, rather than as a failure of individuals to find consensus.

[90] Wilfrid Sellars, "Philosophy and the Scientific Image of Man", *Science, Perception, and Reality*, 1963, 35–78.

Within both threads, questioning takes places with an expanded methodological 'dynamic range' from abstract to concrete. At one extreme, individuals ask intimidatingly broad, unanswerable questions of the world ("when is music?", "what is technology's essence?"). At the other, they find provisional answers and refined lines of questioning through concrete everyday activities. Experimental musicians, as participant-observers in cultures impacted by technology, often respond to tough cultural questions by treating them as prompts for musical attempt; here, musicians benefit from the longstanding ambiguity of the artistic frame, wherein a 'suspension of disbelief' at once supports saying and not being seen to have said otherwise controversial propositions. The efficacy of this approach, too, might benefit from questioning; the jester serves the court, in the end.

2.5. all intertwingled

Where all three threads come into contact, they offer a space for thinking through the complexities of computing in musical practice, each thread challenging assumptions latent in the others. Since many musicians find neither an outright rejection of computing nor its naive embrace sufficiently nuanced, such a framing helps in describing how music and computing coproduce meaning.

The following sections outline a growing body of scholarship concerned with questioning music technology, each eroding the view of technology as 'neutral'[91] by exhibiting the various entanglements of computing with cultural systems of value. These are introduced

[91] I use the term 'neutral' here in two senses. In a broader sense, it references a set of standpoints towards technology, invoked with skepticism throughout much 'philosophy of technology' literature. Feenberg highlights four standpoints key to 'neutrality': that technology is merely instrumental, politically indifferent, culturally universal, and contextually independent. See Andrew Feenberg, *Transforming Technology: A Critical Theory Revisited* (Oxford University Press, 2002), 5–6. For a 'classical' example of skepticism towards neutrality, see Jacques Ellul, *The Technological Society*, trans. John Wilkinson (Vintage Books, 1964), 159; for a more recent example, see Don Ihde, *Technology and the Lifeworld: From Garden to Earth*, Indiana Series in the Philosophy of Technology (Indiana University Press, 1990), 128. In a narrower sense, the term translates these four standpoints into the concerns of music technology and aesthetics, where they have been challenged by the authors and publications cited in the following three sections. Such views elaborate on the consequences of non-neutrality within music making beyond simplistic oppositions (like that of a 'neutral reverb' versus a 'reverb with character'). To these perspectives, I add mine within the field guide, culminating in its discussions on 'presence' and 'residual aesthetics'.

by the proximity of the author's own musical practices to the practices they discuss, and by the specific communities to which they are addressed.

2.5.1. cultural practices, studied

At one extreme, historical and cultural studies of music technology examine the complexities of meaning surrounding specific musical technologies, institutions, and activities. Of these, Georgina Born's *Rationalizing Culture*,[92] Paul Théberge's *Any Sound You Can Imagine*,[93] Timothy Taylor's *Strange Sounds*,[94] and Hannah Higgins and Douglas Kahn's *Mainframe Experimentalism*[95] are most significant to this project.

These authors, while having their own musical practices, appear as dispassionate historians, ethnographers, and theorists. Their own musical practices appear only implicitly through the selection of the subject matter, rather than within the framing of the studies. When these authors rarely adopt a tone of advocacy, it is towards practices of scholarship, not of music making.

2.5.2. patterns of practice, observed

Other writings reveal patterns of computing within experimental musicians' practices, analyzing them beyond merely describing their stylistic effects. Of these, this project high-

92 Born, *Rationalizing Culture*.
93 Paul Théberge, *Any Sound You Can Imagine: Making Music / Consuming Technology*, Music / Culture (Wesleyan University Press, 1997).
94 Taylor, *Strange Sounds*.
95 Hannah B. Higgins and Douglas Kahn, eds., *Mainframe Experimentalism: Early Computing and the Foundations of the Digital Arts* (University of California Press, 2012).

lights articles by Kim Cascone,[96] Agostino Di Scipio,[97] Luc Döbereiner,[98] Owen Green,[99] Michael Hamman,[100] and Christopher Haworth.[101]

While these writings typically exclude the author's own music as a source of primary evidence, they exhibit a much closer relationship between the author's own practices and those under study. Since these authors often have commitments to the practices and communities they discuss, their writings can be understood to endorse particular practices through advocating for specific interpretations of their significance.

2.5.3. individual practices, scaffolded

Finally, an emerging genre of doctoral theses engages critically with computing in context of the authors' own musical practices. From these, this project depends on key contributions from Newton Armstrong,[102] Owen Green,[103] and Thor Magnusson.[104]

Each of these authors harvests insights from surrounding disciplines to rationalize their own particular approach and reflect on their disciplinary context — especially focusing on the design of digital musical instruments and making of live electronic music. That these writings involve a self-conscious teetering between theories and their extrusion through practice is characteristic not only of musical 'practice-based research' but also of post-empirical-turn technology studies more generally.

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96 Kim Cascone, "The Aesthetics of Failure: 'Post-Digital' Tendencies in Contemporary Computer Music", *Computer Music Journal* 24, no. 4 (2000): 12–18.

97 Agostino Di Scipio, "Questions Concerning Music Technology", *Angelaki: Journal of the Theoretical Humanities* 3, no. 2 (1998).

98 Luc Döbereiner, "Models of Constructed Sound: Nonstandard Synthesis as an Aesthetic Perspective", *Computer Music Journal* 35, no. 3 (2011): 28–39.

99 Owen Green, "More Than 'Just a Hammer': Critical Techniques in Electroacoustic Practice" 2006.

100 Michael Hamman, "From Technical to Technological: The Imperative of Technology in Experimental Music Composition", *Perspectives of New Music* 40, no. 1 (2002): 92–120.

101 Christopher Haworth, "Sound Synthesis Procedures as Texts: An Ontological Politics in Electroacoustic and Computer Music", *Computer Music Journal* 39, no. 1 (2015): 41–58.

102 Newton Armstrong, "An Enactive Approach to Digital Musical Instrument Design" (PhD thesis, Princeton University, 2006).

103 Owen Green, "User Serviceable Parts: Practice, Technology, Sociality and Method in Live Electronic Musicking" (PhD thesis, City University London, 2013).

104 Thor Magnusson, "Epistemic Tools: The Phenomenology of Digital Musical Instruments" (PhD thesis, University of Sussex, 2009).

2.5.4. navigating a way through

This project resides squarely within this final practice-oriented genre, with all its attendant virtues and hazards. I will briefly pose and respond to a few challenges that were integral in shaping this project's form. These highlight areas of particular sensitivity within the project, especially around the treatment of language and practice as distinct but mutually constituting.

Use language to contextualize your practice, but without reducing the practice to its description.

As evidenced by 'career kebabs' like *composer–performer* or *live–electronic–improviser*,[105] many contemporary musical practices fall through the sizable cracks between the professional archetypes of yesteryear. As these lists grow, their constituent parts increasingly delimit the extremes of a liminal space, with decreasing commitment to any single affiliation. The archetypes, then, suggest themselves only asymptotically and through negating their neighbors; practically, more words sometimes mean less when placed together.[106]

Further, the often hazy boundaries between an individual's artistic practice and their practices of everyday life might call into question the prevalence and acceptance of some archetypes ('composer') over others ('listener', 'mother'). To form an identity exclusively through a set of professionally-regulated archetypes might mean obscuring those very contexts central to understanding a given practice.

My practice, which once resembled that of a 'composer-programmer', has since dilated towards rather composing myself as a whole person, with less regard to whether this yields a single, stable kebab for others' consumption. This reflects the latest manifestation of my long-term tendency to treat music making and computing as broad areas of shared knowledge to bask in, rather than to draw from merely tactically. So, while I remain interested and engaged in composition, programming, and their reconciliation, these activities are

[105] inspired by the programmer jargon 'kebab case' (imagine the hyphen as a skewer).

[106] "The theories of feminist identity that elaborate predicates of color, sexuality, ethnicity, class, and able-bodiedness invariably close with an embarrassed 'etc.' at the end of the list. Through this horizontal trajectory of adjectives, these positions strive to encompass a situated subject, but invariably fail to be complete." Judith Butler, *Gender Trouble* (1990; repr., Routledge Classics, 2006), 196.

now subordinated to those of understanding, connecting, navigating, and integrating.[107] These activities and their relative priorities permeate all of the project's materials.

Clarify the relationship between your written account and the practice itself.

Another shift throughout the project has been from viewing the writing as being 'outside' my practice to it being inextricably 'inside', and, furthermore, to embracing that any perspective from 'outside' is foreclosed to me as a possible means of expression. This shift began with me slowly coming to regard scholarshipping as a set of creative acts not so dissimilar from others I undertake. Observing this pattern helped me, keenly aware of my status as a non-native scholar, to consider how best to 'pass' as one.[108] But this shift accelerated as I tried to incorporate aspects of Butler's *Gender Trouble* into those particular arenas of trouble I hold dear.

This written account, then, results from a set of acts occurring in parallel with the musical and technical ones it takes as its content, originating from the same underlying impulses, and competing for the same attention. The text is therefore best understood as a *thinking-through-with*, rather than as a *description-of* or *justification-for*.

Leave unambiguous your 'original contribution to knowledge'.

Ah, those words![109] In recurring dreams, I try fruitlessly to shovel my Coal Nuggets of Contribution onto a massive Heap of Knowledge, guarded by two menacing, bespectacled dragons.

These dreams clearly caricature aspects of a bygone academic world, fallen from favor: knowledge as a single, 'universal' agglomerate; contributions as tiny, isolatable, and incremental; scholars as myopic, surly gatekeepers. If we agree that *isn't* the model, then, what is?

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107 I think often of Ted Nelson's identification as a 'nexialist'.

108 one is not born, but rather becomes, an academic?

109 these come from the University of Huddersfield's document "Regulations for Awards (2018)", Section M.1, "Regulations for the Awards of PhD and EntD", 106.

I approach such questions cautiously and pragmatically in the face of recent debates concerning the status of practice-based musical research.[110] As a reader of practice-based accounts, I appreciate them as candid glances into other musicians' systems of value and how they see best to massage these — often under institutional duress — into a necessarily partial, aspirational self-representation of their work's significance. As such, I endorse the genre as a celebration of *doing* and *rigorously reflecting on doing* as sources of potential insight, without then implying that these constitute an unquestionable shared Knowledge. Rather, if the intent is to compose discourse with one another, it seems essential that we document whatever it is that we think we are doing, and do so with the utmost sincerity.

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From having sustained parallel academic and 'industry' lives for the past few years, I see the opportunity to attempt a reconciliation of some of the differing perspectives on knowledge and contribution I have experienced in these communities. Rather than viewing them as oppositional forces engaged in various exaggerated binary standoffs — public/private, open/closed, altruistic/exploitative, etc. — my experience has been of their considerable overlaps, convergences, and potential collaborations. The differences, while most certainly present, might best serve as productive conversation starters.

Among other observations, I now appreciate just how experimental it is to develop music software used by millions of people. I also realize how integral 'mass market' music products are in co-producing musical identities, but *especially* those of musicians most vocal in rejecting them. Most importantly, I realize the crucial role that routine musical decisions play in preserving or foreclosing the 'interpretative flexibility' of computing technologies for everyone, not just for the handful of musicians who might encounter such terms in academic literature.

Within a broader audience, I observe an insatiability for new musical experiences not so dissimilar from that seen in music research communities. At the very least, this curiosity

[110] thinking here of John Croft, "Composition Is Not Research", *Tempo* 69, no. 272 (2015): 6–11 and its fallout.

outpaces the depressingly low expectations held by some who spuriously link musicians' market behaviors (as consumers of commercial software) with their artistic ambitions (as allegedly passive consumers of musical thought, generally). Curious musicians, beyond simply feeding off whatever technical means and aesthetic resources they can find, also feed off of a variety of sources providing permission and encouragement to attempt. In that capacity, practice-based 'contributions to knowledge' — coal nuggets or none — could ideally be mobilized to contribute to the knowledge of more than a select few.

While I make no claims regarding this project's broader public dissemination or impact, it at least strives for a greater degree of approachability than many of the sources it relies on. This reflects my own experiences during this project, through which I have grown concerned that the stylistic affectations of 'scholarly tone' bar many insights in the literature from reaching those people best positioned to make use of them. To this end, I deliberately trade away some amount of academic meticulousness (piousness?) in favor of the more casual authorial voices you have already encountered, more true to my own.

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To an open community of musicians concerned with questioning music technology, I contribute a practice-level account of 'computational ambivalence' in experimental music. This account gives voice to the relatively common, under-documented experience many musicians have of needing to continuously reevaluate how, when, and why computers are involved their music making. This contrasts with musical practices for which a single, overarching approach to computing suffices, which might allow technological questioning to recede from the experience of music making.

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And now for some Hannah Arendt:

> You ask about the effect my work has on others. If I may speak ironically, that's a masculine question. Men always want to be influential. I see that somewhat as an onlooker. Do I see myself as influential? No, I want to understand. If

others understand in the same way I've understood that gives me a sense of satisfaction, like being among equals.[111]

[111] http://www.critical-theory.com/watch-hannah-arendt-discusses/

II.

a field guide

3. introduction

Where previous sections have alluded to various struggles of music computing, this one aims to make these explicit. It introduces a selection of topics encountered by musicians who develop and use software, and addresses how practical strategies of negotiation can themselves lead to unexpected consequences.

As before, this material comes from extrapolating from concerns within my musical practice outward to surrounding literature.

3.1. note to myself, age 5

So, I heard you've got a computer with some music software on it. It seems you even licensed it properly. Way to go!

I certainly can't help you to use it, but I am confident you'll figure that out on your own. Instead, I just want to play devil's advocate: to remind you to go outside periodically, and to encourage you to pick up a thrift store guitar as well.[112]

[112] "**Eric Lyon:** if suddenly all the code that you had written accidentally was erased from every hard drive — do you have any concept of what might be a completely different way to approach the problems that we deal with? **James McCartney:** Well, I think most of us have already rewritten our software too many times. **Gareth Loy:** Personally, I think I would start playing my guitar more …" Eric Lyon, ed., "Dartmouth Symposium on the Future of Computer Music Software: A Panel Discussion", *Computer Music Journal* 26, no. 2 (2002): 15.

Don't get me wrong, it's perfectly fine to use computers for music. I just don't want you to be too surprised or disappointed later on about how you've spent your time…[113]

[113] "At an age when most young composers are learning … the difference between *sul pont* and *sul tasto*, I was … learning … to scale the output of a two-pole feedback filter in Fortran IV, … and when I looked up I was no longer a young composer." Paul Lansky, "Keynote: Reflections on Spent Time", in *Proceedings of the International Computer Music Conference*, 2009, `http://paul.mycpanel.princeton.edu/lansky-icmc-keynote.pdf`.

4. accretion & subtraction

4.1. accretion

Within the 'black boxes' of software artifacts, one finds chaotic, sedimentary, and dynamic agglomerations of human making. Far from comprising pure structure, software acts out an inextricably cultural project, offering a purportedly 'neutral' medium onto which people project their desires, and which builds itself from the accumulated history of these projections — a collective Rorschach Test rendered palimpsestic.[114]

This section takes a cross-section through various accumulations in order to reflect on their potential consequences to musicians. It proceeds 'top down', beginning with some of the accreted metaphors used to understand software as a cultural phenomena, proceeding through the interfaces encountered by users, and arriving at the technological underpinnings.

[114] a number of authors compare computing to a Rorschach Test; I encountered this first in Theodor H. Nelson, "Computer Lib / Dream Machines" 1974, and later in Sherry Turkle's work (for instance, Patrick D. Hopkins, ed., *Sex/Machine: Readings in Culture, Gender, and Technology*, Indiana Series in the Philosophy of Technology (Indiana University Press, 1999), 378.). I combine this with the imagery of a collective cultural palimpsest as a reformulation of Bernard Stiegler's *epiphylogenesis*, described more in Thor Magnusson, "Epistemic Tools: The Phenomenology of Digital Musical Instruments" (PhD thesis, University of Sussex, 2009), 68.

4.1.1. in the sky: (meta-)metaphors for software

To make sense of software, people make use of a wide variety of metaphors, comparing computing to both organisms and machines,[115] weaving,[116] painting,[117] cinema,[118] and more. Even descriptions of computing in terms of adjacent fields, such as math, engineering, and business, are best understood metaphorically.[119] This section considers three software metaphors, starting with two also used within music — as *text* and as *architecture* — then one specific to software: as *city*.

as 'text'

On the surface, that one 'writes' and 'reads' code using 'programming'[120] 'languages',[121] which are 'interpreted' by a machine, speaks for treating software as 'text'. Among its virtues, this metaphor extrapolates easily to powerful surrounding concepts like literacy,[122] and helps to ground today's computers in their history — many contemporary computers still strongly resemble their teletype forbears.

At their most insightful, such analogies can reveal profound aspects of both software and language. Maurice J. Black's *Art of Code*, for instance, observes in computing cultures a tendency to describe code in literary terms, and investigates the relationship between

115 Tomi Dufva and Mikko Dufva, "Metaphors of Code: Structuring and Broadening the Discussion on Teaching Children to Code", *Thinking Skills and Creativity* 22 (2016): 97–110.

116 The punched cards of the Jacquard Loom, for instance, precede their use in computing. Alex McLean revives this legacy in the "Weaving Codes — Coding Weaves" project.

117 see http://www.paulgraham.com/hp.html and rebuttal: http://idlewords.com/2005/04/dabblers_and_blowhards.htm

118 see Nelson, "Computer Lib / Dream Machines" and Lev Manovich, *The Language of New Media* (MIT Press, 2001).

119 see Janet Abbate, *Recoding Gender: Women's Changing Participation in Computing*, History of Computing (MIT Press, 2012), 53; also Richard P. Gabriel, *Patterns of Software: Tales from the Software Community* (Oxford University Press, 1996), xv: "Building software — some call it *software engineering* — is only 30 or 40 years old, and it shares with other engineering disciplines virtually nothing".

120 Thor Magnusson reminds us of the etymology of 'program': πρόγραμμα, a public writing.

121 See David Nofre, Mark Priestly, and Gerard Alberts, "When Technology Became Language: The Origins of the Linguistic Conception of Computer Programming, 1950–1960", *Technology and Culture* 55, no. 1 (2014): 40–75.

122 See Alan Kay, "The Future of Reading Depends on the Future of Learning Difficult to Learn Things", in *The Digital Turn: Design in the Era of Interactive Technologies*, ed. Barbara Junge et al. (University of Chicago Press, 2012).

practices of coding and writing.[123] It finds, through a comparative treatment of Joyce and object-oriented programming, an ironic alignment of software with a modernist sensibility and hermeneutic strategies, rather than a postmodern one.[124] Conversely, hermeneutic treatments of technology allow software artifacts to be 'read', revealing in them meanings obscured by a more functionalist orientation; software is by no means immune to the post-structuralist tendency to read artifacts as 'texts'.

But the comparison of software to language can just as easily mislead: people might conclude not only that computers somehow 'understand' language, but also draw false comparisons between the digital processor and the human brain.[125] That computers so often display and process text strengthens such perceptions, despite nothing of their construction or operation suggesting that they can 'understand' language to a greater degree than they can('t) any other symbolic form.[126]

At the same time that computationalists might quantize our language, dispossessing it of nuance, exchanges between authors of text and of software ensure an ever-renewing vitality. Flowing from literature towards software, generations of students of New Media now encounter Borges, Burroughs, Deleuze and Guattari, Haraway, and the Oulipo as influences.[127] From software towards literature, authors explicitly confront their software-saturated surroundings in their work. Kenneth Goldsmith, for instance, encourages us to harvest linguistic value from the contemporary glut of data, for instance, by simply

123 Maurice J. Black, "The Art of Code" (PhD thesis, University of Pennsylvania, 2002).

124 "… because programmers often understood their code as an art form, and, more often than not, as a *literary* art form, it is a strange irony of the history that I trace that the text-based hermeneutic strategies so frequently derided by cultural theorists as politically retrograde and theoretically naive simply provide the most progressive and illuminating tools available for articulating the special aesthetic valences of programming practice". ibid., 12.

125 David Golumbia, *The Cultural Logic of Computation* (Harvard University Press, 2009).

126 The fate of so-called 'natural language programming' corroborates this: when source code is made to resemble human language, it often results in an 'uncanny valley', where it resembles language only superficially and retains little of its flexibility. Programmers therefore commonly prefer languages purpose-built for programming, so they don't need to relearn a machine-regulated subset of their native language. 'Literate programming' strikes a deliberate balance, embracing the differences between natural languages and programming languages, and advocating for the two to be productively mixed. 'Natural-language processing', meanwhile, has found a new home in voice assistants in people's mobile phones and home-speaker-plus-surveillance devices; these definitely accomplish more than nothing, but still fail humorously to 'wreck a nice beach'.

127 this tiny selection comes from the *New Media Reader*.

reading it.[128] Caught in between, code and poetry have intertwined in various forms, from obfuscated code contests to postmodern text generators, 'code poetry' to programming language aesthetics, and more.

Whatever richness 'text' might offer in explaining and critiquing existing software, it lacks in applicable insights for those trying to 'author' software in the first place.

as 'architecture'

Within programming communities, 'architecture' has been appropriated to mean something akin to the art and practice of structuring complex software programs. The need for such structuring became apparent in the so-called 'software crisis' of the late 1960s,[129] when rapidly-expanding hardware capabilities outpaced the abilities of programmers to make use of them.[130] The growing complexity of software, coupled with the limited ability to correct faults at runtime, meant needing to devote up-front effort to formal specification. As documented by Fred Brooks, this encouraged divisions of labor between the comparatively few individuals tasked with designing a system's architecture and the comparatively many who would subsequently transform the architecture into runnable code.[131]

Brooks argues that this division helps ensure the 'conceptual integrity' of the system, which he bolsters with an appeal to the 'glorious unity' of the Reims cathedral: "the result proclaims not only to the glory of God, but also His power to salvage fallen men from their pride".[132] Lest software makers get swept away in the religious fervor, such 'conceptual in-

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128 "What we take to be graphics, sounds, and motion in our screen world is merely a thin skin under which resides miles and miles of language. […] Besides functionality, code also possesses literary value. If we frame that code and read it through the lens of literary criticism, we will find that the past hundred years of modernist and postmodernist writing has demonstrated the artistic value of similar seemingly arbitrary arrangements of letters." Kenneth Goldsmith, *Uncreative Writing* (Columbia University Press, 2011), 16.

129 see http://homepages.cs.ncl.ac.uk/brian.randell/NATO/NATOReports/index.html

130 "… as the power of available machines grew by a factor of more than a thousand, society's ambition to apply these machines grew in proportion, and it was the poor programmer who found his job in this exploded field of tension between ends and means". http://www.cs.utexas.edu/users/EWD/transcriptions/EWD03xx/EWD340.html

131 Frederick P. Brooks Jr., *The Mythical Man Month: Essays on Software Engineering* (Addison-Wesley Publishing Company, 1975), 44.

132 Ibid., 42.

tegrity' often crumbles at its first encounter with the physical media for real architects and software ones alike.[133] The insufficiently-supported cantilevers of Fallingwater, humidity issues of the Stata Center, or the blazing microclimate surrounding the Disney Concert Hall are just a handful of higher-profile examples that should resonate with anyone working closely with software. The architectural comparison appears to strengthen when one includes real failures among idealized successes.

Beyond the system designer as 'architect', the most protracted architectural analogy concerns 'design patterns' for software's creation. Influenced by the architectural classic *A Pattern Language* ('APL'),[134] the authors of *Design Patterns* document some collected wisdom for structuring software written in an object-oriented style. Among their patterns, now pervasive, they propose the `Abstract Factory`, `Memento`, and `Iterator`. While useful, these hardly approach the human-scale ambitions of the *APL*, with its 'mosaic of subcultures', 'dancing in the street', 'ring roads', and 'degrees of publicness'.

Richard Gabriel contributes an altogether more nuanced take on *APL* in his own *Patterns of Software*.[135] Weaving together decades of software development experience and a deep knowledge of Alexander's writing, he offers a witty, critical take on how software is *really* made. Alexander provides the book's forward, closing the disciplinary circle — aware and skeptical of the broader 'software patterns movement', Alexander challenges 'software people' to raise their ambitions.[136] With software contributing to a "vision of a technical world out of control, soulless, in which we are merely digits", the software people are called upon to take corrective action:

> If the heart of human existence, what matters most deeply to man, woman, child, really can find its way into computer programming, and into the programs, and into the meanings of those programs, and into the actual code and

133 "… since 1983, our group has worked as architects and general contractors. Combining these two aspects of construction in a single office, we have achieved what was impossible when one accepts the split between design and construction." Gabriel, *Patterns of Software*, ix. though, this is addressed on ibid., 60.

134 Christopher Alexander, Sara Ishikawa, and Murray Silverstein, *A Pattern Language* (Oxford University Press, 1977).

135 Gabriel, *Patterns of Software*.

136 "What is the Chartres of programming?" ibid., vii.

> substance of those programs, and into their effects — then the future world will be changed immeasurably.[137]

as 'city'

Treating software as a 'city', meanwhile, lets us understand software through the lens of our own daily experiences as city inhabitants. Paul Miller's "Photoshop is a City for Everyone",[138] for instance, offers insights into why the manufacturer can't prune Photoshop's extensive feature set: each feature satisfies the needs of someone within their broad constituency. While any given artist may use only a tiny fraction of the software, each uses a different fraction; even features since removed from the interface must be preserved to not break existing scripts. "Adobe can't simply decree how people use its product; as with a city, users find their own way through it."[139]

Where the writing and architecture metaphors emphasize acts of *creation*, the comparison to cities emphasizes software's ongoing *maintenance* — its continual, dynamic shaping in relation to the various interests of a broad group of stakeholders. In that sense, it echoes the call by Langdon Winner to consider the full socially-embedded lifetimes of technologies.[140] Even if 'inhabitants' managed to share a common vision for the cities they dwell in, such a vision would still need to be reconciled with the perspectives of city planners, structural engineers, etc., to make these visions into reality.

The comparison also illuminates the complex interplays of dependency, maintenance, and disruption. Frequent travelers along a metro line will surely understand that its planned extension will take ages, simply because they know it involves boring a giant hole under the city. Likewise, public utilities present a paradox found also in software 'infrastructure': that electricity and potable water are so essential to inhabitants means that they must be

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137 Ibid., xi.

138 Paul Miller, "Photoshop Is a City for Everyone: How Adobe Endlessly Rebuilds Its Classic App" (The Verge, 2013), `https://www.theverge.com/2013/2/13/3959868/`.

139 Ibid.

140 Langdon Winner, "Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology", *Science, Technology, & Human Values* 18, no. 3 (1993).

maintained with minimal disruption. This tends towards either complacency, leading to encrusted technological hodgepodges perpetually on the brink of high risk failure, or a continual stream of seemingly unnecessary modernizations.

The city analogy also reaches provocative breaking points. If individual programs are cities, what metaphor encompasses the total ecosystem of all programs, operating systems, and hardware?[141] How should we interpret programs like Minecraft, in which prodigious children build Turing machines out of the virtual materials intended to simulate new civilizations? or SimCity, which, by taking the city metaphor literally, can model dystopic neoliberal future societies?[142] or, finally, the use of software to design computing hardware of astounding complexity?[143]

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While somewhat removed from music making, this exercise examining our language around computing already goes some way to illustrating a heterogeneity that also permeates software itself.

4.1.2. on land: hybrids, metamedia, and the 'universal' machine

Beyond simply accreting explanatory metaphors, software as a medium directly incorporates and reconciles metaphors in its construction.

Lev Manovich, for instance, describes in *Software Takes Command* how the 'softwarization' of pre-existing media results in distinctly new 'hybrids'.[144] As a medium becomes digitized, replacing its physical media with digital simulations, the results make their own distinct combinations of 'media-specific' and 'media-independent' properties and techniques.

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141 maybe Buckminster Fuller's "World Game", or "Deep Thought" from the *Hitchhiker's Guide to the Galaxy*?

142 Paolo Pedercini, "SimCities and Simcrises", in *Proceedings of the International City Gaming Conference*, 2017, `http://molleindustria.org/GamesForCities/`.

143 Friedrich Kittler, "There Is No Software", *ctheory*, 1975, 10–18.

144 Lev Manovich, *Software Take Command*, International Texts in Critical Media Aesthetics (Bloomsbury, 2013).

Bringing media together within software does not imply their convergence, rather, that "the unique properties and techniques of different media have become software elements that can be combined together in previously impossible ways".[145]

Computing musicians encounter such hybrids constantly in their daily work. In one common software paradigm, we work with 'files' of sound, drawn as tiny seismograms,[146] and edit them using techniques derived from paper-era manuscript editing, analog tape splicing, and studio mixing. Another paradigm presents us with pictures of studio gear we can't directly touch or afford, but gives us the luxury of undo, and to dispense with the (virtual) drummer without drama. Any time at all spent thinking about the origins of concepts, representations, and terminology in these hybrid environments confirms the delightful inanity of it all.[147]

The same technical constructions that bring these media into collision also allow for the construction of new media having no physical precedents. Kay and Goldberg describe software as a 'metamedium' — a medium "whose content would be a wide range of already-existing and not-yet-invented-media".[148] If artists are 'metaphor explorers', as Eno suggests,[149] the metamedium offers not only a medium for making new music or new musical tools,[150] but also for reconsidering musical metaphors by making them malleable.

4.1.3. underground: abstractions from bits to Babel

Below software's graphical interfaces reside Goldsmith's "miles and miles of language": the layers of technical accretion encountered by software developers. As with the computing metaphors and hybrids, these technical constructions reflect a collective effort to navigate

145 Ibid., 171.
146 See Edgard Varèse and Chou Wen-chung, "The Liberation of Sound", *Perspectives of New Music* 5, no. 1 (1966): 12.
147 if this is meant to be my desk, who put a recycling bin *on top* of it?
148 Alan Kay and Adele Goldberg, "Personal Dynamic Media", *Computer*, 1977, 40.
149 Brian Eno, "Generative Music", *In Motion Magazine*, 1996, `http://www.inmotionmagazine.com/eno1.html`.
150 Kay and Goldberg, "Personal Dynamic Media", 38.

an open-ended medium, moving from the ideology that computers could do anything to a reality where getting a computer to do anything meaningful requires effort.

Connecting the promise and the practice of computing are heaps upon heaps of 'abstractions', the little white lies software developers tell themselves to get work done. Abstractions, a hallmark of structured programming, quarantine the complex inner workings of a system behind 'mind-sized' facades,[151] freeing a developer to think in terms of their higher-order relationships.

At their best, abstractions gain 'expressive' potential as they combine into ever-higher orders of abstraction — simple parts giving rise to complex systems. This is exemplified by the *NAND to Tetris* curriculum, which progresses in discrete steps from the boolean logic enacted by a computer's hardware to constructing applications in a high-level programming language.[152] Worth highlighting in this progression is the nebulous lower boundary of 'software': the lowest abstractions in software code for instructions in the hardware, the hardware having been designed through software. In Kittler's *There is No Software*:

> This postmodern tower of Babel reaches from simple operation codes whose linguistic extension is still a hardware configuration passing through an assembler whose extension is that very assembler. As a consequence, far reaching chains of self-similarities in the sense defined by fractal theory organize the software as well as the hardware of every writing.[153]

This situation is mundane for software developers, who encounter call stacks far less idealized than those of *NAND to Tetris* in their daily work. A typical call stack evidences a collective process of software building spanning decades, institutions, and programming languages. Even within a single program, people speak of digging through layered, complex code and trying to understand it as 'archeology'.[154]

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151 Seymour Papert, *Mindstorms: Children, Computers, and Powerful Ideas* (Basic Books, 1980), 103.

152 Noam Nisan and Shimon Schocken, *The Elements of Computing Systems: Building a Modern Computer from First Principles* (MIT Press, 2008).

153 Kittler, "There Is No Software".

154 See Andy Hunt and Dave Thomas, "Software Archaeology", *IEEE Software*, 2002, 22–24.

While abstractions are essential to computing systems, they also over-promise and under-deliver from at least three significant angles.

First, when abstractions evoke our previous knowledge of the world through their naming and claimed purpose — for instance, `number`, `date`, `pitch`, `instrument` — they set unattainably high expectations around their usage. Representing these concepts in software involves so many simplifying assumptions as to render much of the pre-existing knowledge they evoke irrelevant, or worse, misleading. A singer might find it strange to think of 'pitch' in terms of MIDI note numbers, or a guitarist to think of an 'instrument' as a graph of signal processing opcodes. Software representations, even in domains stereotypically associated with computing, perpetually remind us through their idiosyncracies that the 'map is not the territory'.[155]

Second, abstractions commonly 'leak' — they fail to conceal the details of their implementation fully, forcing developers to always consider both the abstraction and its instances. Joel Spolsky goes as far as to say that "all non-trivial abstractions, to some degree, are leaky".[156] These leaks often have surprising consequences, from unexpected performance degradations and security holes to global crises like Y2K. Developers encounter these idiosyncracies everywhere, all the time, and tolerate them in a sort of Faustian bargain.

Finally, the utility of abstractions makes them also easily abused, especially within programming environments that encourage specific forms of abstraction, irrespective of whether they are a judicious choice for the task at hand.[157] Various claimed purposes for abstraction — reuse, modeling, encapsulation, etc. — can easily get mixed and remixed within a single abstraction, yielding bewildering agglutinations.[158]

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155 Gregory Bateson, *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology* (University of Chicago Press, 2000), 455.

156 https://www.joelonsoftware.com/2002/11/11/the-law-of-leaky-abstractions/

157 thinking here of critiques of OOP, and especially Mike Acton's "Data-Oriented Design and C++": https://www.youtube.com/watch?v=rX0ItVEVjHc

158 a well-known multinational surveillance firm, for instance, has a class in their mobile phone application called `FBBoostedComponentCreateInputDataCreativeObjectStorySpecLinkDataCallToActionValue`.

When over-applied, abstractions cease being 'mind-sized'; they distribute their meaning across the software, forming "a big web, in which groups of abstractions are tightly interwoven with others by means of interfacial glue".[159] Making even simple changes to such a web requires painstaking attention to all of its interconnected parts.

4.1.4. accretion alienation

So, where does that all leave us?

Musicians, arriving at the computer, encounter software containing elaborate, hybridized musical models and workflows, built to address a broad constituency of musicians with conflicting needs, and having a correspondingly limited degree of possible change. This state of affairs, while especially attributed to commercial software, applies equally to Free and self-made software. Within music, the sheer social and technical complexities of building useful, usable software seem to dwarf even economic considerations as the predominant bottleneck.

The interpretation favored here is that our current approaches to building music software establish conditions of scarcity that all but ensure the results fall short of the aspirations of both their designers and musicians generally. New approaches to software development might make possible the DynaBook dream, that normal people might create their own bespoke software and share it with their friends; in the meantime, we continue to face the gap between software's promises and its concrete realizations as heaps of accumulated pragmatism.

4.2. subtraction

For musicians desiring more from software, hearing of giant interfacial webs, Rorschach palimpsests, or cities of disagreeing citizens provides little consolation. While these com-

[159] Gabriel, *Patterns of Software*, 19.

parisons do little to improve the situation, they can suggest tactics for coping — if software builds through accretion, why not just peel back the irrelevant, constraining layers, and rebuild on top of the useful ones?

Tactics of subtraction are altogether familiar within experimental music, where musical attempts often require forgoing ready-made conveniences in favor of the self-produced — forging new instruments, opening new venues, defining new notational schemes, and more. Even within sound alone, Aaron Einbond uses 'subtractive synthesis' to speak of the condition of contemporary musicians curating their music from the acoustic totality.[160]

Within software, subtraction makes available both new promises and new difficulties, as one set of constraints and affordances become replaced with another. This section considers a few pertinent questions: how far should one subtract? to what effect? and, how possible is subtraction, anyway?

4.2.1. non-use

Given how much wonderful music the world has developed without the supposed benefits of computing, giving up software entirely has its appeals. Unsurprisingly, even such a straightforward proposition already brings complications.

At the very least, as cultural norms shift towards pervasive computer use, non-use becomes an increasingly marginal perspective, subject to misinterpretation or scrutiny.[161] Sally Wyatt observes this phenomena in policy discussions around internet access, where non-use is often presumed as "a deficiency to be remedied", associated with a 'digital divide' between the 'haves' and the 'have-nots'.[162] When juxtaposed with the trope of technological

[160] Aaron Einbond, "Subtractive Synthesis: Noise and Digital (Un)creativity", in *Noise in and as Music*, ed. Aaron Cassidy and Aaron Einbond (University of Huddersfield Press, 2013), 58.

[161] at the least, these shifting norms lead to the reinterpretation of past behaviors, most intensely exhibited within historically-informed performance practice.

[162] Sally Wyatt, "Non-Users Also Matter: The Construction of Users and Non-Users of the Internet", in *How Users Matter: The Co-Construction of Users and Technology*, ed. Nelly Oudshoorn and Trevor Pinch (MIT Press, 2003), 68.

progress, choosing to make music without computers might increasingly read as reactionary or nostalgic, irrespective of the musician's intentions.

To capture the variety of motivations for non-use, Wyatt et al. (2002) provide four preliminary categories: 'resisters', 'rejecters', 'excluded', and 'expelled'.[163] Where the 'resister' foregoes use out of a belief that use doesn't benefit them, the 'excluded' never get an opportunity to find out, having been systemically denied access. The 'rejecters' and 'expelled', meanwhile, both give up use for variety reasons, but with the 'expelled' having done so involuntarily. This framework, though simple, already highlights that the ability to reject reflects a privilege of access denied to the 'excluded' and 'expelled'; a musician may well come to have their music understood in relation to technological possibilities unavailable to them.

Since approaches to developing and analyzing technologies conventionally focus on use, the needs of the 'invisible group' of non-users are left problematically unaddressed, irrespective of their underlying cause.[164] When these heterogenous stakeholders are ignored, technological development predominantly serves the needs of the more visible, vocal users, which may in turn yield an even less habitable result for the non-users.[165] As this cycle reinforces, the groups can undergo a progressive differentiation, a schismogenesis,[166] after which they become naturalized as having essential differences.[167]

For musicians, these consequences notably undermine the effectiveness of rejection as a means of critique. For instance, when academics isolate their subset of music computing

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163 Sally Wyatt, Graham Thomas, and Tiziana Terranova, "They Came, They Surfed, They Went Back to the Beach: Conceptualizing Use and Non-Use of the Internet", in *Virtual Society?: Technology, Cyberbole, Reality*, ed. Steve Woolgar (Oxford University Press, 2002), 36.

164 Wyatt notes that that while "resistance and rejection play an important shaping role" in several historical accounts of technologies, "informed, voluntary rejection of technology is not mentioned". Wyatt, "Non-Users Also Matter", 79.

165 "would mobile phones make such irritating noises if non-users had been involved in their design?" ibid., 78.

166 Gregory Bateson, *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology* (University of Chicago Press, 2000).

167 With some hesitation, I suggest that a systemic failure to take seriously the causes of music software rejection can partly account for the emergence of the camps of 'electronic' and 'acoustic' music in many academic music communities and institutions. This elevates a shallow distinction of musical means into a structural division, which conceals from each group the input from the 'non-users' of the other.

into specialized departments, events, and communities, these become unlikely venues for substantial challenges, since the fundamental othering and expulsion of dissent has already occurred. To raise and address the underlying causes for rejection in these contexts might then require representation from within, for instance, through esteemed elders with organizational karma to burn. Their 'state of the field' writings often recapitulate perspectives lost to the community through such a division.[168]

4.2.2. 'from scratch'

A slightly less extreme approach than non-use can be seen in claims to build 'from scratch', a slogan that provocatively reframes subtraction as addition. While used in a variety of contexts, it commonly celebrates an individual crafting significance from insignificance; this trope pervades computing and modernist musical literatures, typified by these bold quotes by Frederick Brooks and Herbert Brün, respectively:

> The programmer, like the poet, works only slightly removed from pure thought-stuff. He builds his castles in the air, from air, creating by exertion of the imagination.[169]

> Composers do not simply attempt to translate traditional techniques of composition into programming languages, nor are they interested in having the computer simulate conventional stilistic prejudices. They tend rather to start from scratch, to begin by stipulating what music is to be once the assistance of computers has become available.[170]

'From scratch' has a particularly close affinity to 'experimental music', in that it projects an identification with an unexplained subtraction. This leaves open exactly what the 'scratch' in question is, allowing for a variety of interpretations, from modifying a preset sound of a pre-made virtual instrument in a pre-made software program ("building a drum sound from scratch") to, say, point-to-point soldering components on paper circuits ("building

168 thinking here of the contributions of Lansky, Moore, Ostertag, and Zicarelli.

169 Frederick P. Brooks Jr., *The Mythical Man Month: Essays on Software Engineering* (Addison-Wesley Publishing Company, 1975), 7.

170 Herbert Brün, "Infraudibles", in *Music by Computers*, ed. Heinz von Forester and James W. Beauchamp (John Wiley & Sons, 1969), 118.

a synthesizer from scratch").[171] An avid do-it-yourselfer, having just hand-spliced their music out of carbon atoms under an electron microscope, might retain some lingering guilt that they didn't go far enough.

Say, as long as we're building from atoms, how about we bake an apple pie?[172]

If we're in a rush, maybe we should probably skip Sagan's recipe this time; just heat up a frozen one, slap a dollop of whipped cream on it, and call it a day. (But we've got our reputation as professional bakers on the line![173]) Maybe we could take a shortcut: since the universe we would need to invent would need to be the same sort of universe in which apple pies pre-exist, we could probably just reuse the existing universe without compromising on flavor too much.[174] But, as long as we're not following the recipe, and not in a rush, maybe we could consider other options?

What about inventing a new universe in which peoples' notions of apple pie were so radically different, the resulting pie could never have a'risen in our current one?[175] Or, inventing new universes in which our desire for an apple pie has already been satiated without need of baking? Or, what if we dispensed with this tiresome pie? We could practice inventing better and better universes, some with and some without pies, and without any specific allegiance to apples…[176]

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171 thinking here of Peter Blasser's work.

172 "If you wish to make apple pie from scratch, you must first invent the universe." Carl Sagan in *Cosmos*.

173 thinking here of Matthew Herbert's manifesto: https://matthewherbert.com/about-contact/manifesto/

174 "If you wanted to do everything Photoshop does, you'd have to do it in the same way Photoshop does." Paul Miller, "Photoshop Is a City for Everyone: How Adobe Endlessly Rebuilds Its Classic App" (The Verge, 2013), `https://www.theverge.com/2013/2/13/3959868/`.

175 thinking of "reinventing the square wheel". Square wheels aren't as absurd of a thought when the road is made of catenary curves: https://www.youtube.com/watch?v=LgbWu8zJubo

176 "If anything, 'Don't Reinvent the Wheel' should be used as a call to arms for deeply educating yourself about all the existing solutions — not as a bludgeoning tool to undermine those who legitimately want to build something better or improve on what's already out there. In my experience, sadly, it's much more the latter than the former. So, no, you shouldn't reinvent the wheel. Unless you plan on learning more about wheels, that is." Joel Spolsky, https://blog.codinghorror.com/dont-reinvent-the-wheel-unless-you-plan-on-learning-more-about-wheels/

4.2.3. 'presets of the mind'

These sorts of cascades of subtraction and reinvention need to bottom out at some point if anything at all is to get done. As Robert Henke puts it, "the entirety of music, its entirety of possibilities, is too huge for one individual. […] you need to identify the aspects that are closest to your heart and concentrate on these".[177] This means taking some musical choices as axiomatic — irrespective of what they are — to allow responses to flourish.

Stefan Goldmann, through his interviews in *Presets: Digital Shortcuts to Sound*, finds artists holding radically different aspects of music constant, including guitar tunings, chord progressions, rhythmic patterns, instruments, sounds, effects, and more.[178] Beyond simply freeing musicians' attention to focus elsewhere, these choices encode deeply-held convictions about what is and is not important within music — they form 'presets of the mind'.[179]

In practice, these 'presets' reflect both an individual's musical taste and their underlying preferences about what one *does* when they are making music. If the impulse to make music at all constitutes a subtraction — from enjoying existing music to making something new — this impulse also frames which musical activities are seen as rewarding. Software developers face a similar dilemma in their eternal balance between reusing existing software libraries and creating new ones. The most satisfying and effective resolution typically lies somewhere between the extremes of rejecting all existing software ('not invented here syndrome') and rendering oneself irrelevant through embracing reuse.

In both software and music, the selection of 'presets' engages questions around personal purpose and sense of accomplishment. In the vocabulary of 'flow', too little subtraction might result in boredom, too much, in anxiety. Balancing these all but ensures overemphasizing reinvention, the self-satisfaction associated with having succeeded at *doing something* overtaking our judgement about whether it was worth it.[180]

177 Stefan Goldmann, *Presets: Digital Shortcuts to Sound* (The Tapeworm, 2015), 34.
178 Goldmann, *Presets*.
179 Ibid., 13.
180 "People set out for new timbral horizons, get lost along the way in the writing of the code, the troubleshooting of the systems, and the funding to make the whole thing possible, then fail to notice that the results do not justify the effort." Bob Ostertag, "Why Computer Music Sucks", *Resonance*, Texts

4.2.4. digging for radishes

Another prominent approach to subtraction observes patterns across peoples' 'presets of the mind', and subtracts past them to reveal them as negotiable constructions.

Luc Döbereiner describes 'non-standard' approaches to sound synthesis like Koenig's SSP and Brün's SAWDUST in terms of Badiou's 'radical subtraction': "The subtractive strategy seeks 'to purify reality […] by withdrawing it from its apparent unity so as to detect in it the miniscule difference, the vanishing term that is constitutive of it.' "[181] By eschewing a 'reproductive' modeling of sound in favor of the "reduction of composition to the coordination of time and amplitude points", they bring about an 'axiomatic disorientation'.

This approach — *digging for radishes*[182] — means committing to a shift in what is taken to be axiomatic to music, but also to the specific disorientations this shift brings about when juxtaposed with the alleged 'preset'. In Döbereiner's examples, writing music from individual audio samples commits both to the sample being a relevant musical material and to foregrounding the difference between what *can be done* with samples and what *has been done* with them. Both of these levels of analysis are essential, since not all potential axioms or disorientations may be equally worth the commitment. A short sequence of radical subtractions from the culinary world helps illustrate this.

The drink Soylent rather radically subtracts food from food: designed as a complete 'meal replacement', it contains the sum of the nutrients thought to be essential for sustaining human life in the form of a powder. In designing the drink, the manufacturer takes state-of-the-art knowledge about nutrition and reverses it into a literal additive synthesis. Doing so risks taking an analytical approach as a sufficient explanatory account: that *what we know about nutrition* is *how nutrition works*. Since our explanatory models are always

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on improvised and experimental music, 2001. See also Michael I. Norton, Daniel Mochon, and Dan Ariely, "The IKEA Effect: When Labor Leads to Love", *Journal of Consumer Psychology* 22, no. 3 (2012): 453–60.

181 Luc Döbereiner, "Models of Constructed Sound: Nonstandard Synthesis as an Aesthetic Perspective", *Computer Music Journal* 35, no. 3 (2011): 32.

182 thinking here of the roots — etymological and otherwise — of 'radical'.

necessarily incomplete leads to experiential gaps — various exciting 'bugs' from having not modeled certain complexities of digestion.[183]

Additive synthesis within music, at least in an orthodox form, adopts a similar axiomatic shift, treating sounds as the sum of sine waves. This view, arising from the exciting possibilities of understanding sound spectrally, risks conflating that sound *can be usefully understood* as a sum of sines with the stronger, problematic assertion that sound *is* a sum of sines.[184] When encoded directly into our tools, this can lead to specific sonic aesthetics, for instance, the pervasive ringing heard from inattentive use of spectral effects. (Questions of digestibility are left to the reader.)

Following a similar line of thinking — that food can benefit from applying scientific knowledge — molecular gastronomy adopts a markedly different approach, privileging and enhancing the experience of dining rather than seeking to eliminate it as a nuisance. These chefs use their knowledge to stage playful, clever disorientations — a culinary 'alchemy' of surprising flavors, textures, and appearances.[185]

Finally, and to close on a root vegetable, Dan Barber's Mokum Carrots present an even more charged axiomatic disorientation. These carrots reflect an ecological approach to food that elevates the plate to being the focal point connecting nature with human ingenuity. There, all of the planet's vital systems, from soil to sunlight, express themselves into a glorious tuber. Within a world that dislocates humans from the 'vegetable matrix',[186] this makes especially poignant that our default orientation towards our natural surroundings is one of disconnection.

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183 the Soylent release notes, while mercifully non-specific, indicate various improvements to the powder's texture and color, but also to exchanging various constituent ingredients for others of the same function that can be more easily digested.

184 "It was thought that any timbre could be synthesized simply by setting up a series of oscillators to produce each component partial frequency of the timbral spectrum as a steady-state sine wave. But this produced woefully poor results, since it omitted several other crucial and idiosyncratic elements of timbre, in particular the interrelated evolution of each partial in time and variable degrees of noise, both of which are now known to contribute to the organic quality of interesting timbres." Georgina Born, *Rationalizing Culture: IRCAM, Boulez, and the Institutionalization of the Musical Avant-Garde* (University of California Press, 1995), 59.

185 thinking here of the music of Paul Koonce.

186 to borrow Terence McKenna's phrase.

4.2.5. selective non-use

By far, the most common relation to software is that of selective subtraction, where a musician makes use of some opportunities afforded by software while foregoing others. As with 'presets of the mind', these choices highlight and emphasize the musician's own values, even when these present apparent inconsistencies.

The recent resurgence of modular synthesizers, for instance, reflects in part a desire by electronic musicians to get out of the glow of monitors and to enter a more tactile, exploratory way of making music. This recalls the division Georgina Born observed at IRCAM between those deploying "high rationalism and scientism" on the expensive 'high technologies' and those who "countered 'high-tech domination' with a practice centered on the celebration of the small and low-tech".[187]

David Behrman's forward to Nic Collins's *Handmade Electronic Music* accounts for similar motivations within hardware hacking:

> Only in recent recent decades have music instruments and software become corporate, mostly mass-produced and mass-marketed, and only recently are the computers used for music generally the same ones found in tens of millions of business establishments. It isn't surprising that there had to be a reaction among artists to this corporate stain, if one could put it that way, that has spread into the fabric of music.[188]

This 'stain' seems to have caught up with analog electronics. Rather than competing with or supplanting computers, modular systems now coexist in hybrid music making environments with them, often embedding computers of their own, narrowing the gap between these approaches.

In another curious resurgence, a number of younger composers now publish handwritten musical scores. While such a choice would be unremarkable some decades ago, it now projects a conspicuous non-use in an era when these composers increasingly use computers

187 Ibid.
188 Nicolas Collins, *Handmade Electronic Music: The Art of Hardware Hacking* (Routledge, 2006), ix.

in other aspects of their musical and non-musical lives, when neither scores nor publishing should be taken as given, and in which software for graphics and music notation has finally attained a level of maturity. Irrespective, these musicians have precedent among computing academics from decades prior:

> There is, indeed, a significant (and to the outsider, a surprising) current of ambivalence about mechanization in the culture of élite, theoretical computer science. The iconic representation of this ambivalence is in the matter of writing. Within this strand of computer science, the fountain pen, to others an archaic technology became something of an icon. Dijkstra's beautifully handwritten lecture notes and correspondence have become famous. One of Dijkstra's students even hand-wrote, and published in handwritten form, his PhD thesis (van de Snepscheut 1985), to which Dijkstra contributed a handwritten forward.[189]

To the extent that this non-use is intended as a critique — say, as a foregrounding of the materiality of hand, pen, and ink, or on the death of writing — this takes on another dimension of interpretation when these scores and writings inevitably become digitized. As scanned copies flit about on the internet, they come to even more aggressively foreground their digital mediation through the compression artifacts that plague them as bitmap images.

[189] Donald MacKenzie, "Computing and the Cultures of Proving", *Philosophical Transactions of the Royal Society* 363 (2005): 2341.

5. control & subversion

5.1. agency & control

When computers augment our capability to act, our actions carry expanded potential consequences. Within the literatures of computing and of experimental music, such increased stakes often appear through exaggerated dichotomies of control and freedom, domination and liberation, authoritarianism and democracy.

Sherry Turkle, for instance, found through her extensive fieldwork with young men their "intense need to master things; their addiction is not to computer programming but to playing with the issue of control. It is about exerting power and domination within the unambiguous world of machinery".[190] This is no less true with computed music, where control signals, control flow, and controllers (at least) indulge the needs of the control freak. Tara Rodgers's interviews, meanwhile, highlight women who "stake out philosophical positions that run counter to using dominant technoscientific priorities of precision and control as ends in themselves".[191]

This section addresses a few scenarios in which control becomes a central topic of discussion, in order to highlight the importance of evaluating claims of control in their originating contexts, beyond a simplistic dualism of *having* or *not having* it, and with a sensitivity to informed and non-coercive consent.

[190] Judy Wajcman, *Feminism Confronts Technology* (Pennsylvania State University Press, 1991), 142.
[191] Tara Rodgers, *Pink Noises: Women on Electronic Music and Sound* (Duke University Press, 2010), 8.

5.1.1. (under)determining humanity

Viewed broadly, the question of whether humans have any agency at all regarding technology, and to what extent, can be seen in the caricatured dichotomy of 'technological determinism' and 'social constructivism'.

As a stance, technological determinism "claims that technologies have an autonomous functional logic that can be explained without reference to society".[192] Whatever one holds as the 'essence' of this functional logic — typically efficiency — directs the overall course of humanity.[193] Therefore, society might merely reflect an inevitable technological 'progress', relegating us to being the "reproductive organs of the machine world".[194] Social constructivism inverts this relationship, understanding technology as resulting from distinctly human concerns, and arising out of human actions embedded within social contexts. Among those observations that support this view is that technologies are always 'underdetermined',[195] their development proceeding along very different paths depending on those involved and their interactions.

Between these extremes lie more nuanced positions, 'softening' determinism to allow for resistance and 'shaping', and acknowledging that many of the negative effects ascribed to determinism may well arise instead from peoples' deliberate choices. Donna Haraway captures some of these latent complexities:

> Technologies and scientific discourses can be partially understood as formalizations, i.e., as frozen moments, of the fluid social interactions constituting them, but they should also be viewed as instruments for enforcing meanings. The boundary is permeable between tool and myth, instrument and concept, historical systems of social relations and historical anatomies of possible bod-

192 Andrew Feenberg, *Questioning Technology* (London: Routledge, 1999), 77.
193 Ibid., ix.
194 Marshall McLuhan, *Understanding Media: The Extensions of Man* (McGraw-Hill Publishing, 1964), 46.
195 Feenberg, *Questioning Technology*, 79.

> ies, including objects of knowledge. Indeed, myth and tool mutually constitute each other.[196]

This view highlights the fatal incompleteness of the conventional 'instrumental' understanding of technology, which by focusing only on what tools might offer an individual misses the crucial balancing acts between control and the controlled, between functions and meanings, and between individuals.

5.1.2. command and control(s)

The reduced case of a user interface button, the simplest of 'controls', exhibits a number of these balances. Buttons at once grant us explicit sites of control, where we can inflect running software to bring it in line with our whims, but also highlight how contingent and pre-determined our involvement is: the button's very existence reflects a design decision to expose an action to a user. For every action delegated to a user, a countless number lurk beneath the technological surface, unavailable. In this way, a designer expresses 'control' in making the decision whether to provide one.

Buttons also highlight the conventional nature of the graphical interface: despite all of the layers of translation and transduction separating our real-world motions from their virtual-world effects, we readily identify shapes on a screen as suitably button-like and project our intentions through a cursor surrogate. Pressing a button could have any result, from none at all[197] to setting into motion unintended, irreversible processes. While some designers may strive to match the appearances and interactions of these controls to their effects, others might not, or might exploit these conventions to nefarious aims.[198]

Irrespective, we come to internalize the interaction conventions by which we take control over software, entraining ourselves on them to the point we can replay them with little to

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196 Donna J. Haraway, "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century", in *Sex/Machine: Readings in Culture, Gender, and Technology*, ed. Patrick D. Hopkins, Indiana Series in the Philosophy of Technology (Indiana University Press, 1991), 47.

197 thinking here of 'placebo buttons'.

198 thinking here of 'dark patterns'.

no conscious effort; we become software sleepwalkers, giving over intentional control to habit. The same instincts that allow us to dismiss dialog boxes and licensing agreements without reading them also allow the crew of trains, airplanes, and medical equipment to reflexively disable alarm systems designed to be 'failsafe'. A combination of poorly-designed interfaces, entrained or inattentive users, and inadequate safeguards can easily cause catastrophic failures; even simple errors, like false missile alerts,[199] can have severe consequences when they involve countries embroiled in diplomatic tensions and with well-stocked thermonuclear arsenals. This makes it all the more 'pressing' that, as Søren Pold describes, "buttons are verbs that rule out tenses other than present tense, and rule out modal auxiliary, subjunctive, and other more sophisticated ways in which our language expresses activity".[200]

Where buttons typically enable a one-to-one correspondence between action and result, 'control flow' structures such as conditionals and loops provide programmers with the building blocks for more complex algorithms. These allow repetitive or undesirable work to be delegated to the computer, shifting the role of a human towards 'steering' increasingly higher-level processes. Such automation, abstracting away labor, often comes with lofty claims of increased productivity and leisure time — at least for those not finding their own work displaced. Since automation disproportionately eliminates the labor of those already in precarious economic positions, an individual's surface-level choice of whether or not to automate a process already implies their deeper position of macroeconomic power: to control whether specific work is more profitably done by human robots[201] or machine ones.

When automated, processes proceed without exception, losing the possibilities for direct human intervention.[202] The feeding machine in Charlie Chaplin's *Modern Times*, for instance, showcases a new corn-on-the-cob lathe, meant to efficiently feed Chaplin's working-class character. When it instead spins erratically against his face, the team of dap-

199 thinking of the two in Hawaii and Japan earlier this year.
200 Matthew Fuller, ed., *Software Studies: A Lexicon* (MIT Press, 2008), 34.
201 from *robota*: forced labor.
202 thinking here of the molten steel blobs formed by robot welders in Laurie Anderson's "Dr. Miller".

per bureaucrats looking on is apparently more concerned with the machine's malfunction than with the distressed human. A software parallel, 'inadvertent algorithmic cruelty',[203] results from systems engineered to work properly most of the time, but which cause undue suffering in exceptional cases. When social networking sites prompt people to 'reconnect' with their deceased loved ones, or a camera's facial recognition algorithm only identifies light-skinned faces, we then face a gap between what an empathic person might do in these circumstances and the behavior of the algorithms that replaced them.

This gap widens when we defer our decision making to statistical algorithms, common within machine learning, rather than to deterministic, auditable control flow. When these decisions have profound human consequence, for instance in steering self-driving cars, technical choices take on a significant ethical dimension. At the very least, responsible design requires scrutinizing the consequences of algorithmic failures, not just the opportunities of their successes; this also suggests approaches to ethical accountability that analyze failures back to the development processes that permitted them. When algorithms systematize racism, for instance through denying bank loans, it is hardly an acceptable response that they functioned most of the time on a cross-validated training set.[204] If deterministic algorithms can enable subjugation, statistical ones can enable subjugation *arbitrarily*.

Further, many algorithms work against individual agency even in their properly functioning state. Haraway's "Cyborg Manifesto" speaks to an 'informatics of domination' associated with a military-industrial 'command, control, communication and intelligence'.[205] She proposes noise as a form of resistance — a perspective also evoked in various ways in experimental music literature.[206] In light of more recent approaches to information, this metaphor proves more aspirational than effective: techniques for harvesting and processing 'big data', for instance, flatten any distinction between noise and signal; the data

[203] https://meyerweb.com/eric/thoughts/2014/12/24/inadvertent-algorithmic-cruelty/

[204] Safiya Umoja Noble introduces the concept of 'technological redlining' in *Algorithms of Oppression: How Search Engines Reinforce Racism* (New York University Press, 2018).

[205] Haraway, "A Cyborg Manifesto", 444.

[206] for instance, Attali's *Noise: The Political Economy of Music*; Luigi Russolo, "The Art of Noises", 1913, `https://www.unknown.nu/futurism/noises.html`; Rodgers, *Pink Noises*.

debris of resistance simple get hoovered and analyzed as easily as any other data. Exploiting this, multinational 'advertising' firms now unapologetically blanket the internet with interconnected behavioral trackers — a 'data dragnet' through which they can deal in microtargeted 'influence'. No longer limited to selling products, these companies now sell public sentiment more broadly, leading to broader questions about the extent to which democracy itself is 'under control'.

5.1.3. controll(er)ing music

Within music, the tendency towards steering higher and higher-level processes has supported a shift from the era of "twenty men furiously bent on the redoubling the mewing of a violin"[207] to one where similar mewing no longer requires any human involvement at all. Loop-based, algorithmic, and generative musics highlight this through their elevation of algorithms to aesthetic objects; meanwhile, music computing in general benefits from the possibilities of automation, deferral, and the disconnection of human effort from its effects. As George Lewis put it, the composer now "relinquishes some degree of low-level control over every single bloop and bleep in order to obtain more complex macrostructural behavior from the total musical system".[208]

Within the 'digital musical instrument' literature (DMI), these concerns are addressed explicitly through the separation of 'control', 'sound generation', and the 'mappings' which bind them together.[209] This separation enables previously impossible musical behaviors, but also raises new challenges, for instance around the intelligibility of a performance to an audience, the relevance of skill and virtuosity, and the degree of attainable musical diversity.[210] While DMIs can offer musicians new challenges — for instance, by dynamically reconfiguring their instrument before each performance — normative approaches to in-

207 Russolo, "The Art of Noises".

208 Robert Rowe and Brad Garton, eds., "Editor's Notes: Putting Max in Perspective", *Computer Music Journal* 17, no. 2 (1993): 11.

209 See Marcelo M. Wanderley and Philippe Depalle, "Gestural Control of Sound Synthesis", *Proceedings of the IEEE* 92, no. 4 (2004): 633.

210 Sile O'Modhrain, "A Framework for the Evaluation of Digital Musical Instruments", *Computer Music Journal* 35, no. 1 (2011): 39.

strument design adopt reliability and predictability as design principles; as described in Wessel & Wright (2002), "although we want our generative algorithms to fill in musical details not directly specified by the control gestures, we always want to feel that we have complete control, at least at a high level of abstraction, over the sounds our instruments produce".[211] O'Modhrain adds to this the expectation that even unpredictable algorithms "too must behave in a reliably unpredictable way".[212]

An effect of such predictability could be to help audience members to perceive cause and effect relationships between physical movements and sound, with the intention of reassuring them that the music they are experiencing is, in fact, being controlled by a human.[213] This could help legitimize a new approach to music making by aligning its practices with accepted ones from acoustic instruments, but, in doing so, could also discard those musical possibilities unique to digital instruments to satisfy assumptions about the audience experience. Ultimately, audience members may not notice, desire, or privilege treating digital musical instruments in a causal way, and may not care deeply whether the performance they experienced was genuine or an elaborate pantomime.

Embracing these tensions, Thomas Royal reframes computer music as a form of play, a theater through which the audience can discover the underlying rules.[214] Rather than transplanting performance norms from acoustic music, computer music then "sonically aestheticizes the relinquishing of control of human performers to their technologies".[215]

5.1.4. musical agents

Systems like George Lewis's *Voyager* and Agostino Di Scipio's *Audible Eco-Systemic Interface* stage this play explicitly by constructing 'non-hierarchical' relationships between

211 David Wessel and Matthew Wright, "Problems and Prospects for Intimate Musical Control of Computers", *Computer Music Journal* 26, no. 3 (2002): 14.
212 O'Modhrain, "A Framework for the Evaluation of Digital Musical Instruments", 33.
213 See W. Andrew Schloss, "Using Contemporary Technology in Live Performance: The Dilemma of the Performer", *Journal of New Music Research* 32, no. 3 (2003): 239–42.
214 Thomas M. Royal, "The Performance of Music Using Computers and Its Reconception as Play" (PhD thesis, University of Florida, 2014), 21.
215 Ibid.

musicians, technologies, audiences, and acoustic spaces. While authoring these systems necessarily impresses into them musical norms, authorship recedes from the site of performance, where human and machine contributions become equalized. This tendency appears also in other arts, similarly faced with the generative possibilities of computing:

> As computers have developed, we have seen our relationship with them change and the computer's role shift from that of a 'tool' under the direct control of the artist to that of a collaborator or creative partner and, potentially, an autonomously creative entity. This suggests a continuum of creative agency, assigned in shifting proportions between human and machine and inversely proportional to the degree of control and intention in the role of the human artist.[216]

By successfully deprivileging the human musician, these systems set the stage for their complete removal. Software-based musical agents, for instance, begin to model, extend, and displace many human musical behaviors. Some approaches to the computer simulation of musical creativity contain closed feedback networks of agents tasked with composing, performing, listening, and evaluating music, leaving their human authors on the sideline to observe their behaviors.

5.1.5. letting sounds be (what we decide)

If we grant musical agency to algorithms, why not also to sounds themselves?

Cage's well-known call to "let sounds be themselves"[217] expresses this desire in a characteristically paradoxical way — simultaneously embracing sounds as autonomous, but making their agency contingent on the human structuring force concealed behind the word 'let'. (How fragile a sound's agency must be if it always depends on human approval!)

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[216] John McCormack et al., "Ten Questions Concerning Generative Computer Art", *Leonardo* 47, no. 2 (2014): 136.

[217] "one may give up the desire to control sound, clear his mind of music, and set about discovering means to let sounds be themselves rather than vehicles for man-made theories or expressions of human sentiments", John Cage, *Silence* (1961; repr., Wesleyan University Press, 1973), 10.

Within many Cage classics, sounds become 'themselves' through extensive human efforts — the construction of *Williams Mix* (1952), for instance, involved a year worth of tape splicing by his friends, following a 192-page score, in which sounds had been meticulously recorded and pre-categorized.[218] Or, *Atlas Eclipticalis*, with a similarly laborious score production process, and involving large performance forces.[219] Further, not all sounds are equal candidates for 'letting': Charlotte Moorman's sound selections for *26' 1.1499" for a String Player* differ starkly from those Cage might have made: 'cats copulating', 'orgasms', and 'flatulent lady'.[220]

These examples demonstrate the very sort of controlled categorization and manipulation of sounds that many musicians have since come to reject. Kaffe Matthews, in embracing the rich connections between herself, her instrument, a performance space, and its audience, seeks out "ways of making music using electronics that are away from things being fixed and super-produced and predetermined and controlled".[221] Or, as Annea Lockwood describes, "through media, we think, we feel we can fix [sounds]. But in their natural state, *sounds in their natural state* — that's a concept I sort of like — are not fixable are they?"[222]

Since sounds sound without our permission, the contentious 'let' mixes at least three distinct perspectives on agency: the sounds themselves as agents, the possibility for people to capture and structure them, and the possibility to structure peoples' encounters with them. A musician truly concerned with upholding sounds' agency might dismiss acts that impose structure upon them — they might, to use Cage's tripartite language, listen without composing or performing. Some steps in that direction could be to rubber stamp 'LISTEN' on peoples' hands and send them out into the world,[223] engage in documentary field

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218 Tom Erbe, "The Computer Realization of John Cage's *Williams Mix*", in *Proceedings of the International Computer Music Conference*, 2016, 154–58.

219 See Benjamin Piekut, *Experimentalism Otherwise: The New York Avant-Garde and Its Limits* (University of California Press, 2011), ch. 1.

220 Ibid., 154.

221 Rodgers, *Pink Noises*, 41.

222 Ibid., 125.

223 here using Max Neuhaus's LISTEN as a representative sound walk. http://www.max-neuhaus.info/soundworks/vectors/walks/LISTEN/

recording practices,[224] or develop practices of sonic mindfulness.[225] But these, too, impose human structure.

Ascribing agency to sounds, then, may well function more as a sociopolitical allegory than as an actual call for a non-anthropocentric understanding of sound. This plays out famously in Feldman's anecdote:

> My past experience was not to 'meddle' with the material, but use my concentration as a guide to what might transpire. I mentioned this to Stockhausen once when he asked me what my *secret* was. "I don't push the sounds around." Stockhausen mulled this over, and asked: "Not even a little bit?"[226]

This anecdote gains its charm largely from the received, mythologized history of how these two composers related to music and musicians[227] — the 'sounds' in this exchange could just as easily stand in for the people making them.

5.1.6. performing control

Even in the simplified case of an artist performing their own work, performance can highlight challenging questions around agency. In Yoko Ono's *Cut Piece* (1964), for instance, she surrenders control of her own clothing to an audience, given scissors. Marina Abramović takes this dynamic to its extreme in her *Rhythm 0* (1974), surrendering her whole body. The audience members, as co-performers, acted in a variety of ways from protecting the performer to sexually assaulting and torturing her. That a loaded gun brought the performance of *Rhythm 0* remarkably close to the artist's death highlights a deep divide between consent and desire; even when the work defers control to the audience members, it does not absolve them of the consequences of their actions.

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224 for instance the World Soundscape Project.

225 for instance Deep Listening.

226 In Christoph Cox and Daniel Warner, eds., *Audio Culture: Readings in Modern Music*, Revised Edition (Bloomsbury, 2017), 291.

227 "Stockhausen's *Refrain*, the piece I have been asked to talk about, is a part of the cultural superstructure of the largest-scale system of human oppression and exploitation the world has ever known: imperialism." Cornelius Cardew, *Stockhausen Serves Imperialism* (Latimer New Dimensions Limited, 1974; ubuclassics, 2004), 47.

While far less extreme, these questions have resonance with the experiences of performers of contemporary music, who typically face far more subtle demands, but who work within deep power structures that complicate notions of consent. While some contemporary music does make steep demands — for instance, to "creep into the vagina of a living whale"[228] — compositions more commonly include invasive demands within their notations. What appear as inert and innocuous symbols code for the circumstances of performance, the performer's movements, breaths, and thoughts.

Computing can amplify these concerns, bringing abstracted notions of control into the performance situation. O'Modhrain highlights the importance of involving a performer's perspective in the evaluation of DMIs, to ensure that the resulting instruments meaningfully consider their perspectives on playability, transferability of skills, and effort.[229] As an example, Sarah Nicolls highlights that augmenting a performer with sensors can turn their previously subconscious or involuntary movements into gestures of musical significance, with the consequence of denying the typical opportunities for recovery.[230] This dynamic becomes even further foregrounded in dance performances that attach sensors to dancers, where sensor augmentation easily evokes an invasive medicalization, with all of its fraught gendered implications.[231] Where Alvin Lucier's *Music for Solo Performer* was at one point singular, it now serves as grandparent to a whole generation of works using intrusive body metrics, from emotion-sensing helmets to the sonification of sphincter muscle contraction.[232]

With these stakes, it becomes essential to scrutinize those social structures that could condition or constrain a musician's ability to select the music they perform. While a professional musician could outright reject performing Paik's *Danger Music for Dick Higgins*, quoted above, a performance student might think twice, and begrudgingly head to the

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228 Nam Jun Paik's "Danger Music for Dick Higgins". `https://njpac-en.ggcf.kr/archives/artwork/danger-music-for-dick-higgins`

229 O'Modhrain, "A Framework for the Evaluation of Digital Musical Instruments", 33.

230 Ibid., 34.

231 Chris Peck, "Composition in an Expanded Field of Performance: Experimental Music in Collaboration with Contemporary Dance" (PhD thesis, University of Virginia, 2015), 83.

232 `http://www.newmusicostrava.cz/en/ostrava-days/press-reviews/371-prague-culture-blog-ostrava-days.html`

nearest aquarium. The steep power gradient present in educational contexts means that an independent, professional musician's decision to tackle Cage's *Freeman Etudes* raises far fewer ethical quandaries than would the ABRSM mandating them as examination repertoire.[233]

But the agency of professional musicians is also constrained; they may need a touring or workshop gig to make ends meet, to make connections, or at the insistence of an agent, and therefore find themselves working against their own values. They might risk losing a professional reputation, developed painstakingly over decades, when a visiting performer gig plugs them into a steampunk-inspired technological monstrosity to realize a student's *Ping Body* style study at 'mate's rate'.

5.2. subversion

"Be subversive, very subversive."[234]

Faced with an encroachment of technologies and the various structures of control these carry, musicians often assert their agency by making creative misuse of technologies. We have become accustomed to these interventions into musical hardware, from classic examples such as the orchestra members destroying Cage's contact mics in *Atlas Eclipticalis*,[235] to more recent examples of hardware hacking, circuit bending, turntablism, and more.

A whole host of interventions prove impossible, though, within the ever-shrinking integrated electrical landscape of computer hardware, where a soldering iron has astonishingly little to do short of wreak wholesale destruction. Within a modern laptop, perhaps the closest one could get to Collins's legendary 'mute hack' would be to disable its microphone and camera as a privacy measure. This closed electrical world shifts attention towards soft-

233 the exceptionally difficult chance-derived content of the *Freeman Etudes* would then highlight not just a subjugation of the student, but their *arbitrary* subjugation.

234 Pauline Oliveros in Tara Rodgers, *Pink Noises: Women on Electronic Music and Sound* (Duke University Press, 2010), 33.

235 Benjamin Piekut, *Experimentalism Otherwise: The New York Avant-Garde and Its Limits* (University of California Press, 2011), 38.

ware, where more interesting interventions can take place, but also within narrow margins: software tends to either work as designed or crash quickly and uninterestingly.

This section briefly considers unorthodox uses of software for music making, questioning topics such as when 'use' becomes 'misuse', when local transgressions enact broader 'subversion', and whom or what such subversion is seen to subvert.

5.2.1. digital 'misuse' from 'affordance' to 'affordance'

A common productive form of 'misuse' takes place in the gap between the total set of 'action possibilities' latent within a piece of software and the normative subset of these encouraged by its design — the gap between Gibson and Norman's differing notions of 'affordance'.[236] The creative possibilities within this gap can surprise even the software's creators, for instance, that "people are always discovering ways to use Photoshop that Adobe never envisioned".[237]

On the one hand, such opportunities may arise from robust, defensive programming: open file formats, plugin architectures, protocols, and scripting bridges, for instance, all intentionally extend the possible uses of a software program beyond those conceived by the manufacturer. On the other hand, many surprises simply come from lower-than-warranted expectations of what a given software program can do: programs often arrive accompanied by preconceptions that limit or caricature their capabilities, for instance, representing their simplest 'baked-in' workflows as being their *only* workflows. Making use of the broader set of capabilities that were intentionally built into a piece of software hardly constitutes a 'subversion', except perhaps of the authority complicit in lowering expectations around these capabilities in the first place.

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[236] By Gibson's definition, an affordance describes the offerings an environment makes to an inhabitant, irrespective of whether these offerings are perceived. Within a software system, responsibility for this 'environment' ultimately resides with the engineer, whose implementation decisions shape not only the expected experience, but also the errant ones. Don Norman's definition constricts this to only the *perceived* action possibilities, which emphasizes the role of the interaction designer, responsible for shaping the idealized use cases and workflows.

[237] Paul Miller, "Photoshop Is a City for Everyone: How Adobe Endlessly Rebuilds Its Classic App" (The Verge, 2013), `https://www.theverge.com/2013/2/13/3959868/`.

Another source of interesting 'misuse' comes from pushing software into its error handling states. Interactive software faces unique complexities from needing to respond to real world, real-time inputs; in this context, a significant amount of engineering effort goes into keeping a system functioning when expectations go awry. As one example, for all of the delightful unpredictability of skipping CDs, all of the software involved is functioning perfectly to plan, just along an error correction path rather than the 'happy path'. These 'subversive' sounds could easily be considered co-composed with the engineering intern who likely sat in their cubicle for months on end ensuring the error correction was *Red Book* conformant, doing a competitor analysis to find the most delightful skipping sound, writing acceptance criteria, and shepherding it through a quality assurance process. Even a blowtorched CD will either play or won't; if it plays, it'll play to the fullest extent possible given the error correction as implemented.

Finally, software indisputably contains bugs, from simple programming errors to dreaded 'specification bugs' — fundamental oversights in design. Finding and exploiting these bugs offers gratifying musical possibilities, but of a more ephemeral nature — the more intriguing a malfunction, the more likely it is to either be patched by the developer or to be made into a proper, supported use case. The transgressive glitches of yesterday so easily become tomorrow's popular plug-in.[238]

5.2.2. limits to 'subversive rationalization'

Discussions of 'misuse' often interleave aesthetic claims with broader political ones — that local transgressions might stand in for sociopolitical subversions. This section takes one such claim as an example, urging caution: overstating the 'subversive' effects of 'misuse' may well support complacency more than political change.

[238] Robert Henke: "I'm fascinated by how a lot of what we define as 'character' now refers to aspects developers saw as errors or shortcomings." in Stefan Goldmann, *Presets: Digital Shortcuts to Sound* (The Tapeworm, 2015), 29.

One of the more compelling arguments for musical subversion as political work occurs when Agostino Di Scipio aligns specific computer music practices with Andrew Feenberg's concept of 'subversive rationalization'. Feenberg observes that through deliberate engagement with technologies, people can shape them towards better serving their own needs and desires, and away from contributing to an inevitable, deterministic 'technical rationalization'. As peoples' interventions feed back into the design and dissemination of artifacts, the logic of democratic participation can counterbalance a prevailing technical logic.

As one example, Feenberg describes how Minitel users in France shaped the device's meanings over time. Introduced as an "adjunct to the domestic telephone", the Minitel was intended to replace printed telephone directories, as well as to enable convenient purchasing of train tickets and consumer goods. Once installed in their homes, many of its users preferred using it for social purposes rather than for commerce, and "employed it primarily for anonymous on-line chatting with other users in the search for amusement, companionship, and sex".[239]

Michèle Martin's "The Culture of the Telephone" describes a similar shift within the development of the telephone itself, as women in the United States made use of phones originally intended for extending business into the home:

> Women's contributions to the forms of telephone practices, unforeseen by the male inventors and owners, forced telephone companies to rethink their expansion plans. They definitely influenced the use of the telephone, shifting it from a strictly business-oriented one to one oriented towards socialization. In addition, women's use *en masse* of the telephone stimulated expansion of the system, not only in business areas of cities and big towns, but in residential sectors and in rural areas.[240]

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239 Andrew Feenberg, "Subversive Rationalization: Technology, Power, and Democracy", *Inquiry* 35 (1992): 308.

240 Michèle Martin, "The Culture of the Telephone", in *Sex/Machine: Readings in Culture, Gender, and Technology*, ed. Patrick D. Hopkins, Indiana Series in the Philosophy of Technology (Indiana University Press, 1991), 72.

Di Scipio adopts 'subversive rationalization' for discussing computer music, calling it a "reasonable alternative to both conservative, anti-technological views and technocratic views as well".[241] He considers the origins of electronic music as a precedent, since its early history involved appropriating "instruments which were solely meant for scientific measurements and control […] bent to a form of creative production — *poiēsis*".[242]

Certainly, a sensitivity to the origins and appropriation of technologies pervaded early computer music, for instance, with IRCAM engineers working on the 4X concerned with the device's proximity to government defense contracts. One engineer reported that "it's a very, very thin layer that separates the technological base of computer music from that used in advanced radar systems for things like cruise missiles".[243] Another: "they should be ashamed — not proud, *ashamed!* — that the world's most beautiful and powerful musical instrument is being used to train people to *kill* other people".[244]

Tense associations between electronic instruments and industry persist, as noted by Nic Collins:

> In the early days of homemade electronic instruments, all our components seemed to be guilt-laden by-products of the dreaded military-industrial complex. Now, we lap up trickle-down from the automobile industry: pressure sensors control fuel injections systems, accelerometers trigger airbags, compasses keep us on the straight and narrow.[245]

More recently, Owen Green represents some electroacoustic practices such as glitch, lo-fi, hardware hacking, and circuit bending as subversive rationalizations, each with their own embedded critiques — challenging dominant notions of mastery, technological transparency, quality, correctness, and commercialization.[246]

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241 Agostino Di Scipio, "Questions Concerning Music Technology", *Angelaki: Journal of the Theoretical Humanities* 3, no. 2 (1998): 36.
242 Ibid., 37.
243 Georgina Born, *Rationalizing Culture: IRCAM, Boulez, and the Institutionalization of the Musical Avant-Garde* (University of California Press, 1995), 160.
244 Ibid., 162.
245 Nicolas Collins, *Handmade Electronic Music: The Art of Hardware Hacking* (Routledge, 2006), 201.
246 Owen Green, "More Than 'Just a Hammer': Critical Techniques in Electroacoustic Practice" 2006, 3.

No matter how transgressive appropriating and 'misusing' technologies for musical purposes may feel, we should scrutinize claims that these activities intrinsically enact a democratic rationalization. Depending on the context, such activities may instead entrench these technologies and their original purposes rather than displacing them. So, by presuming an intrinsic link between these activities and the powerful societal shifts Feenberg describes, we may overstate the transformative potential of such work, and subsequently act out complacency in the guise of activism.

Within the cases of the Minitel and the telephone, described above, a technological artifact was produced in order to further specific aspects of 'rationalization', principally around extending commerce into the home. In the hands of individuals, these artifacts faced creative 'misuse' towards social purposes that, while unforeseen, proved more useful than their intended purposes. Since these technologies had a constricted set of possible uses, and their manufacturers were forced to accommodate the desired uses under external pressure, the claim for a broader, democratic resistance stands.

The same cannot be so easily stated for the musical examples. While the appropriation of scientific equipment for sound generation had clear impacts on music making, it did little to shift these devices' functions away from their original purposes; their use for music instead simply revealed that this equipment could serve additional unintended purposes. It is therefore far simpler to argue that the rationalized worldview encoded within the design of these scientific instruments left imprints on the practices of music making than the opposite, given how much more lineage, terminology, and design electronic musical instruments share with military and scientific devices than with traditional acoustic instruments.

These issues matter because the appropriation or misuse of an artifact centralizes it within a drama that could just as easily work against subversive rationalization as for it. As Phil Archer notes, "a modified object refers to both its original and altered states, and by signifying what it 'was', it also immediately proclaims itself to be 'not that' anymore, but some-

thing different".[247] This reference to an 'original state' makes possible an interpretation that an artifact, rather than being subverted, is being *exalted* through a theater confirming how resilient it is to accommodating and assimilating dissent.

Sounding the violin with an ever-broadening palette of performance techniques, no matter how transgressive the result may be for a conservative audience, serves to affirm the continued relevance of the violin to a new generation of contemporary musicians. Similarly, the creative misuse of CDs and LPs helps to keep them alive within the social consciousness rather than letting them pass into obsolescence. When the technologies under question come not from musical origins, but from the arenas most strongly associated with 'rationalization' — science, business, and the military — we should be mindful that we may well exalt and preserve these technologies and their politics while seeking to undermine them.

[247] Phil Archer, "Intervention and Appropriation: Studies in the Aesthetics of the Homemade in Real-Time Electroacoustic Composition" (PhD thesis, University of East Anglia, 2004), 26.

6. assimilation & presence

6.1. assimilation

With time and effort, the boundaries slowly dissolve between us and the technologies we engage, giving rise to powerful hybrids, and rendering these technologies progressively invisible. This section considers the boundaries between a music maker and their tools, the communities which make such tools, and their expression online.

6.1.1. an extended self

A number of authors across disciplines have theorized how external objects become assimilated into our sense of self. Rather than duplicating Thor Magnusson's review of these,[248] this section provides a quick highlight reel.

From Heidegger (1927), we move from observing a hammer as an external object to behold (*present-at-hand*) to holding it, prepared to put it to use (*ready-to-hand*). In use, the hammer withdraws from our perception, leaving us free to attend instead to the nail or the board. When impeded, the hammer becomes *un-ready-to-hand*; this could happen through it breaking (*conspicuousness*), missing an essential part (*obtrusiveness*), or needing some preparatory work (*obstinacy*).

[248] Thor Magnusson, "Epistemic Tools: The Phenomenology of Digital Musical Instruments" (PhD thesis, University of Sussex, 2009), ch. 3.

From Merleau-Ponty (1962), we encounter the example of a blind man's cane: "the blind man's stick has ceased to be an object for him, and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch and providing a parallel to sight".[249] Similarly, a person with a feather in their hat avoids bringing it into contact with their surroundings — they protect the feather as an extension of their body.

Don Ihde (1990) incorporates these approaches within his human-technology relations.[250] The cane and feather are joined by glasses, hearing aids, and the car as examples of 'embodiment relations', which through their 'transparency' both *become* and *extend* an individual.[251] Technologies may also offer a transparency of *reference* rather than of *perception*; the 'hermeneutic relations' one has with language or with a thermometer, extend ourselves through indexing a phenomenon in the world without causing us to directly experience it.[252]

Andy Clark and David Chalmers (1998) put forward a theory of *active externalism* in their article "The Extended Mind", which considers the world as an integral, active part of cognition.[253] Among other examples, when Tetris players turn the pieces to see which ones fit, or Scrabble players permute the tiles to find words, these players form with their games "a coupled system that can be seen as a cognitive system in its own right".[254]

These perspectives feed into the developing field of embodied music cognition, which speaks to such issues as the "perceptual illusion that the musical instrument has become part of the body".[255] Luc Nijs, for instance, offers a provisional framework in "The Merging of Musician and Musical Instrument" for how the sensation of having incorporated an

249 Maurice Merleau-Ponty, *Phenomenology of Perception* (London: Routledge & Kegan Paul, 1962), 143.
250 Don Ihde, *Technology and the Lifeworld: From Garden to Earth*, Indiana Series in the Philosophy of Technology (Indiana University Press, 1990), 72.
251 Ibid., 75.
252 Ibid.
253 Andy Clark and David Chalmers, "The Extended Mind", *Analysis* 58, no. 1 (January 1998): 7–19.
254 Ibid., 8.
255 Luc Nijs, Micheline Lesaffre, and Marc Leman, "The Musical Instrument as a Natural Extension of the Musician", 2009.

instrument arises out of repeated flow experiences.[256] Music computing also participates in such assimilations, even when controlled through generic controllers like the mouse; one can develop a virtuosity at using software interfaces far removed from the sound making itself.

Software muddles the subject-object dualism even further, since the 'objects' of interest in a computing system are typically virtual — intangible visual representations accessed through generic controls.[257] These representations often evoke prior media to provide interaction cues, but are not subject to the same physical laws. A word processing application may resemble a typewriter, for instance, but with unlimited 'paper' and no need for correction fluid. As these representations begin to permeate our understanding, we might come to know the act of writing in relation to word processing, but also a specific word processor. After all, "habit expresses our power of dilating our being in the world, or changing our existence by appropriating fresh instruments".[258]

Whether considered in terms of 'augmentations' (Engelbart), 'extensions of man' (McLuhan), 'epistemic tools' (Magnusson), 'tools for thought' (Rheingold), 'thinkertoys' (Nelson), or some other neologism, technology promises us that through "consolidating knowledge into workable tools"[259] such knowledge then becomes reanimated when these tools are put to use.

6.1.2. a social self

Software use also inevitably implies a relation to the larger communities involved in such software's construction. This may happen explicitly, through direct participation in these

256 Luc Nijs, "The Merging of Musician and Musical Instrument: Incorporation, Presence, and Levels of Embodiment", in *The Routledge Companion to Embodied Music Interaction*, ed. Micheline Lesaffre, Pieter-Jan Maes, and Marc Leman (Routledge, 2017), 49–57.

257 Bill Moggridge and Gillian Crampton Smith, eds., "Hiroshi Ishii", in *Designing Interactions* (Cambridge: MIT Press, 2007), 526.

258 Merleau-Ponty, *Phenomenology of Perception*, 143.

259 Agostino Di Scipio, "Questions Concerning Music Technology", *Angelaki: Journal of the Theoretical Humanities* 3, no. 2 (1998): 32.

communities, but more often happens implicitly, through encountering a community's musical values encoded within the software itself. As George Lewis notes:

> Musical computer programs, like any texts, are not 'objective' or 'universal,' but instead represent the particular ideas of their creators. As notions about the nature and function of music become embedded into the structure of software-based musical systems and compositions, interactions with these systems tend to reveal characteristics of the community of thought and culture that produced them.[260]

Within the comparatively small computer music language community, music software arises through direct discussion with musicians, rather than being constructed in isolation and handed down. As David Zicarelli puts it, "if we look only at the software itself, we ignore the fact that one of the major factors determining what tools people use is how they are situated within a community".[261] Likewise, Carla Scaletti highlights that there is "not just a one-way conversation between the developers and individual Kyma users […] it's like a virus acquiring new DNA and then spreading it among other minds (where it exchanges more DNA), etc."[262] This metaphor highlights just how personal the selection of community can be — one should exercise caution in choosing with whom to exchange DNA!

The biological metaphor also evokes the notion of a meme, coined by Richard Dawkins to describe the emergence of cultural behaviors larger than an individual, a concept which has been applied to the dissemination and variation of musical ideas.[263] Whether software determines these ideas or simply participates in their shaping, assimilating music software also implies some degree of assimilation of those cultural values it embeds.

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260 George E. Lewis, "Too Many Notes: Computers, Complexity and Culture in *Voyager*", *Leonardo Music Journal* 10 (2000): 33–39.

261 David Zicarelli, "How I Learned to Love a Program That Does Nothing", *Computer Music Journal* 26 (2002): 47.

262 Tara Rodgers, *Pink Noises: Women on Electronic Music and Sound* (Duke University Press, 2010), 52.

263 for instance, in the work of Steven Jan.

6.1.3. a connected self

If one accepts the genetic metaphor, the exchange of DNA must happen with a transmission medium — and what better petri dish could one ask for than the internet?

When it comes to music making, Nicolas Makelberge argues that the internet can be seen "as more than communication infrastructure", offering "a central part of an emerging networked computer instrument accessing, shaping and sharing recorded material".[264] He places the internet within a historical trajectory of musical instruments granting ever-increasing autonomy to musicians, allowing them to make music alone that previously required collaboration.[265] Rather than this implying a retreat into 'Romantic hero worship', or a social deficiency in need of remediation, he proposes this as a different manner of being social — a *collective creation* in which musical exchange happens outside of real-time. "Individual creation out of collective materials […] has thus emerged as a truly democratic, as opposed to autocratic, activity."[266]

An inspiring claim, we should nevertheless exercise restraint to avoid falling victim to what Turkle calls a 'triumphalist narrative' — "in which every new technological affordance meets an opportunity, never a vulnerability, never an anxiety".[267] While the internet provides the technical means to connect people, this alone does little to provide a safe environment for fostering communities and their collective actions; from behind the safety of a screen, group action just as easily turns to harassment, cyberbulling, and 'doxing'. For a musical instrument, this one has an unprecedented mean streak.

Further, claims that the internet intrinsically democratizes through providing a decentralized medium prove idealized in practice. Even those technologies explicitly designed with decentralization in mind — peer-to-peer file sharing, blockchain-enabled currencies, and decentralized version control systems — all suffer single points of failure in actual

[264] Nicolas Makelberge, "Rethinking Collaboration in Networked Music", *Organised Sound* 17, no. 1 (2012): 29.
[265] Ibid., 30.
[266] Ibid., 32.
[267] Sherry Turkle, *Alone Together: Why We Expect More from Technology and Less from Each Other* (Basic Books, 2011), 242.

use. Given the choice between true decentralization and added convenience, people often choose convenience, leading to the centralization of those individuals or institutions who provide the conveniences. Even ten years ago, it was clear that the internet was becoming more centralized, not less:

> Increasingly the users' local hard drive memory has become augmented or even superfluous as internet companies such as MySpace or YouTube shift to the 'Web 2.0' theme of internet as operating system. In terms of individual use this is a move toward democratization through lay access, but in terms of business ownership it is a move toward monopolization, as only large scale corporations such as Google can afford the economy of scale that such memory demands place on hardware."[268]

Finally, the internet's promise of 'access' comes with significant cultural implications, since an individual's voluntary assimilation of a software program, or of themselves into a musical community, has drastically different ethics than might external forces of 'assimilation'. As Golumbia writes of the One Laptop Per Child project, "there could be almost no more efficient means of eradicating the remaining non-Western cultures of the world than to give children seductive, easy-to-use tools that simply do not speak their languages".[269]

6.2. presence

While the discussion so far has emphasized the experience of someone making music, we should also consider the audience's experience, where the visible and audible presence of technologies can condition an aesthetic experience.

The example of the blind man's cane, introduced earlier in support of 'assimilation', also exemplifies technological presence: as Andrew Feenberg notes, the cane "does more than sense the world; it also reveals the blind man as blind".[270] In his formulation, the "extended

[268] Matthew Fuller, ed., *Software Studies: A Lexicon* (MIT Press, 2008), 59.
[269] David Golumbia, *The Cultural Logic of Computation* (Harvard University Press, 2009), 124.
[270] Andrew Feenberg, "Active and Passive Bodies: Comments on Don Ihde's *Bodies in Technology*", 2003, `http://www.sfu.ca/~andrewf/Ihde1.htm`.

body, then, is not only the body that *acts* through a technical mediation, but also a body that *signifies itself* through that mediation". From this perspective, a musician may become the *least* privy to the aesthetics of their work, having rendered critical aspects of it invisible to themselves.

6.2.1. technologized space

Beyond providing mere vessels for musicking, the physical sites in which we experience music shape its sound, configure social relationships, and contribute their own rich meanings. That one seldom hears electronic dance music in gothic cathedrals is clearly not merely a question of reverberation time — the cathedral provides little space for dancing, offers incongruous musical technologies (though, that organ…), and carries additional, potentially unwanted associations from its primary day-to-day uses. Attending to how music is experienced *situated* requires purposeful curation, irrespective of whether this curation serves to ensure congruity or to delight in purposeful incongruities.

Computers, depending on how they are put to use, can exert a significant presence within a musical space. Fully embraced, software can itself *become* an immersive environment for musicking, a virtual musical space. Bolstering this illusion, headphones often stand in for a direct cochlear tickling, also helping to keep real world sounds at bay. Embracing a virtual space often means suppressing the surrounding real one, a bifurcation that creates a world within — the 'matrix' — and the world without. Immersive interfaces like virtual reality headsets make especially visible the experiential gap between *being immersed* and *watching someone else* be immersed.[271]

This immersive gap finds its way onstage when computers function as musical instruments in performance. With their screens typically facing away from the audience, the computer serves as a mysterious prop, leaving an audience to infer its musical functions. Since a

[271] "'Illusion!' he told himself. Clever optical devices, not reality. He groped for the chair's arm, found it, and clung to it; he scraped his feet and found again an inconsistency. To his eyes the ground was mossy verdure; to his touch it was merely a thin hotel carpet." from *Pygmalion's Spectacles*, Stanley G. Weinbaum, 1935.

computer's musical uses cannot be so easily disentangled from its more mundane ones, Behrman is not alone in considering this setup "just too depressingly similar to what hundreds of millions of workers have to do from nine to five at the office".[272] Though, an association with office work could just as easily speak *for* this setup, given music that engages meaningfully with these signifiers.[273]

Alternatively, a musician could make the contents of their screen visible, as done in many live coding contexts — as they say, "show us your screens".[274] This shifts the focus from the computer itself as a hardware device to its running software, which may help the audience to understand and appreciate what purpose the computer serves. Or, it may not; whether or not the projected code is meant to be understood, and further, whether a given performance makes that understanding possible, varies greatly. Though not specific to live coding, projected source code underscores the role of specialized knowledge in making sense of any musical experience.

Irrespective, these projections bring a conspicuous technological presence to a musical encounter. Watching somebody slowly type, run, and revise code will prove familiar to programmers in the audience, who may practice pair programming, mob programming, or in-person code review in their daily work. Meanwhile, the disposition of the audience towards the performer — a group watching an 'expert' use music software — easily evokes conventional classroom dynamics or those of product demonstrations. As with the computer itself, these interpretations can just as easily enhance as much as detract from a musical experience.

As musical instruments, computers often are accompanied by a whole host of cabled, blinking technological paraphernalia: sensors, microphones, displays, controllers, power adapters, audio interfaces, pedals, and more, all contributing to a significant technological presence. Keeping in mind the demographics of computer music, this gadgetry may

272 Nicolas Collins, *Handmade Electronic Music: The Art of Hardware Hacking* (Routledge, 2006), x.
273 for instance, in Chris Peck's musical use of PowerPoint.
274 https://toplap.org/wiki/ManifestoDraft

contribute to the perception of computer music as a field for 'boys with toys',[275] especially when this motto is made literal through prominent use of game controllers.

Finally, music made with computers often finds its way through loudspeakers — sometimes *lots* of them. As one limit case, the loudspeaker orchestra elevates speakers to privileged sources, using them to construct an immersive environment for focused acousmatic listening. Whether or not the speakers successfully disappear from a listener's awareness — whether the listener resides on the inside or outside of the immersive gap — depends on a variety of factors, many of which are specific to an individual listener. To strengthen the illusion, these spaces are typically dimmed to privilege hearing over sight, and dampened to privilege the virtualized, composed spaces over the surrounding real ones.

Before the lights dim, though, the technological means are on full display. A room bedecked with high technology will evoke different responses for attendees on the basis of their own lived experience. To some, it may promise an evening of cutting-edge electronic music; to others, it may represent the culmination of various exclusions. Victoria Armstrong's *Technology and the Gendering of Music Education*,[276] for instance, examines how the classroom use of music technology can unwittingly reinforce the problematic gender dynamics found within both computing and music composition. When social environments intended for teaching about these technologies instead end up regulating access to them — both through direct control over physical space and through control over acceptable approaches to skill, knowledge, and learning[277] — it supports the view of a music technology 'priesthood'. A typical recording engineer or acousmatic diffusionist may well then appear as an electroacoustic priest, presiding over the high machinery from their mixing-console-turned-pulpit.

Speakers themselves also carry a variety of meanings. Individuals who work routinely with speakers, for instance, often carry the embodied repercussions of previous sound-related incidents. Whether from feedback, routing mistakes, or simply from accumulated

[275] Tara Rodgers, *Pink Noises: Women on Electronic Music and Sound* (Duke University Press, 2010).
[276] Victoria Armstrong, *Technology and the Gendering of Music Education* (Ashgate Publishing, 2011).
[277] Ibid., 120.

exposure, something is bound to go wrong from time to time, and when it does, we are confronted with a loudspeaker's capability of being really, really loud. Since a speaker's electrical transduction decouples its energy output from human effort, and its effects pass through an invisible medium, speakers have a history of deployment as weapon, from the annoying 'mosquito devices' used in 'hostile architecture' to the deadly sound cannons used in warfare.[278] A room full of loudspeakers can then carry a low-lying sense of risk, exacerbated by their proximity to the audience, heavy supporting equipment, and abundant caution tape, but also from the historic associations of electronic music with noise, warfare, and excruciating volume.

6.2.2. genre as preset

A technological presence can also manifest within the music itself, as expressed through shared 'presets of the mind'. If, as Brün says, "music, in its final appearance, as it arrives at the listener's ears, preserves at least traces of the processes by which it emerged from chaos",[279] music arising from similar processes or premises end up sharing similar traces. Whether one listens *through* these 'presets' or listens *to* them presents another experiential gap.

As one example, chiptunes as a genre share not only a distinctive timbre, but also idiomatic treatments of chords, arising from the limitations of the programmable sound generating chips on which they were originally produced. A chiptune aficionado easily hears when the limitations of the chips have been lifted, whether through compositing recordings, or by merely emulating their sounds through virtual instruments. A listener without the specialized knowledge of how chiptunes are typically made may simply recognize a synthesizer timbre, irrespective of how it was produced.

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278 for instance, see Juliette Volcler's *Extremely Loud: Sound as a Weapon* and Steve Goodman's *Sonic Warfare: Sound, Affect, and the Ecology of Fear*.

279 Herbert Brün, "Infraudibles", in *Music by Computers*, ed. Heinz von Forester and James W. Beauchamp (John Wiley & Sons, 1969), 120.

Meanwhile, genres can just as easily form around *timbre itself*, rather than around *a timbre*. Some schools of 'Computer Music', for instance, elevate timbre to being the privileged site of musical concern, owing a debt of influence to Schaeffer's reduced listening, and reflecting an understanding of music oriented around 'organized sound'.[280]

Francis Dhomont, for instance, gives acousmatic music prominence within those musical and technical concerns shared by electroacoustic composers in Québec.[281] He answers his own question "is there a Québec sound" with resounding affirmation — "there can be no doubt".[282] Those listeners most engaged with these composers' shared concerns will find in their output a broad set of differing backgrounds, interests, and approaches to music making; otherwise, one might be struck by the similarities, hearing instead an undifferentiated 'house style'.

Stylistic similarities arise not only from shared musical values, but also how these become flattened in practice through the use of shared tools — for example, moving from thinking spectromorphologically to using specific 'spectral' software or techniques. This exchange breeds conformity and similarity, converging on a small number of concrete approaches within a continuous field of possibility. As Bob Ostertag puts it: "after listening to the 287 pieces submitted to Ars Electronica, I would venture to say that the pieces created with today's cutting edge technology (spectral resynthesis, sophisticated phase vocoding schemes, and so on) have an even greater uniformity of sound among them than the pieces done on MIDI modules available in any music store serving the popular music market".[283]

This critique highlights the importance of keeping open reflection around genre; a musician might move fluidly between embracing and distancing genre 'presets' as a way of avoiding unwittingly flattening their musical output. Both Ostertag and Zicarelli high-

280 Edgard Varèse and Chou Wen-chung, "The Liberation of Sound", *Perspectives of New Music* 5, no. 1 (1966): 18.
281 Francis Dhomont, "Is There a Québec Sound?", *Organised Sound*, 1996, 24–28.
282 Ibid., 27.
283 Bob Ostertag, "Why Computer Music Sucks", *Resonance*, Texts on improvised and experimental music, 2001.

light how this flattening has led a handful of genres of computered music, oriented around specific approaches to timbre, to identify as 'Computer Music' more broadly.[284]

> We have moved from the title of Max Mathews' classic book, *The Technology of Computer Music* to *The Music of Computer Technology*. This is not necessarily a bad thing, but we should get some sense of how it might be operating. The similarity between works reflects an increasing dominance of the machine over the individual even as it leads the individual to believe he or she is the master of the machine.[285]

While evoking a technomusical determinism — a musician merely performing the (re)productive organ of the Maschine world — this quote calls for scrutiny around how peoples' situated actions cause this apparent inversion of agency.

6.2.3. residual aesthetics

Finally, a technological presence can be heard within sounds themselves. With no earlids, we accumulate rich personal histories of sonic meaning through our uninterrupted experiences as hearers of the world. This history subsumes sounds as mere vibration into a web of associations — of sources, memories, movements — that continually reasserts itself in any present listening.[286] Many of these associations are linked with sounds not intended to be focal, making possible the recording engineer's parlor trick of identifying microphones, compressors, and even mixing consoles in finished recordings, synthesizer enthusiasts identifying sounds down to the specific preset, and the ability to hear computer music environments in the music they help produce. This exhibits what Denis Smalley calls

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[284] "The concept of an '*electronic* music' or a '*computer* music', as espoused by Gaburo and others, is based on a musical and an historical error that seeks, in typically modernist fashion, to divide these musics from all previous or contemporaneous musical forms, thus making claim to an unprecedented uniqueness and originality." Paul Théberge, *Any Sound You Can Imagine: Making Music / Consuming Technology*, Music / Culture (Wesleyan University Press, 1997), 159.

[285] David Zicarelli, "Keynote", in *Proceedings of the International Computer Music Conference* (International Computer Music Association, 2001), `https://finearts.uvic.ca/icmc2001/after/keynote.php3`.

[286] "The ear is always open, always supplementing its primary materiality, always multiplying the singularity of perception into the plurality of experience." Seth Kim-Cohen, *In the Blink of an Ear: Toward a Non-Cochlear Sonic Art* (Continuum, 2009), xx.

the 'technological listening' mode, where "a listener 'perceives' the technology or technique behind the music rather than the music itself".[287]

As Taylor describes, webs of sonic associations present a challenge to the 'reduced listening' of musique concrète: "This problem of what we might call residual signification is central. Recognizable sounds might evoke residual meanings that listeners might associate with the sounds' origins, which would mean that the composer is neither creating nor in total control of, a self-contained aesthetic object."[288] This all but ensures a rich heterogeneity of possible meanings; how dull music would be with only one 'correct' listening!

These audible imprints of technologies used in music making — music's *residual aesthetics* — critically extend from a musician's actions, but not necessarily from their intentions. A purely utilitarian microphone choice, for instance, leaves indelible traces within a recording, carrying significant aesthetic weight to microphone-oriented listeners. A similar tendency to treat music software merely functionally, as if it were aesthetically 'neutral', discourages reflection on whether its inevitable aesthetic contributions are welcome. It seems music software always participates in both the utilitarian and musical meanings of the 'instrumental'.

From the perspective of software development, the myth of 'neutrality' presents a paradoxical demand to create musical environments that cater to creative work, but that somehow avoid privileging any particular creative outcomes over others — in a sense, composing the conditions for composing without composing the resulting compositions. As Miller Puckette describes, "ideally, it should not be the case that the choice of software used to realize a piece of music makes a perceptible stamp on the music, in either overt or more subtle ways. And yet this reasonable-sounding goal seems always to recede as we try to approach it".[289] The goal recedes in part because any capability at all that might make a

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287 Denis Smalley, "Spectromorphology: Explaining Sound-Shapes", *Organised Sound* 2, no. 2 (1997): 109.

288 Timothy D. Taylor, *Strange Sounds: Music, Technology, and Culture* (Routledge, 2001), 46.

289 Miller Puckette, "The Deadly Embrace Between Music Software and Its Users", in *Proceedings of the Electroacoustic Music Studies Network Conference*, 2014, 8.

computer music environment worth using could, under some set of circumstances, form a 'stamp'.

When Zicarelli describes Max as "the program that does nothing",[290] for instance, this 'nothing' arrives already with its own tendencies — at the very least towards reactivity. As Puckette describes it, "the prevalence of over-reactive and over-obviously reactive pieces of live electronic music in today's repertory can be partly blamed, perhaps, on the fact that Max's and Pd's designs make it so easy to code up that sort of knee-jerk behavior".[291] These environments also, without any implied criticism, contain built-in objects that follow in specific computer programming and electronic music lineages, and adopt a 'blank canvas' approach that sets a high initial barrier to learning, typically overcome through emulating and remixing supplied tutorial patches.

Given the vanishing possibility of attaining 'neutrality', we could instead embrace the inevitable musical dance of agency that occurs when musicians involve software in their music, emphasizing that this dance often implies a co-production of musical aesthetics. So, if one truly needed to assign 'blame' for a proliferation of 'over-reactive' music, the composers, performers, curators, and patrons of such works may well deserve their fair share, over the software involved or those who developed it. This view also respects that musicians are best positioned to determine their musical priorities, including the extent to which the audible presence of their technological choices matters.

If one discounts the phantasm of 'neutrality', the question shifts from whether this 'stamping' occurs at all to whether it occurring *matters* — whether these residual aesthetics align with or detract from those musical values with which they coexist.

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290 David Zicarelli, "How I Learned to Love a Program That Does Nothing", *Computer Music Journal* 26 (2002): 44.

291 Puckette, "The Deadly Embrace Between Music Software and Its Users", 8.

6.2.4. computationalized musicking

Finally, since our musical experiences are coextensive with our experiences with computers, music can project computing signifiers even when computers were not used.

For instance, process-oriented musical forms might be heard as enacting algorithms, despite the rich pre-existing traditions in folk music and music for children;[292] music that uses performers as each others' echoes might be heard as mimicking digital effects, despite a history in canons and madrigal text painting;[293] music that makes creative use of the locations of performers might be heard as recalling audio spatialization, while antiphonal treatments of real spaces have long precedents; finally, parametric approaches to music might be understood in light of studio automation, even when they simply attempt to smooth out a notational striation.

Grant Taylor discusses similar signification questions in early computer art, comparing two 'serial-based artworks': Sol LeWitt's *Variations of Incomplete Open Cubes* and Manfred Mohr's *Cubic Limit* series.[294] While both explored variations on the cube generatively to strikingly similar results, Mohr's approach, associated with computer use, faced considerably more scrutiny than LeWitt's, associated with conceptualism.[295]

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[292] compare, for instance, Tom Johnson's *Narayana's Cows* or *Chord Catalogue* with cumulative songs like *Rattlin' Bog* or *99 Bottles of Beer*.

[293] compare, for instance, Louis Andriessen's *Hout* or Alejandro Rutty's *Witchcraft Recipes* to Orlando di Lasso's *O la, o che bon eccho!*

[294] Grant Taylor, "The Soulless Usurper: Reception and Criticism of Early Computer Art", in *Mainframe Experimentalism: Early Computing and the Foundations of the Digital Arts*, ed. Hannah B. Higgins and Douglas Kahn (University of California Press, 2012), 17.

[295] Ibid., 25.

III.

looking outward

The following chapters move from the abstracted complexities presented in the field guide to concrete case studies of existing music. These address two works from the 1970s — Iannis Xenakis's *Theraps* and James Tenney's *Quintext* — reflecting also on the role of computing in my process of learning about them.

This musical selection will likely appear odd to many readers, that in this decade I should pick two celebrated male composers, identified for their work at the intersection of art and science, and with considerable prominence in the normative literature on music composition. This configuration was arrived at neither accidentally nor with a blissful unawareness of its implications; as the chapters progress, a patient reader will hopefully find that the narrowness of these selections helps aid discussion around some of the very social issues that might make them odd upon first glance.

7. Xenakis's *Theraps* as Techne Tapestry

Xenakis's solo bass work *Theraps* provides a productive case study into the technological approaches of a composer renowned for his pioneering art/science hybrids.[296]

An initial section focuses on the work itself, providing an updated account of the materials and form, informed by archival sources, secondary literature, and purpose-built visualization software. This account explores how the extreme performance demands of the work arise directly and deliberately from Xenakis's varied compositional approaches.

The construction of *Theraps* suggests broader reflections on the technologies employed and their relationships to the body, society, and knowledge; a second section provides speculative readings of *Theraps* through the work of Albert Borgmann and Don Ihde, two authors identified with the philosophy of technology.

[296] An earlier version of this chapter was published for some time on my personal website (`http://www.braxtech.com/`); this version supercedes that one.

7.1. examining *Theraps*

7.1.1. background

Xenakis's lone work for double bass, *Theraps* (1975–6), was written for and dedicated to Fernando Grillo. In the early stages, Grillo and Xenakis explored possible sounds and techniques for the work; Xenakis's notes from January 1975, for instance, show the option to "detune a string — hold it with a finger [the thumb] that can change the tension" or to use "two bridges for two strings". However, a note indicated that these techniques "don't provide much"; of all the techniques in this session, only an 'engine sound' made on the bridge seems to have survived to the final work.

The manuscript of *Theraps* was finished in 1976 and premiered in March at the Festival de Royan,[297] with successful followups at the Middelburg Xenakis Festival and Darmstadt, at which Grillo received the Kranichsteiner Musikpreis. Grillo thanked Xenakis by post, enclosing an annotated score with recommended notational changes and bowing indications. These were not incorporated.

In 1981, Éditions Salabert published a new edition of the work, professionally engraved by J. L. Sulmon.[298] In addition to the much-improved legibility, this edition includes time signatures and drastically modified tempo markings, as well as expanded program and performance notes in English and French.[299]

7.1.2. performance difficulties

Much of the work's reception concerns its many performance difficulties. In an early account, Bernard David Neubert's 1982 dissertation addresses challenges he encountered

[297] Iannis Xenakis, *Theraps*, Iannis Xenakis, copyist. (Paris, France: Éditions Salabert, 1976).

[298] Iannis Xenakis, *Theraps*, J. L. Sulmon, copyist. Plate EAS17430p. (Paris, France: Éditions Salabert, 1981).

[299] This engraving process faithfully preserved several idiosyncrasies of the original manuscript, but introduced some unintentional errors which remain to the present.

working from the manuscript, such as the small, "cumbersome to read" notation.[300,301] For the 'microtonal passages', which he noted extend "beyond the practical limits of the instrument", he recommends two quarter-tone fingering patterns to simplify performance;[302] the engraved edition instead urges that these sections be performed "as much as possible with just one finger".[303]

In the engraved edition, Barry Guy's program note describes the "mental and physical commitment" required in the work as "taking the player to the edge and beyond". In one passage, he focuses on the boundaries between the areas of flux and the natural harmonics, saying:

> Withdrawal to the ethereal harmonics is in many ways a painful process, but ultimately rewarding. Here lies a possible paradox, for the physical limitations of the human frame can all but cope with the intensity of the music leaving an area of instability in the ongoing music.[304]

Robert Black's account in *Performing Xenakis* details his approach to learning the work, which involved developing exercises to overcome a number of the technical challenges. He also describes "a coming to terms with the extremes of dynamics, range, tonal colors, and bow pressure", saying that "the emotional commitment, and sheer physical effort required to play the work was something that I had not encountered before".[305] Xenakis requested that he further exaggerate these extremes, making the work "more […] savage, grotesque and beautiful";[306] a similar request was made of Guy, who was asked to exaggerate the dynamic range to "obtain both a sensitive fineness and a savageness".[307]

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300 Bernard David Neubert, "Contemporary Unaccompanied Double Bass Works: An Analysis of Style, Performance Techniques and Notation Practices" (DMA Diss., University of Texas at Austin, August 1982).

301 He also noted difficulties arising from the pitches being written at sounding pitch. ibid., 56.

302 Ibid., 59.

303 Xenakis, *Theraps*.

304 Ibid.

305 Robert Black, "Theraps", in *Performing Xenakis*, ed. Sharon Kanach, The Iannis Xenakis Series 2 (Hillsdale, New York: Pendragon Press, 2010), 241.

306 Ibid., 242.

307 Xenakis, *Theraps*.

John Eckhardt noted that these extremes reveal fragile feedback cycles between a performer and the configuration of their instrument. For example, too little rosin compromises the bow's traction for the extreme dynamics, but too much rosin interferes with the random walks when they wander into the residue on the string. The height of the strings presents another compromise, between the increased fatigue of higher heights and the unintended slapping of the string against the fingerboard at lower heights. The instrument also pushes back: Eckhardt grows thick calluses as he prepares for performances, a manifestation of the required human-instrument symbiosis!

7.1.3. examining the texture form

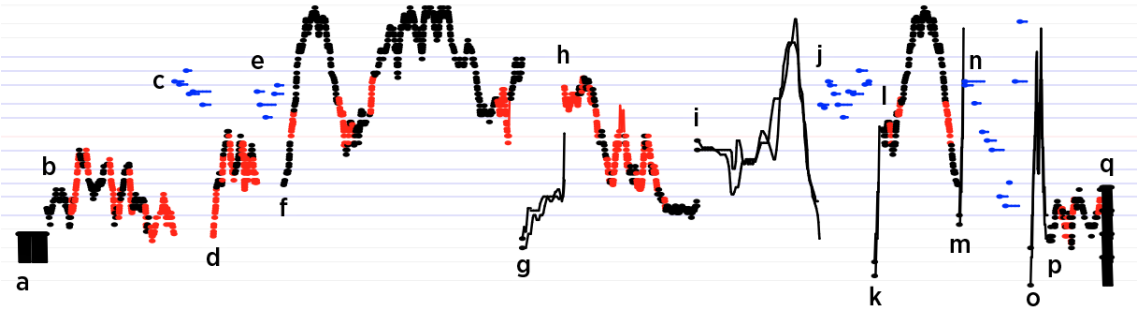

Figure 7.1.: *Theraps* overview

To understand these challenges more acutely requires study of the work's content and its varied compositional processes. As shown by the overview in Figure 7.1,[308] *Theraps* comprises seventeen musical 'blocks' of four main types, here labeled according to Ronald Squibbs's dissertation.[309] These blocks are generally assigned to four types: 'Short Glissandi', 'Random Walk', 'Harmonics', and 'Two Voice Glissandi'. This study further divides the 'Two Voice Glissandi' into two subtypes: the 'Freehand Glissandi' (`g` & `i`) and the 'Leapfrog Glissandi' (`k`, `m`, & `o`) on the basis of their differing manners of composition.

[308] The visualizations in this paper come from *Thermograph*, a domain-specific encoding and visualization tool described in more detail in the next chapter.

[309] A form chart comparison is available from the author.

random walks

Of the four main types, the random walks dominate the analytical discourse on *Theraps*, perhaps unsurprisingly, given their ubiquity in Xenakis's music of the 1970s. Squibbs provides an overview of Xenakian random walks in his dissertation, clarifying their metaphorical relationship to Brownian motion and elucidating how the walks can equally apply to contours as to absolute pitches.[310] This supports his detailed computer-assisted analysis of *Theraps*.[311]

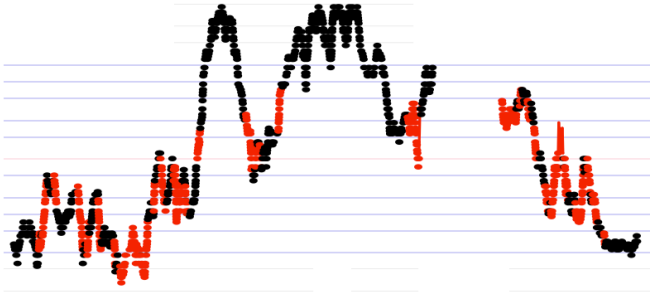

Figure 7.2.: Random Walks

While random walks could systematically supply content for instrumental music, Xenakis's approach at this time involved compositional 'transfer', as discussed by Makis Solomos.[312] In *Mikka*, for instance, an initial transfer occurs in using an "image of Brownian movements (in the physical sense) to conceive a new way of sound synthesis"; a second transfer occurs in "transferring the graph of a sound curve to a graph for instrumental music".[313]

The random walks in *Theraps* unfold through a similar 'double transfer'. The sound curve graph exists as two hand-copied graphs on millimeter graph paper, preserved in the archives at Biblothèque nationale de France, reconstructions of which can be seen in Figure 7.2. Sections `b`, `d`, and `f` originate from one such graph, a single continuous curve broken into

310 Ronald James Squibbs, "An Analytical Approach to the Music of Iannis Xenakis: Studies of Recent Works" (PhD thesis, Yale University, 1996), 110.
311 Ibid., 252.
312 Makis Solomos, "The Unity of Xenakis's Instrumental and Electroacoustic Music: The Case for 'Brownian Movements'", *Perspectives of New Music* 39, no. 1 (2001): 244–54.
313 Ibid., 247.

pieces; `p` and `l` present the same content in temporal retrograde. A second graph contains section `h`, a descending contour.

Several processes of curation, mapping, and rearrangement imprinted the resulting music with characteristic features, often quite different from other works exhibiting ostensibly similar conceptual foundations. *Mikka*'s highly volatile rhythms and unquantized pitches, for instance, would be hard to confuse with the mountain-like fractal symmetries of *Theraps*.

The graph paper sketches reveal the details of the curve mapping. Time was mapped horizontally in eighth notes, and pitches vertically in quarter tones; nearby were rhythmic calculations for determining the speed of the eighth note as well as desirable rhythmic derivations. The pitch mapping was anchored within the compass of the bass, extended somewhat by the technique described in a note, "pull the strings laterally to go very high!!!" Pitch sieves were marked next to the curves, used later to select specific pitches from the otherwise undifferentiated field. No further compositional debris connects the rhythmic calculations and eighth-note time mapping to the final score's tuplets.

The quantizations in pitch and time required Xenakis's meticulous intervention. Simply generating rhythms stochastically, as suggested by Neubert,[314] would irregularly sample the graph, interrupting the fluid contour. Conversely, deriving the rhythms from the pitch changes would not produce the consistent tuplet rhythms like those in *Theraps*. The sheer number of idiosyncrasies in the contour, pitch, and rhythm of the random walks corroborate that this final transfer was performed manually; this may well transform the 'double transfer' into a triple transfer.[315]

[314] Neubert, "Contemporary Unaccompanied Double Bass Works", 53.

[315] Since random walks yield self-similar, symmetric contours, visualizations aid in identifying the many small contour deviations. For example, measure 5 shows a three pitch melodic cell that repeats immediately at a faster speed, breaking the expected symmetry, and providing a sense of musical grouping. This pattern repeats in measure 8 (`<c2+3, c2+2, c2+1>`), measure 81 (`<a4+0, g4+2, g4+1>`), and measure 89 (`<a3+0, g3+2, g3+1>`). Many other asymmetries occur at moments of emphasis, for example the `f2+0` in measure 4, the leaps ending measure 10, the prolonging `c5+2` in measure 50, and the `c6+2` by leap in measure 57.

In addition, these sections are characterized by continuously changing expressive techniques — most notably the *sul pont* markings, dynamics, accents, and additional glissandi. These decisions mirror Xenakis's self-described tendency to remove stasis, as described to Varga:

> The aim is to make the sound itself live. There are different ways of doing that: we change the timbre, employ tremolos and accents, repeat the sound and change dynamics. […] In this way the inner life of the sound is not only in the general line of the composition, of the thought, but is also within the tiniest details.[316]

harmonics

The harmonics, a dramatic foil to the random walks, receive considerably less scholarly attention. Only Squibbs has analyzed these sections, collecting and describing the pitches,[317] noting that "only the random walks and the successions of harmonics show clear evidence of structural differentiation within the work's equal-tempered quarter-tone p-space".[318]

To compose these sections required Xenakis to resolve a number of constraints: the 'presieved' pitch material arising from the instrument's tuning, the physical locations of the harmonics on a given string, and an apparent desire to mimic random walk contours. For the pitches, Xenakis made a table containing the first fifteen harmonics over each string, labeled in abbreviated solfège, connected by lines to show an ascending path. After eliminating some of the high partials, he then plotted these pitches as an ascending scale, which underwent some basic explorations.[319]

316 Bálint András Varga, *Conversations with Iannis Xenakis* (London: Faber; Faber, 1996), 64.
317 Squibbs, "An Analytical Approach to the Music of Iannis Xenakis", 263.
318 Ibid., 254.
319 This also included identifying equivalent harmonics (for instance $II_3 = II_4$), and the quarter-tone relationship between II_4 and III_5.

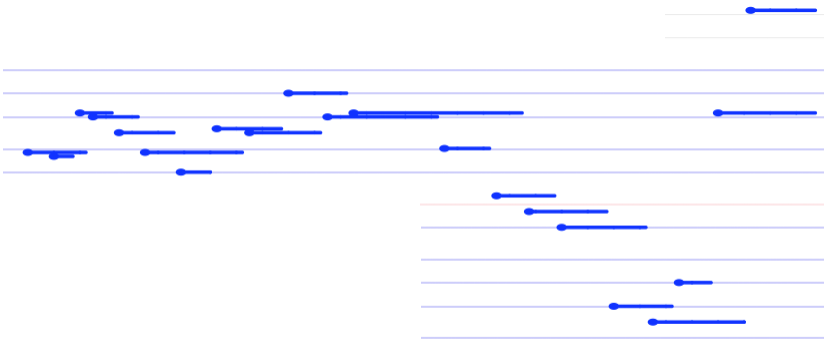

Figure 7.3.: Harmonics Trajectory (sections `j` and `n`)

From these, he composed a single trajectory of harmonics, shown in Figure 7.3, which resembles the contours of the other random walks. In musical context, this trajectory is split into two parts, forming sections `j` and `n`, with sections `c` and `e` formed by reading `j` in temporal retrograde and at a slower pace. These sections, then, reconcile the resultant pitch structures, derived "outside of physicality", with the physical limits of harmonic dyads on the bass, ultimately forming a random-walk-like pitch contour through a physical 'random walk' across neighboring string pairs.

freehand glissandi

Where the random walks and harmonics involved curation and reconciliation, the free-hand glissandi in sections `g` and `i` were conceived directly onto graph paper.

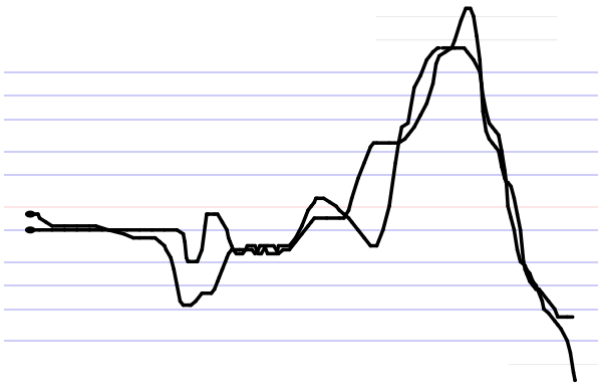

Figure 7.4.: Freehand Glissandi in section `i`

This approach reflects his contemporaneous interest in visual and sonic feedback relationships, seen in his production of arborescences.[320] He described this in context of his piano work *Evryali*:

> The drawing and thinking of the sound-image go hand in hand, the two can't be separated. It would be silly to leave out of account, when drawing, what will sound in reality. We have also to be able to find on paper the visual equivalent of the musical idea. Any changes and modifications can then be carried out on the drawing itself. This feedback has to operate all the time.[321]

Here, this feedback took place at the very least through starting, abandoning, and modifying paths. Much like *Evryali*'s arborescences, which facilitated "continuity on an instrument which has an opposite nature", these freehand glissandi served as a sound-image representation for direct composition, free from physical limitations.

Because transcending these limitations could only be temporary, he took additional steps to check their playability. We know from Robert Black's account that Xenakis made use of his own 'bass', a wooden board marked with the physical locations of pitches, to "determine that it was possible to play everything that he had written".[322] A page of sketches contains dyads representing the extremes of a hand span, labeled "for the two voice glissandi", as well as measurements of physical distances, suggesting he was particularly sensitive to this issue.

leapfrog glissandi

The leapfrog glissandi[323] found in sections `k`, `m`, and `o` make generative application of these same hand span dyads. Xenakis constructed six trajectories from the dyads, each assigned an identifying letter (section `k` is α, section `m` is γ). Pivot points on `e3`, marked on the trajectories, maintain the illusion of continuity while switching strings. A final dramatic

[320] two small arborescence doodles, unrelated to *Theraps* also occur alongside the surveyed sketches.
[321] Varga, *Conversations with Iannis Xenakis*, 90.
[322] Black, "Theraps", 242.
[323] This name reflects the similarity of the intertwined pitch contours in these sections to the childhood game Leapfrog, in which children repeatedly jump over each others' backs.

appearance of these trajectories as a composite (taking the rough shape of the letter 'M') appears in section o, shown in Figure 7.5.

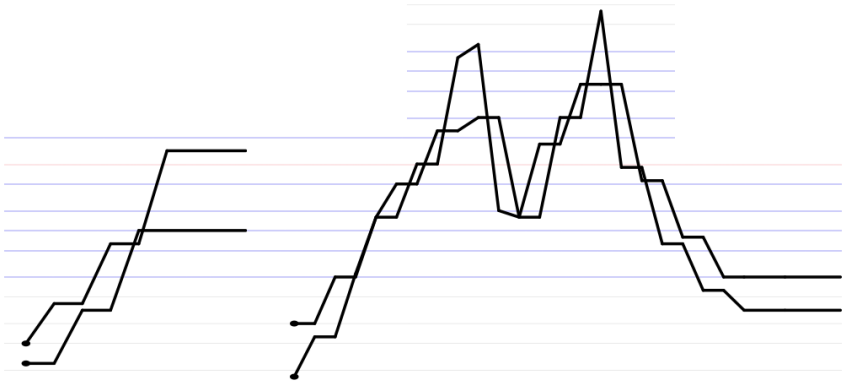

Figure 7.5.: Sample Leapfrog Glissandi (left) and the Composite 'M' (right)

This dual use of the wooden 'bass' typifies Xenakis's thoughts on playability. He describes to Varga that he will "take into account the physical limitations of the performers", but also consider "that what is limitation today may not be so tomorrow".[324,325]

short glissandi

The short glissandi at the beginning and end of the work have an "effect of framing", as described by Squibbs. "Both occur at the low end of the p-space, thereby producing a gruff sound whose precise pitches are difficult to discern".[326,327] While the short glissandi did not develop through sketching, they figured prominently in several form diagrams.

Figure 7.6.: Short Glissandi and repetitions in section a

[324] Varga, *Conversations with Iannis Xenakis*, 65.

[325] Similar dual uses occur in *Khoaï* and *Gmeeoorh*, where a double-manual cardboard keyboard supported the endeavor to play both organ manuals simultaneously in a single hand.

[326] Squibbs, "An Analytical Approach to the Music of Iannis Xenakis", 255.

[327] Squibbs further notes that the staccato repetitions in the opening section were an 'anomaly' in his categorization.

The overall form of *Theraps* developed through sketching and sequencing blocks, represented by visual shorthands, alongside labels. One such sequence contained: four descending lines, unlabeled; a rough descending contour, labeled '*Mikka*'; a straight line with a wavy line against it, labeled 'deux voix'; a single trill-like line, labeled '*Cendrées*'; five parallel horizontal lines, labeled 'harmoniques'; and a random walk, labeled 'Φλέγρα' (*Phlegra*). These references corroborate the work of Benoît Gibson on Xenakis's self-borrowing.[328,329]

Another sequence shows the random walk ('Φλ') alternating with the descending short glissandi. Converging towards the final form, another shows a balancing of the harmonics and the leapfrog glissandi towards the work's conclusion, including the constituent modules of the 'M'.

This interest in blocks finds elaboration in the program notes to *Phlegra*:

> As in other recent compositions of mine, I have continued here the construction of textures and their organisation on a higher level. I refer to textures in the general sense of form. For example, a melodic arborescence… a random walk… repeated notes following rhythmic rules…
>
> Textures in the sense of form are the keystone of art and knowledge.[330]

7.2. questioning technology

By exploring the varied compositional approaches taken in composing *Theraps*, the above account suggests fruitful connections to surrounding philosophical inquiries into technology and its relation to society, the body, and knowledge. The following sections explore two such speculative connections: first, between the 'transferred' random walks and Al-

328 Benoît Gibson, *The Instrumental Music of Iannis Xenakis: Theory, Practice, Self-Borrowing* (Hillsdale, New York: Pendragon Press, 2011).

329 Other mentioned works include *Orient-Occident* (in a margin), *Mikka S* (in the second random walk), and *Gmeeoorh*.

330 Iannis Xenakis, *Phlegra: Pour Onze Instrumentistes* (Paris, France: Éditions Salabert, 1976).

bert Borgmann's device paradigm, then between the freehand glissandi, wooden 'bass', and Don Ihde's human-technology-world relations.

7.2.1. from claustrophobic molecules to focal practice

As described above, several acts of translation separate the random walks within *Theraps* from any scientific or algorithmic origin. These acts begin with a conceptual shift from Brownian motion to random walks, and proceed through several musicalizing processes, used to compose instrumental music from algorithmically-generated data.

While 'Brownian motion' and 'random walks' both refer to stochastic processes, these terms differ significantly in their relation to the natural world. Brownian motion typically refers rather specifically to those "small, chaotic movements of molecules suspended in a liquid or gas";[331] random walks, on the other hand, carry no implied physical phenomenon, most often used to describe stochastic behavior of variables within a data set (or, to algorithms which yield such data).

Since Xenakis used algorithmically-generated random walks in his music, the references to Brownian motion in his writings, interviews, and program notes must therefore be understood metaphorically. This fluidity between scientific matters and practical compositional ones was not uncommon, as Matossian notes:

> Critics have often been confused by the balance of science and music, a confusion often fueled by Xenakis' own rhetoric. Their favourite insult in the old days was "scientist, technocrat, philosopher but not a musician", while scientists were quick to point out inconsistencies, errors and 'unscientific' procedures.[332]

As algorithm, random walks gain repeatability and controllability, and lose scarcity and physicality. The data they yield gains new means of manipulation, separable from the means of its origin. These new means of manipulation prove vital to an artistic appropria-

[331] Solomos, "The Unity of Xenakis's Instrumental and Electroacoustic Music", 247.
[332] Nouritza Matossian, *Xenakis* (London: Kahn; Averill, 1986), 243.

tion. The musicalizing processes in *Theraps*, dependent on such a shift, inextricably forge the character of this material.

Borgmann's device paradigm

Albert Borgmann's 1984 book *Technology and the Character of Contemporary Life* took notable steps to diagnose perceived ills of technologized culture and propose shifts of thinking that could lead to their resolution.[333]

His 'device paradigm' identifies in technologized society a fundamental pattern by which *means* and *ends* become decoupled, subsequently supporting specialized *means* 'machinery' and a culture of commodities and consumption.[334] Those technologies with linked means-ends become identified as 'things', and are associated with traditional forms of engagement. 'Devices' on the other hand, with their severed means-ends, require specialized roles and impede engagement. In one such example, the hearth (*thing*) centralizes activities of the home around the production and enjoyment of heat, while central heating (*device*) dissipates these home activities and requires expertise to repair.

To remedy a tendency towards devices, he advocates a renewed engagement with what he identifies as 'focal' things and practices.[335] Examples include running, the culture of the table, and music. Since Borgmann considered philosophical discourse to be shaped by the device paradigm as well, he faced the challenge of finding a unified means-ends for his rhetoric. He finds resolution in *deictic* discourses, those identified by rhetorical appeal, denouncing those 'quasi-rational' philosophical approaches of logical persuasion.[336]

The random walks in *Theraps* might mirror such a logical chain. To a composer who finds musically-desirable features in Brownian motion, their uncontrollability towards any spe-

333 Albert Borgmann, *Technology and the Character of Contemporary Life: A Philosophical Inquiry* (University of Chicago Press, 1984).
334 Hans Achterhuis, ed., *American Philosophy of Technology: The Empirical Turn*, trans. Robert P. Crease, Indiana Series in the Philosophy of Technology (Indiana University Press, 2001), 14.
335 Ibid., 22.
336 Ibid., 21.

cific ends presents a real challenge (keeping a house warm by neighboring volcano).[337] When random walks substitute for Brownian motion, as a simulation 'device', they bring a severed means-ends relationship (central heating). The computational and statistical expertise required for servicing the 'machinery' as a musical 'means' bears no direct relationship to the perceived 'ends' encountered by a listener.

The acts of transfer might then be understood as bringing the random walks into alignment with specific focal practices of music making. Bringing random walks to the bass, for instance, activates those means-end relationships associated with acoustic music, here including exhaustive and exhausting practice by the soloist, the ritual of concert-going, and the culturally thick practices of notation and engraving. The additional musicalizations serve to further emphasize the linked means-ends; they reflect additional distinctions made in composition with the dual intentions of adding differentiation for the listener and challenges for the performer.

That the random walks contribute so strongly to an understanding of *Theraps* as an activity at the limit of human physical capability, and so weakly to it as an activity of science or computing, speaks to the effort by which Xenakis brought the random walk 'device' into alignment with focal practices.

Borgmann's advocacy for deictic discourse also finds resonance within Xenakian rhetoric. The well-known opening of *Formalized Music*, for instance, extolls music's power to 'catalyze sublimation',[338] a Dionysian 'transportation of state' he compares to the effects of alcohol and love.[339]

337 Dewey: "Nature as it exists at a given time is material for arts to be brought to bear upon it to reshape it, rather than already a finished work of art… The attitude of control looks to the future, to production". Larry A. Hickman, *John Dewey's Pragmatic Technology*, Indiana Series in the Philosophy of Technology (Indiana University Press, 1990), 109.

338 Iannis Xenakis, *Formalized Music* (Bloomington: Indiana University Press, 1971), 1.

339 Iannis Xenakis, Roberta Brown, and John Rahn, "Xenakis on Xenakis", *Perspectives of New Music* 25, no. 1/2 (1987): 18.

7.2.2. drawn sound and the wooden instrument

Additional technological distinctions arise from Xenakis's varied relationship to physical artifacts. This section proposes that the phenomenological approach to technology taken in Don Ihde's 1990 *Technology and the Lifeworld* can enhance an understanding of the composition of the two voice glissandi.[340]

pencil as cane, arborescence as thermometer

As discussed above, the freehand glissandi intertwine acts of drawing and imagining sounds, an approach later exemplified by his arborescences. This practice unfolds across several 'human-technology-world relations'.

In terms of raw sensory perceptions ('microperception'), Xenakis would have at least felt the pencil in his hand, seen the graph paper lines, watched graphite curves fill the discretized space, and felt the uneasy friction of eraser debris as he brushed it from his working surface. In this context, the technologies may be subjects of perception, but perception itself remains technologically unmediated.

The pencil, while instrumentally essential to the act of drawing, also notably contributes to the drawer's sense of self. Within Ihde's classification, this special mediation constitutes an *embodiment relation*, mirroring Merleau-Ponty's oft-cited examples.[341] In embodiment relations, Ihde notes the necessity of special skills or techniques; a novice with a cane will find it a poor sensory organ.

Once drawn, these curves require additional acts of interpretation to transform them from *image* into *sound-image*. This interpretation finds music through a representational mediation, rather than mediated sensory perception. This constitutes a *hermeneutic relation*.[342] By way of an example, the thermometer does little to extend our raw physical sensations

340 Don Ihde, *Technology and the Lifeworld: From Garden to Earth*, Indiana Series in the Philosophy of Technology (Indiana University Press, 1990).
341 Ibid., 72.
342 Ibid., 80.

of temperature, but shapes our understanding and interpretations of temperature through its form of representation.[343]

wooden 'bass' as spinning top

Neither the embodied nor hermeneutic relation adequately explains the usage of the wooden 'bass' in the two voice glissandi. The board, while instrumentally useful for composition, does not fuse into its holder's body image as in the embodied relation [(Xenakis-Board) → Music]. Additionally, while using the board requires acts of interpretation, these acts do not mediate macroperception as in the hermeneutic relation [Xenakis → (Board-Music)].

Instead, the board serves as a non-mediating object of relation, an *alterity relation* [Xenakis → Board-(-Music)].[344] The board replicates Ihde's example of the spinning top: "what was imparted through an embodiment relation now exceeds it".[345] Just as the top gains autonomy from its human spinner once spun, the wooden bass becomes a 'quasi-other', detached both from the composer's perception and the double bass.

hearing the relations revealed

The earlier discussion of *residual aesthetics* raises the question how Xenakis having extended himself through these various tools might leave behind aesthetic traces.

The freehand glissandi, for instance, project the conflicts of their construction into the musical result: what appear as two smooth curves in a sketch manifest musically as embodied struggles between the body and the bass. Drawing made possible a music that seeks to transcend, but requires, bowing.

The wooden bass, meanwhile, as a two-dimensional pitch ruler, has a complex relationship to 'playability'. Since basses are commonly three dimensional, using a two-dimensional

343 Ibid., 85.
344 Ibid., 97.
345 Ibid., 100.

measurement of distance all but ensures challenges around finger positioning and hand span. Nothing about using such a ruler accounts for the complications of string height (Eckhardt), the many pains associated with the textural juxtapositions (Guy), nor the commitment and effort required (Black).

If anything, Xenakis's decontextualized measuring of pitches ensured that *even the pitches alone* would be difficult to play. Guy comments, "on paper it is all possible, but when overbalanced in favour of the final result, a new philosophy has to be reckoned with".

7.2.3. considering the techne tapestry

The sections above explore the blocks as isolated entities, rich and variegated in their approach. When juxtaposed within the work's timeline, the resulting texture form only hints at the 'techne tapestry' woven below. "Techne was for the Greeks a pro-duction, a leading toward, and a con-struction, a drawing together, of various parts and pieces in order to make something novel".[346]

These interwoven compositional techniques reflect one attempt among many to resolve questions of the interrelations between art and technology. Xenakis often described these relations dialectically:

> Technology allows the exploration of new domains proposed by theoretical thought and esthetics; but once these domains are explored, we must push further. In fact, computer science is a product of simple rationality; as a composer, I unceasingly bring complexity, sometimes irrational, to this rationality.[347]

If viewed through the lens of John Dewey's instrumentalism, such a conflict recedes. " 'Technology,' as [Dewey] understood the term, cannot be the enemy of art. It *is* art".[348]

346 Hickman, *John Dewey's Pragmatic Technology*, 18.
347 Xenakis, Brown, and Rahn, "Xenakis on Xenakis", 27.
348 Hickman, *John Dewey's Pragmatic Technology*, 68.

In *Theraps* one finds a musical artifact, a 'focal thing' that brings the technologized world to bear on art, but also a philosophical inquiry into what art might mean in such a world.

8. my *Theraps* of mashed potatoes

As an integral part of my investigations into *Theraps*, described in the previous chapter, I found myself enmeshed in a multi-year project trying to understand the work through modeling and visualizing it.

Characteristic of my work in general, this went through various phases of activity and interest, from bursts of activity to avoidance, compulsion to repulsion. Further, it proceeded from not involving computers at all to eventually modeling the work through a domain-specific programming language, an activity a colleague likened to the famous mashed potatoes scene in Spielberg's *Close Encounters of the Third Kind*.

This chapter recounts the path of discovery I took, with the primary aim of disclosing various tendencies in my practice, especially my approach-avoidance relationship towards computing, my tendency to continually rework the same ideas from slightly different approaches, and my strong preference for learning at the expense of completing projects. A secondary aim of this chapter is to introduce the software outcomes of this work: a visualizer `Thermograph` and the language `thermal`.

8.1. steeping in accidental insights

From my first encounter with *Theraps* back in 2010, I felt driven to understand how the work was put together. I had access to both Robert Black and John Eckhardt's record-

ings,[349] as well as the engraved edition of the score, but was perplexed by the experiential gap between the score as an aesthetic object and the performances. This was especially pronounced for the random walks, where the notated thicket of quarter-tone accidentals and 64th-note beaming gives overstated precision to material that inevitably becomes smeared and concealed in its performance.

My conviction back then, since softened, was that those aspects of the piece I found striking should emerge from, and therefore have representation in, the score. While this clearly overstates the score as 'text', my approach always considered the score in relation to my sonic memory of the two recordings; I found encouragement that these two bassists managed to find quite different interpretations of the work.

Without having ever played a double bass, my available techniques for making sense of the work were far removed from those of a bassist. Initially, I spent a while staring at the score, sometimes recopying bars, humming, tapping rhythms, sometimes playing numerologist, all with the hope of finding any sort of pattern within its material. From a previously undifferentiated field, I eventually started seeing repeated patterns in the accidentals, points of connection between different random walk sections, missing clefs, and discrepancies of pitch and rhythm. As my staring yielded insights, it also opened new lines of questioning — more than the just the measure lengths didn't add up.

8.2. restoring the cartesian coordinates

Focusing first on the random walk sections, I decided to address the basic notational issues most hindering me from seeing what I heard. The conventional staff notation used in the score has the effect of squashing the random walks from their original 24-TET pitch space into the lumpy diatonic space, requiring accidentals for almost every note. Practically, this means that seeing the melodic contours so prominent in the recordings required actually

[349] Robert Black, "Theraps" (Compact Disc: Neuma Records., 1988); John Eckhardt, "Theraps" (Compact Disc: Mode 152., 2005).

reading the music, not an uncommon expectation with musical scores, but nevertheless an extra layer of mediation beyond simply seeing the contours as contours.

Further motivated by having seen a variety of sketches by Xenakis reproduced in books, typically on millimeter graph paper, I figured a reasonable step would be to transfer the notation (back) into a two dimensional graph. I chose to do this with the aid of graphics software, in part to ease editing, but also to allow me to easily change the dimensions and proportions of the transcription. After assembling a simple 24-TET staff on a digital artboard, I began manually snapping noteheads to it, representing events in the score.

This process put me into a heightened state of *anti-flow*, facing simultaneous boredom and anxiety in equal measure, and experiencing far lower-than-usual attention to detail. I would make frequent mistakes in my recopying, and then, upon later discovering these mistakes, consider my alleged findings as some sort of notational nitpicking triumph over Xenakis himself. After several rounds of deluding myself in this manner, I started taking more care in transferring the score, but also learned to be more cautious in attributing its inconsistencies. My desire to discover anything at all about the work made me a bit too eager for my own good, especially as the project started approaching the upper limits of a reasonable hobby, towards something resembling musical analysis.

When the recopying presented oddity after oddity — and when these held up on second and third inspection — I had to make decisions about how to treat these in my renotation. How do I represent measures with the wrong duration? Tied notes that change accidental over a barline? Missing rhythmic beams? Should I scale the time between sections? In the end, I made choices, felt uneasy about them, and nevertheless wrapped up the work. The result is the '*Theraps* Listening Score and Notation Nitpicking Guide' in the attached portfolio.

While productive, this approach clearly was not sustainable: for all my work digitizing, very little *usable data* came out of it — the effort simply transferred the score from one opaque visual notation to another, adding a layer of tenuous interpretation along the way.

I knew that if I returned to the work, I would need to approach it with less recourse to my own interpretation.

8.3. modeling the work

By 2012, I became preoccupied with how musical notations, their representation and encoding as data, and the use of domain-specific programming languages could interrelate. I was struck by how much of my own compositional work involved coping with the concepts of music expressed in off-the-shelf computer music languages and notational systems; these were never completely suitable, nor were they useless enough to forego. I entertained the fantasy that musicians might just model their music directly as new languages, rather than expending their efforts wrangling the existing ones. This came from imagining a flourishing of idiosyncratic musical programming languages, designed around the specific tendencies within works or peoples' practices, to augment the typical 'common property' ones.

With this in mind, when I started window shopping for a music encoding to use for *Therapsaps*, it was already almost certain that I would just make my own. This decision, while not made rationally, was easily rationalized. From one angle, the notation contains a number of unique features not common to many encodings, for instance the pervasive glissandi with rhythmic continuation lines and the sharp-only 24-TET accidentals. From another angle, I wanted to encode directly those ambiguities that previously required my interpretation. Given how many curiosities I encountered with pitches — for instance, that accidentals occasionally change on ties — I wanted to capture these moments at the level of the *glyph*, rather than to capture my interpretation. Finally, I wanted an encoding suited to my direct manipulation, verification, and version control.

The result of this work was the domain-specific language `thermal` (**ther**aps **ma**rkup **l**anguage) and an assortment of accompanying tools. A few command-line tools take over tasks I had previously done manually, for instance, checking rhythms and tabulating statistics on

pitch class usage. A syntax-highlighting plugin for text editors improves the experience of editing in the language. Finally, to supplant the 'Listening Guide', I built a visualization application for the `thermal` files, entitled `Thermograph`. Figure 8.1 shows a representative screenshot.

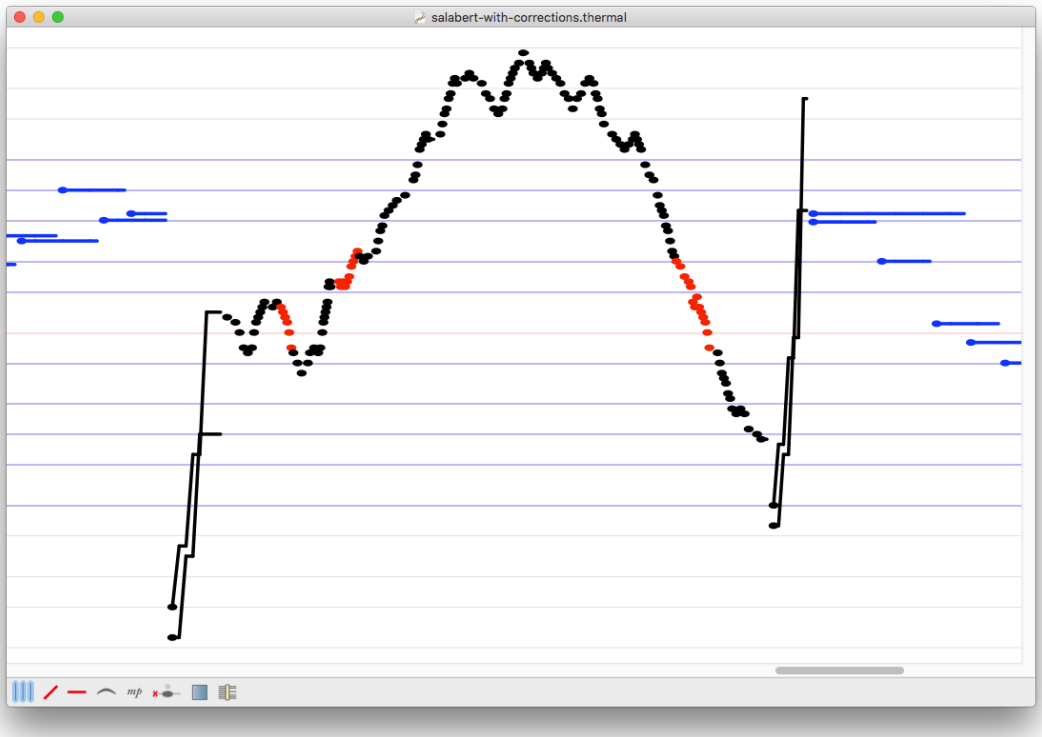

Figure 8.1.: Screenshot of `Thermograph`

After encoding the score, `Thermograph` afforded an active exploration of the work: I deleted various parts of the score, experimented with the zoom scale and aspect ratio, and created variations of the score with hypothetical 'corrections' and modifications applied, each helping me to learn quite a bit about the internal logic of the random walk and harmonics sections. Through these explorations I began to see past the work's patchwork form to the structural interconnection of its individual sections, expressed both through continuity across interruptions and through internal reuse of significant chunks of random walk material. Further, my previous investigations into local-level pitch details progressed more rapidly in context of the visualization — I found I could rely on the visual symme-

try of the random walk materials to guide my efforts. By the time I visited the archival materials at the BnF in the summer of 2013, I was prepared with the 'Listening Guide', a `thermal` encoding of the published score, the command-line tools, `Thermograph`, and various hypotheses to check.

8.4. shifting focus

After an intense, largely successful experience in Paris, then sharing the project with fellow attendees at Ostrava New Music Days, my perspective on the project began to broaden. At the least, my obsessive focus on local-level details of the score proved tiresome: while this effort certainly yielded some findings, it wasn't clear to me what possible benefits could come from them — or my insistence in calling them out — short of producing a critical edition.

At the same time, seeing the graph paper sketches, reading the notes, and thinking about the wooden bass forced me to address bigger questions on my mind about the relationships between music, technology, and the construction of the mythologized masculine 'genius'. I came to a personal understanding of *Theraps* as simultaneously thwarting an overtly masculine interpretation in its approach to technology — visible through its emphasis on musical ends over technological means — but redoubling such interpretations through its emphasis on virtuosity, drama, and violence. Not knowing what to do with this line of thinking, or even whether I was entitled to it, I wrote up my findings with regard to only the technological aspects, leaving aside the social ones.

I also became increasingly concerned with how close I was getting to doing Xenakis scholarship; this was never my intent, nor a particular desire. From reading a fair bit of Xenakis literature in context of my work, I knew better than to contribute my pet project to it, which could easily trivialize the deep personal investments others have made in Xenakis and his work. This made questions about distributing my work especially complicated; I never distributed my 'Listening Guide', encoding of the work, or tools, out of concern that

this might implicate me in a cultural project far more severe than the one I set out on. So, I let the work rest for several years.

8.5. doing it again

Several years later, I revisited the visualizer as a learning exercise, quickly rebuilding `Thermograph` using web technologies and a more 'data-driven' approach to the program's structure. Figure 8.2 shows a screenshot, including its live-updating `thermal` editor.

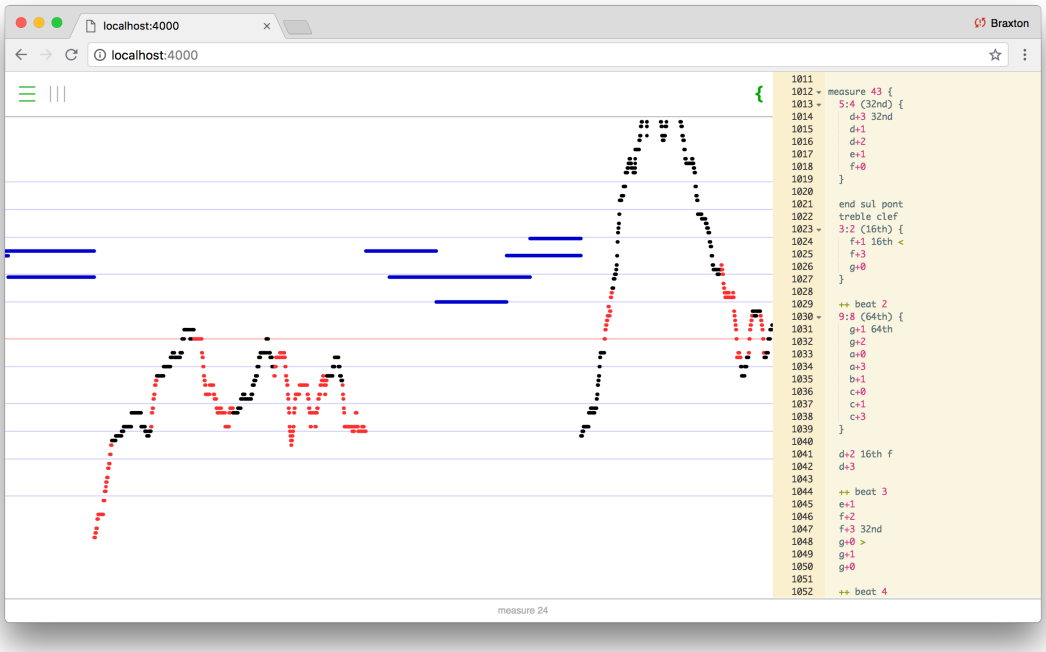

Figure 8.2.: Screenshot of `Thermograph` in browser

This exercise, beyond revealing how overwrought my code was for the desktop version, highlighted an unplanned benefit of `thermal` — despite there being no shared code between the desktop and web versions of `Thermograph`, the encoded scores work fine in either. Though this exercise hasn't shifted my thinking about distribution of the project, it has rekindled some of my former interest in developing music languages, and in using the web as a technical platform for doing so.

9. Tenney's *Quintext* and Relationships of Symmetry

From first hearing James Tenney's *Quintext* on Quatuor Bozzini's 2008 album *Arbor Vitæ*,[350] my interest was piqued, especially by its second and fourth movements; this interest only increased upon seeing the score, with its scattered ellipses and thick, continuous curves on a background of conventional staves.

This chapter recounts my process of learning about these movements and their contribution to the overall work. As with the *Theraps* case study, this started from a positivistic score-focused analysis — scrutinizing the two movements' scores, eventually modeling them in software — and ended with an enriched understanding of the work within Tenney's overall practice, where it serves as an exemplar of his practices of homage.

9.1. introducing the work

James Tenney completed *Quintext* in 1972, and published it shortly thereafter in *Soundings 6*.[351] The work's subtitle, "Five Textures for String Quartet and Bass", outlines its large-scale form: a set of five numbered movements ('textures'), each presenting a single musical concept related to composers and compositions in his community of influence:

[350] Quatuor Bozzini, "Quintext" (On *Arbor Vitae* [CD] Montréal: QB., 2008).
[351] James Tenney, "Quintext", *Soundings* 6 (1973).

I. Recent Thoughts for Morton Feldman

II. Clouds for Iannis Xenakis

III. A Choir of Angels for Carl Ruggles

IV. Parabolas and Hyperbolas for Edgard Varèse

V. Spectra for Harry Partch

This large-scale form relates an overall symmetry: the odd-numbered movements (Feldman, Ruggles, Partch) articulate spectral structures, presented through common practice notation with pitch deviations given in cents; the even-numbered movements (Xenakis, Varèse) each construct symmetrical forms out of stochastically-derived pitch-time points, presented to performers through graphic notations.

For decades, Larry Polansky's coverage of *Quintext* in *Soundings 13*[352] stood as its only rigorous description; he accounts for each movement's materials and references, giving especially careful attention to the origins and applications of the pitches in the odd-numbered movements. Polansky's work was supplemented by Wannamaker's discussion of the fifth movement in *Contemporary Music Review*,[353] as well as a number of reviews of the Bozzini album. In all cases, the ellipses and splines of the even-numbered movements remain comparatively enigmatic, a discrepancy that further stoked my interest. While their notations clearly resist the conventional approaches to analysis taken with note-based music, they have their own internal logic worth observing and discussing.

9.2. cloud gazing

The first system of Clouds, reproduced in Figure 9.1, exhibits the movement's only materials: tutti rests and 'clouds' of statistically-distributed pizzicati. These pizzicati are represented by hand-drawn ellipses, considerably taller than ordinary noteheads, which provide for some intentional variability in pitch; as Tenney states in the movement's front matter,

[352] Larry Polansky, "Quintext", in *Soundings*, ed. Peter Garland, vol. 13, 1984, 208–18.

[353] Robert A. Wannamaker, "The Spectral Music of James Tenney", *Contemporary Music Review* 27, no. 1 (February 2008): 98.

"the pitch notation involves some degree of indeterminacy, each note indicating any pitch within a range of about a major third". A similar variability occurs in time, arising from the unquantized horizontal positions of the ellipses, which are positioned proportionately within second-long time brackets.

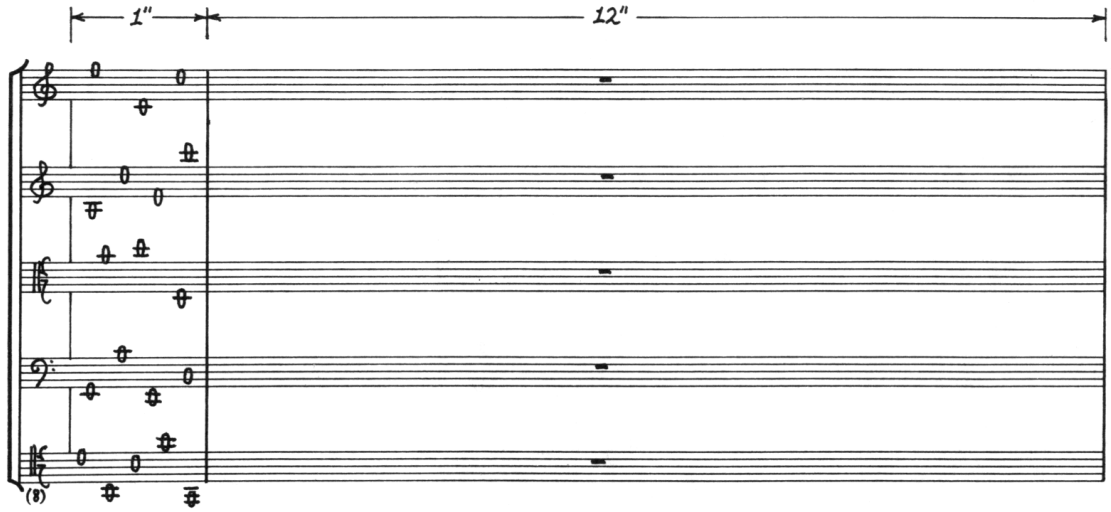

Figure 9.1.: First system of 'Clouds for Iannis Xenakis'
from *Quintext* by James Tenney. Copyright Sonic Art Editions.
Used by permission of Smith Publications, Sharon, VT 05065.

As the piece progresses, the clouds systematically lengthen while the rests diminish until the work's midpoint, at which point the work then proceeds in retrograde. With no rests at the midpoint, the middle cloud sections elide. As Polansky describes it, "the effect [of the form] is that of, say, a cloud gradually covering the sun and then moving on". A form diagram, presented in Figure 9.2, is derived from Polansky's diagram.[354]

[354] Polansky, "Quintext", 210.

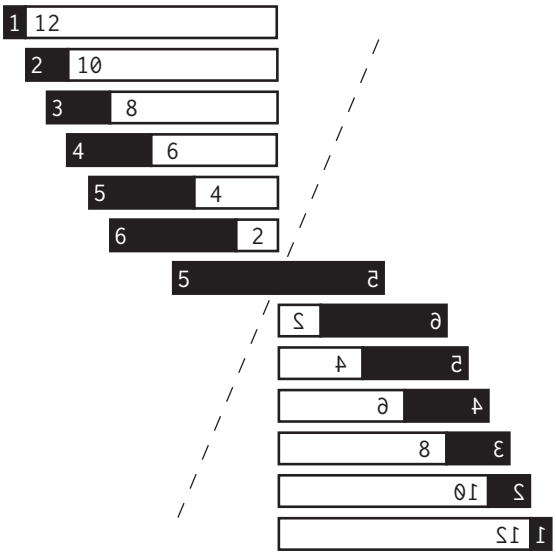

Figure 9.2.: Overall form of 'Clouds'

To confirm that the second half of the work proceeds in retrograde, I scanned the score and constructed from it a retrograde comparison diagram,[355] an excerpt of which is shown in Figure 9.3. In this diagram, the first half of the work is presented forwards in black, while the material from the second half is overlaid in red, flipped horizontally. This score, included in the attached portfolio, shows no significant deviations.

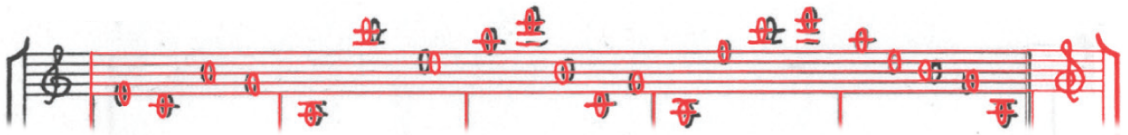

Figure 9.3.: Excerpt from the 'Clouds' retrograde comparison diagram

With this detail confirmed, I began digitizing the ellipses with the aim of enabling alternative visualizations. This involved manually measuring the position of each ellipse,[356] then building from these measurements a database of note events.[357]

[355] this required warping the images as necessary to bring the barlines and staff lines into alignment.

[356] this was done in a graphics editor: I positioned the crosshairs cursor in the center of each ellipse, and noted the pixel position. These were converted into times by normalizing them to reference points on the staff lines and barlines.

[357] using the data, I also found that the pitches are well-fit by a normal distribution, and the event times are well-fit by a uniform distribution. While these give a rough indication of the profile of the clouds,

After constructing the database, I created a program to visualize and sonify it. Figure 9.4 shows a screenshot of this program, called *Cloud Explorer*. The program's rather sparse interface reflects its principal use as a personal reference tool; presenting the ellipses in a single staff reduction, and allowing voices to be shown or concealed, helps make visible relationships between the five parts that might otherwise go unnoticed.

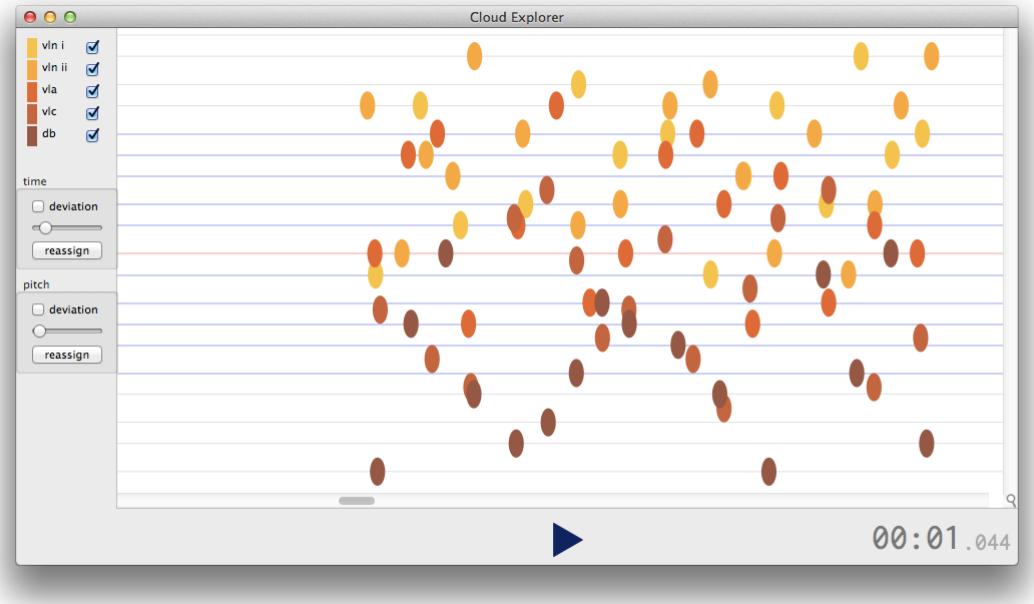

Figure 9.4.: Screenshot of *Cloud Explorer*

My initial plan, reflected in the name of the program, was to develop the software into an exploratory sandbox where the encoded score coexists with algorithmically-generated alternatives. The beginnings of this approach are visible in the controls on the left side of the window, which allow the sounding pitch to be randomized within the range of the ellipse, shown within the notation as in Figure 9.5. My interest in continuing down this path waned considerably after building this feature, in part because of my growing disillusionment with simulating intentional human behaviors in software, but also from my desire to refocus my efforts towards my own music.

it provides no specific insights about the work; at the least, the fact that the ellipses avoid the barlines must indicate a process more involved than simple sonification.

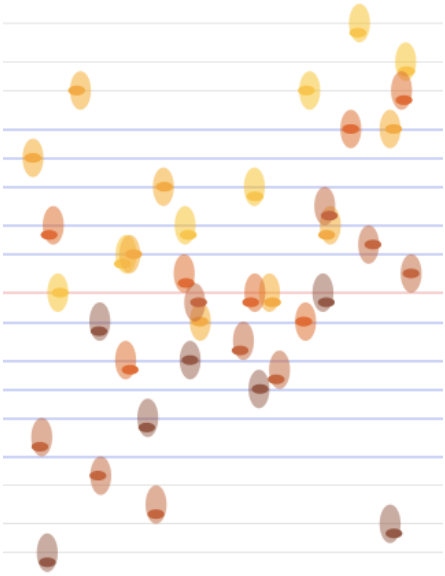

Figure 9.5.: Screenshot of pitch instances in *Cloud Explorer*

9.3. spline fitting

An almost six-minute-long block of *fortississimo* continuous glissandi, Parabolas and Hyperbolas presents a striking contrast to the quiet pizzicati of Clouds.

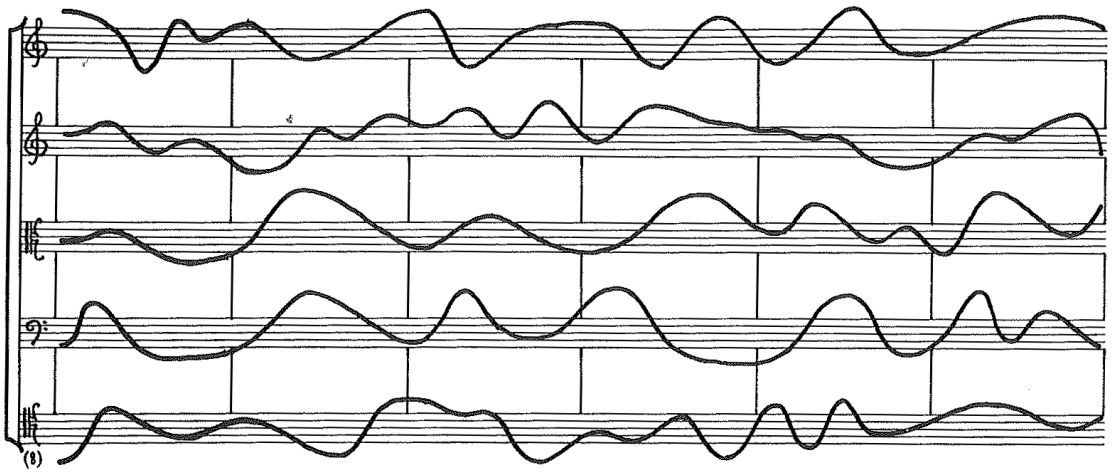

Figure 9.6.: First system of 'Parabolas and Hyperbolas' from *Quintext* by James Tenney. Copyright Sonic Art Editions. Used by permission of Smith Publications, Sharon, VT 05065.

As with Clouds, this movement uses proportional timing, each measure lasting four seconds, and a conventional staff for pitch, through which he has drawn the thick glissando contours. Except when the curves exit the staff lines, presented without ledger lines, they give a continuous and unambiguous relationship of pitch to time.

A retrograde comparison diagram, constructed as before, confirms the movement's symmetry. Figure 9.7, an excerpt of this diagram, shows a rare moment of divergence: a subtle timing difference in the viola part impacts the position of the system break within the pitch contour. This exception, taking place over fractions of a second, merely highlights how closely the second half otherwise mirrors the first.

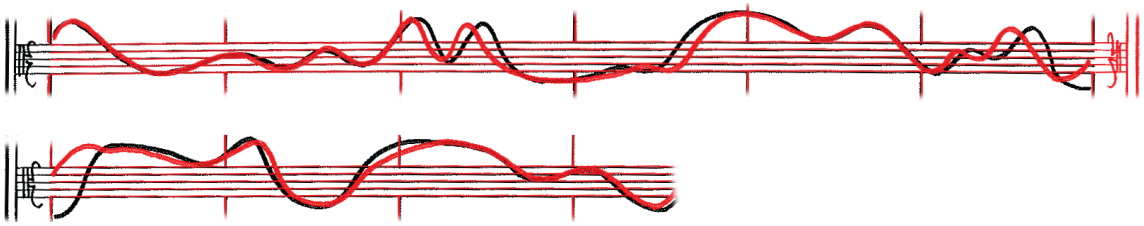

Figure 9.7.: Excerpt from the 'Parabolas and Hyperbolas' retrograde diagram

Since the pitch convergence at the midpoint of this movement gives it its shape, I wanted to see this convergence directly in a reduced score. To prepare a reduction, I teased apart the glissando contours from the barlines and staff lines — using these lines as references for alignment, but hiding all but the grand staff in the final score. The first half of the work, done in this manner, is shown in Figure 9.8.

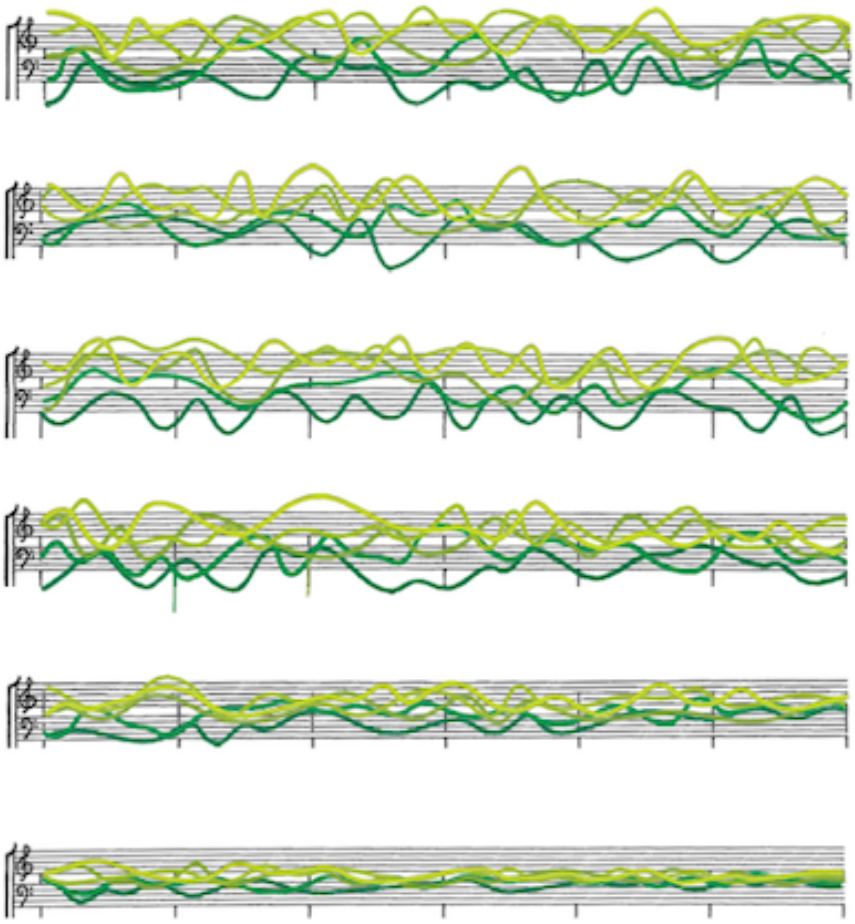

Figure 9.8.: Convergence over the first half of 'Parabolas and Hyperbolas'

Like the *Theraps* 'Listening Guide', this visual representation made possible some interesting local-level observations — especially around fleeting sonorities — but also left me with another idiosyncratic, inflexible, and only partially completed artifact. Rather than complete the second half, I decided instead to digitize the glissandi, 'tracing' the scanned score with matching splines.[358]

The program *Spline Explorer*, shown in Figure 9.9, visualizes the resulting curves. This visualization allows momentary alliances between the voices to be seen as they proceed along their individual paths. Further, seeing the voices overlap and intersect one another high-

[358] This tracing process was done in two passes, first through adding inflection points for the each of the minima and maxima of the underlying glissandi, then positioning the control points to match their curvature. The control points were positioned on a horizontal plane with the inflection point, and tended to be equal distances from their associated inflection point.

lights the tensions, clearly audible, between treating individual lines as truly individual, and as participants in a collective mass. In that regard, I find their interactions evocative of the 'twists' in Ruth Crawford's 1931 *String Quartet*, which Ellie Hisama imbued with such meaning in her analysis.[359]

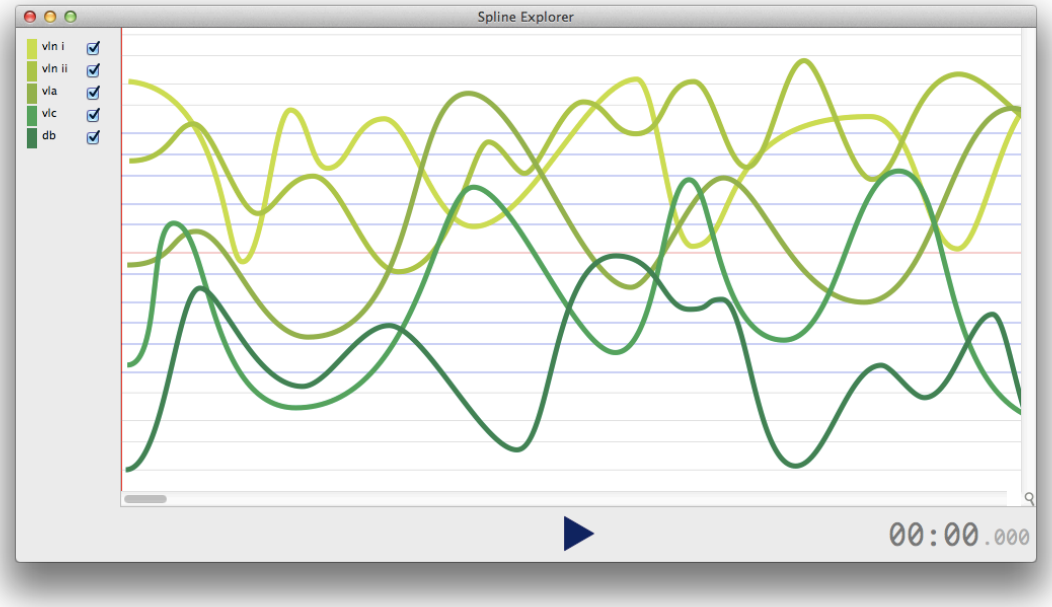

Figure 9.9.: Screenshot of *Spline Explorer*

9.4. hearing across

From working closely with these movements, I came to understand them as deeply related — as radically opposing musical surfaces articulating a profound shared approach. Beyond their mirrored forms, stochastic materials, and use of indeterminancy, these movements articulate the deep dialectic between impulse and tone, also expressed through time and frequency, or energy and power.

This understanding unites the extrema of the glissandi with the points of the clouds, and suggests that each movement might be productively heard through the lens of the other.

[359] Ellie M. Hisama, *Gendering Musical Modernism: The Music of Ruth Crawford, Marion Bauer, and Miriam Gideon* (Cambridge; New York: Cambridge University Press, 2001).

As a representative example, Figure 9.10 shows a single part overlaid with a fitted curve, making explicit how the pizzicati might look as glissandi.

Figure 9.10.: A 'Clouds' staff, parabolized

When the individual parts comprising the clouds collide in the final work, they yield a variety of possible interpretations, from a single uniform mass to 'streams' segregated by instrument, recurring pitch motives, or more. Any specific interpretation depends on a large number of factors, especially the ensemble balance, venue acoustics, and the momentary focus and propensities of the listener. Meanwhile, the changes in glissandi direction grab and direct attention from the overall mass to a specific part. Within a continually shifting texture, these changes of pitch direction — alongside those of bow direction — provide the prominent sources of rhythm.[360]

Albeit speculative, this interpretation relegates the underlying stochastic processes to being mere *means* of musical ends, a technique receding into the musical background. In the foreground, isolating the extremes of impulse and tone to their own movements allows an engaged listener to reflect on their possible reconciliations, making possible a wealth of disparate interpretations on repeated listening.

Beyond the concerns of technology, texture, and perception, the movements of *Quintext* also exhibit Tenney's longstanding practice of dedication — one of among many manifestations of his cultural project of collaboration, interconnection, and community building. Bob Gilmore describes Tenney's practices of dedication at length,[361] treating them as acts

[360] In my own listening, the bowing adds a wry wink to the Varèse dedication: it at once acknowledges his interest in continuity, but presents it tempered by human-scale energy and instrumental technique.

[361] Bob Gilmore, "James Tenney and the Poetics of Homage", *Contemporary Music Review* 27, no. 1 (February 2008): 7–21.

of homage curating an 'ecology of ideas'. As Polansky describes, the practice goes beyond mere reference:

> Not only the titles of many of the pieces, but the particular forms and questions asked in them point to his tremendous sense of musical continuity, both with his contemporaries and with the past. These references are not simple dedications — Tenney makes the things he loves into essential, integral parts of his own works.[362]

In context of Tenney's numerous other connective activities — his performance and advocacy of other peoples' music, teaching, and writing, to pick a few — these suggest not just "a sense of wanting to belong to an artistic community",[363] but an active forging of one. That community building should seem so ironic in the face of the 'stereotypical American pioneer' as 'loner artist'[364] highlights the very importance of such a project, and its promise to unite the 'desert plants'.[365]

362 Polansky, "Quintext", 125.
363 Gilmore, "James Tenney and the Poetics of Homage", 11.
364 Ibid., 15.
365 thinking here of Walter Zimmermann, *Desert Plants: Conversations with 23 American Musicians* (Vancouver, British Columbia, Canada: A. R. C. Publications, 1976), which also contains discussions of *Quintext* and its dedications.

IV.

looking inward

10. my music

This chapter rounds out the discussion by examining my own musical output.

I start by outlining some of my aesthetic tendencies, held constant throughout my work. Next, I discuss two strands of compositions, leading to *inflection study (pizz. gliss. lullaby?)* and *nodes & signs*. The associated works, while composed without direct reference to the music of the case studies, recall their musical textures across a variety of differing musical contexts. Finally, I relate the various uses of computing in these works to the ideas presented in the previous chapters.

10.1. aesthetic tendencies

To help explain why my music is the way it is, I will introduce a few of the musical convictions I have developed over the years. I share these in the spirit of candid self-disclosure, not as general proposals or lines of aesthetic argumentation.

10.1.1. locus of listening

Of the countless ways to listen to music, I gravitate more and more to two distinct approaches, mutually exclusive, through which I have had many rewarding experiences.

In one, I occupy the sounding environment first and foremost, shutting out all of my awareness of my real surroundings except that which comes through my ears. This in-

volves a heightened sonic mindfulness only possible with my eyes closed and my mind and body still. This allows me to hear not only more intricately, but also to listen through the sound, suspending disbelief, to experiencing other peoples' constructed worlds. For all of its pleasures, listening in this way is incredibly personal and exhausting, involving a level of vulnerability and exertion not suited for constant use.

In the other, I attend to the complete physical situation in which music is being produced, experiencing sound as only one among many senses engaged by music. This listening involves attending to how performers are performing, but also how the audience is audiencing — in a sense, celebrating the communality of musicking. I find myself in a heightened state of awareness around how people use their bodies, and around the spectacle itself and its 'ritual frame'.

Resulting from this split, sound in my music emanates from either speakers or intentional human actions, but never both. On the one hand, the incredible indexical potential of sound allows for it to encode tactile, sensitive human action — further, since this can also be *absent*, composed sound offers a unique possibility to point at musical humanness, rather than just presuming or embodying it. Meanwhile, if it really matters that someone is making music — in the room, and at that moment — I feel their presence ought to receive our focus and respect. From that perspective, I avoid decoupling human effort and sounding result, one of the central promises of a digital musical instrument, and avoid treating acoustic and electronic sources dialectically.

10.1.2. reduction, repetition, reservedness

As a listener — also, as a person who listens — I am pretty easily overwhelmed, and therefore find myself preferring repeated encounters to initial ones. I am attracted by the paradoxical 'fixedness' of works and albums, that holding their contents constant allows their meanings to flourish and morph in relation to a passing life and its memories.

I have no answers for how (or when) a first listen encourages a second, but density and volume certainly play a part. While I don't mind a good acoustic pummeling every now and again, I prefer to seek these out deliberately. So, I sympathize with my colleagues who deliberately avoid the "ongoing carpet of never-ending sounds",[366] but confess also having grown weary of the bare flooring of never-ending silence. While a lack of silence might preclude intimacy, its presence alone cannot conjure it — what was *oppressive* can so easily become *opprecious*.

In my performed music, I am often concerned with giving space for *introvertuosity* — rather mundane, inward-facing acts, approached with exceptional care and focus. This might involve anything from getting an ensemble attack *really* together to finding the best-sounding technique for mincing garlic. This means developing performance practices that attend to and elevate the mundane, in contrast to more conventional displays of extrovertuosity.

My music for 'softspeakers', meanwhile, is intended primarily for private listening. Shared online, people can download and experience this music on their own time, in their own headphones, and find their own value in it. When I air this music in public, I take care with its loudness, balancing sounds to the resting noise floor of the room, not to the noise floor of the audience, or the capabilities of the equipment. I prefer a forward-leaning listen to a 'visceral' one.

10.1.3. sustainability, self-determination, scale

Finally, that much of my music takes place on a small scale — performed by soloists or groups of friends, or heard in pre-existing private listening contexts — directly relates to how I have chosen to relate to music economically.

366 Radu Malfatti in Dan Warburton, "The Sound of Silence: The Music and Aesthetics of the Wandelweiser Group", *Signal to Noise*, 2001.

While various social norms work against open discussion of these topics, it should be clear that nurturing a musical practice requires having addressed basic issues of survival. Given this entanglement of musical practice and subsistence, practice-oriented literature would benefit from more honest discussions of the economic circumstances experimental musicians face and how these shape our musical lives.[367]

Over the years, I have come to detach my musical practice from providing for my basic needs. This came in part from acknowledging that my interest in making music has more to do with cultivating my own experience as a listener and learner than it does with striving for external recognition or institutional validation. Further, my own musical needs are quite modest in relation to the expectations any structure would have of me in exchange for paying me to make music. Since I am accustomed to making music with whatever I can find in my immediate surroundings, I resist developing a long-term dependency on elaborate technical setups, or on other people working on my behalf. So, my general tendency is towards the modest, intentional, and sustainable.

This has led to me following a more Ivesian route, supporting my musical life through working various technical jobs instead of starving myself on my consonances. While making this split affords me the freedom to take due time with my music, to emphasize learning, and to turn down musical opportunities that don't feel right, it also presents challenges around my musical identity and my sense of belonging to a musical community. I will return to these in the document's conclusion.

10.2. situating *inflection study (pizz. gliss. lullaby?)*

The solo cello work *inflection study (pizz. gliss. lullaby?)* continues a succession of works concerned with language and gesture. In it, a cellist performs sliding pizzicati on the lowest string of their instrument, derived idiosyncratically from the speech intonation con-

[367] I find especially encouraging how honestly and directly Pauline Oliveros confronts this topic in *Software for People*.

tours associated with a fragment of text. Unlike many speech transcription or 'textrument' pieces, the work dwells on specific representational ambiguities that occur as a function of time and inertia. It proceeds through four different pacings and affects, described in the performance notes. As these unfold, the resulting experience hopefully involves an ambiguity of attention and reference. Figure 10.1 shows a representative excerpt of the score.

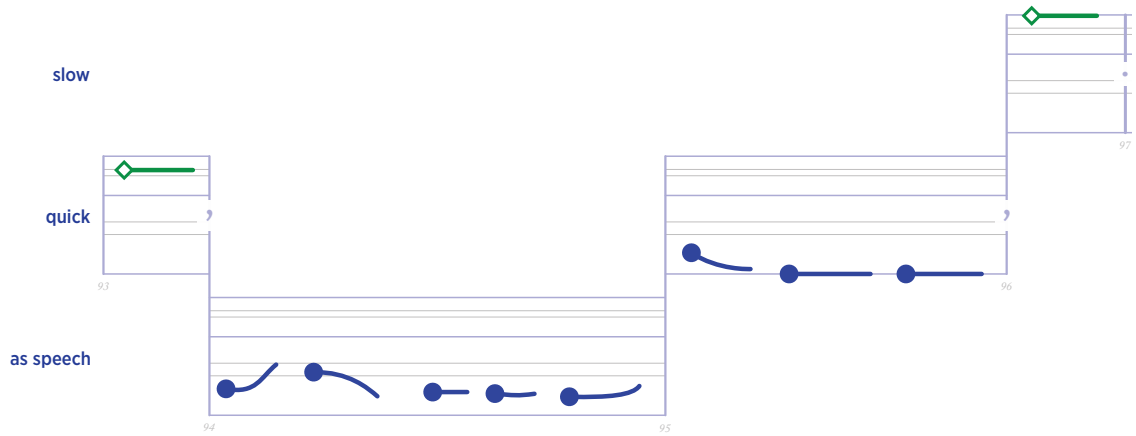

Figure 10.1.: Excerpt from *inflection study*

10.2.1. on language and gesture

Preceding *inflection study* are a number of works concerned with the audible traces of communication-related activities: writing, speaking, typing, and so on. These phenomena interest me in how they encode into sound the limits of attention and memory; the rhythm of typing, for instance, is bound as much to the speed of thought as to the dexterity of finger movement. I see reinterpreting these traces through music making as fruitful, adding additional layers of filtering and commentary on familiar sounds and the gestures that produced them.

The work *mise en place* approaches these questions rather bluntly — at least until the honing steels come out! In it, a quartet of narrating prep chefs recite choice quotes from the academic literature on music, computing, and gesture while performing gesturally and

sonically rich activities with kitchen utensils and produce. While evoking various kitchen classics of experimental music, especially *Proposition* by Alison Knowles ("Make a Salad"), it leaves behind prepared ingredients clearly not suited to any meal in particular. Figure 10.2 shows a still frame from video documentation by Angela Guyton, with Bird Rat Centipede performing.

Figure 10.2.: Still image from a *mise en place* performance

Another work, *dawidziuquet*, commemorates the marriage of my friends Sean Peuquet and Laura Dawidziuk (now Peuquet) through an occasion-specific work. Eight or more friends gather around a single laptop, which displays lines of text, as in Figure 10.3. A participant selects a line of text, slowly scrolling to the left, and reads its contents as they cross the yellow line. After an exposition of their last names (easier said than said!), the syllables and phonemes from these undergo a trajectory of divergence, and ultimately convergence, enacting a dual homage to Laura's background as a linguist and Sean's then interest in composing musical convergences.

Figure 10.3.: Excerpt from *dawidziuquet*

Two works for string instruments form more direct antecedents to *inflection study*, exploring how writing, drawing, and tracing might be musicalized.[368]

In a short study for violin, *for violin*, I adopted a deliberately simplistic approach to sonifying the physical gestures of letter writing. Through the use of a digitizing pen tablet, a short personal letter is subject to reinterpretation as inflections of a single pitch played across two adjacent strings; Figure 10.4 shows a representative example. Only a page long, this study helped me to work through how best to notate these curves, as well as to witness how a violinist responded to the flexible rhythms with little guidance.

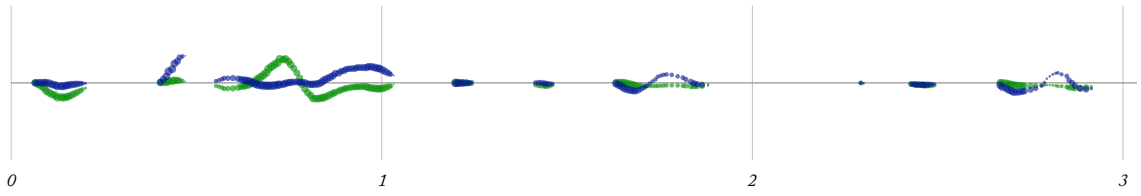

Figure 10.4.: Example of handwriting violinification

This study encouraged me to follow down the path further. When the opportunity came to write for a visiting string quartet, I composed *write, trace*. This work applies many of the

[368] or 'transferred', in the language of the *Theraps* discussion.

same musical concepts — especially around inflecting a 'carrier pitch' microtonally — but was oriented more around the visual appearance of drawn curves than around mapping a physical gesture. I worked with the curves as vector graphics, subjecting them to various processes of manual tracing and inertia. Figure 10.5 shows an excerpt of the work.

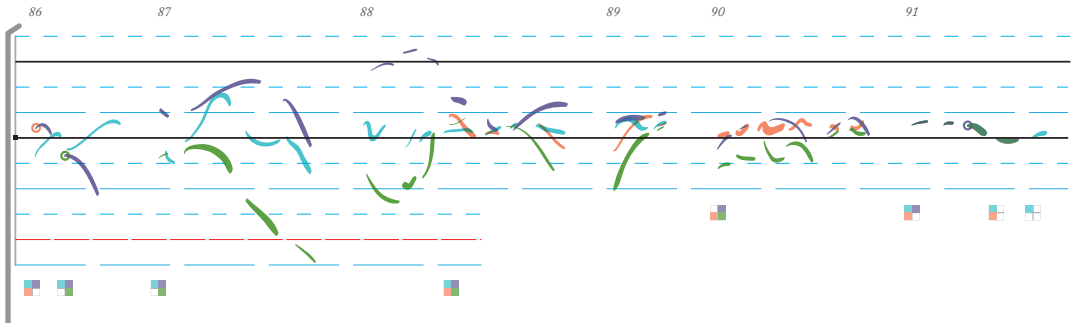

Figure 10.5.: Excerpt from *write, trace*

Looking back, I remember my excitement to expand on the ideas in *for violin* being dwarfed by the dual anxieties of working within the residency model of collaboration and of working in a medium with such a pronounced historical shadow. On the scale of my music, a string quartet might as well be a tenth symphony!

To compensate for these anxieties, I performed a more stereotypically 'composerly' working method; where I typically work directly in sound, and manage pacing through careful listening and refinement, here I insisted on 'internal audition' and a more 'architectural' approach to form.[369] This anchored me to the music as a notational image, allowing my internal hearing of its sound and its eventual actual sound to drift apart. The resulting work fell flat overall; I too easily substituted playing the part of the composer for actually trusting my judgement in composing.

[369] specifically, the 'architect' of the architect/contractor duality critiqued earlier.

10.2.2. from opportunity to performance

When offered the opportunity to write for a solo cellist, I took it, in part to dust myself off after *write, trace*. I thought I would try again to make use of a residency opportunity as a learning experience, this time with greater attention to maintaining my own integrity.

Early in the process, I decided that the work should make use of, but not require, the skills of a professional cellist. This gave early focus to my thinking around technique, notation, and difficulty. It also helped me detach my efforts from the Great Canon of Important Cello Literature. Partly in response to that canon, I decided to steer clear of constructing anything resembling a 'catalog piece' or a musical 'Vegas Mode' — the cello certainly doesn't need my help to be shown off as a wonderfully capable instrument. The burden became mine, then, to determine which aspects of the instrument I cared most to highlight, and which could safely be subtracted away.[370]

So, with a cello in hand, I explored and recorded a variety of techniques in the vicinity of handwriting-like sounds. Many seemed more promising in theory than in practice: noisy bow sounds, fingernails on strings, gentle scraping the body, and so on. After several sessions working in this way, I started to realize how tense I was around the instrument — I felt pressure to make the cello do something, and for that something to be *remark-able*. Stepping back, I realized how much I had been treating the cello as merely a sound producing object, a synthesizer, to the detriment of almost all other concerns.

When I later returned to the cello, it was with the aim of figuring out what I might do *with it*, rather than *to it*. The bow already seemed like an unnecessary distraction, so I left it aside. Doing less, but with more attention, I realized that even the resting position of the cello had some personal significance — a clumsy, timid hug with a new cello acquaintance. What came to matter most in these explorations, ironically, was finding a way to work with the instrument that alleviated the surrounding pressures I felt of needing to work with the instrument. The sessions took on a more reflective character, making it possible for some

[370] or, *digging for radishes* within the accumulated heap of cello techniques.

simple distinctions around the body and 'voice' of the cello to replace handwriting as a central concern of the piece.

From there, I started building up some supporting software. Because of my desire to stay connected to the instrument throughout the working process, I treated software as a site for *hermeneutic* relations — as a place for developing and converging the notation of the final piece — but reading its symbols always through an *embodied* relation with the cello. The work took shape through a fluid process, moving between developing software, playing cello, and listening. Throughout, the program `cello canvas` mediated the production of the score; a screenshot is shown in Figure 10.6.

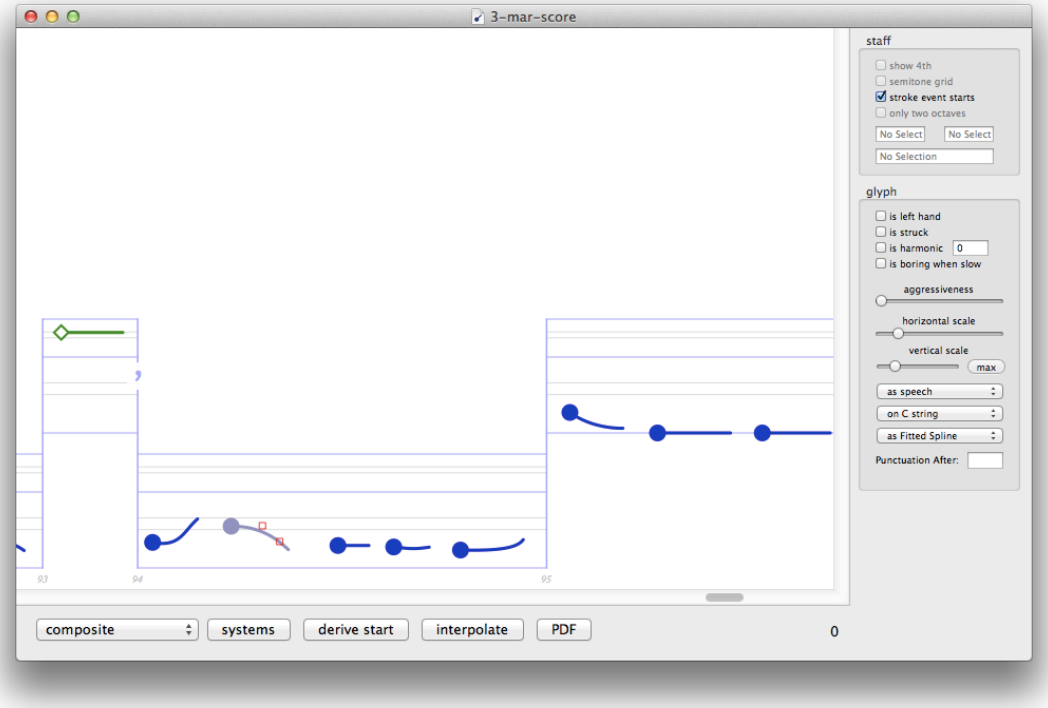

Figure 10.6.: Screenshot of `cello canvas`

The piece was premiered by Séverine Ballon, and has been performed subsequently by Matthias Lorenz.

10.2.3. reflections

A few notation-related concerns aside, I came away reasonably satisfied with both the process of constructing the work and its musical results. I was somewhat less convinced, though, by my renewed attempt to make use of the residency model. Despite an excellent performance, the experience confirmed my suspicions that time-limited opportunities with virtuoso performers are better left to others.

Three notation-related concerns stick with me. First, the visual appearance of the glissandi was the subject of some tittering within the department, appearing a bit 'spermy' to some colleagues. This association was completely unintentional, and a bit unfortunate. While I wasn't exactly going for a Paul Revere Award with the score's design, I somehow missed this interpretation in my focus on its functional aspects. In particular, I was concerned with the score's legibility at a distance in dim lighting, which accounts for many of the design choices.

Considerably less puerile is a remaining question about the ordering of staves. Throughout the process, I wavered on whether the four staves, representing speeds, should be ordered with the fastest on top, or the fastest on bottom. Both have their logic: a *gravity* mental model would put the slowest moving things on the bottom, with faster-moving things positioned above; this tendency can be seen (sort of) within conventional score ordering. Conversely, a *parallax* mental model would put the fastest moving thing closest, with stability in the distance. Similarly, a *thrust lever* mental model would put higher speeds closer to the body — pull backward to go forward. I ended up using the parallax model, but still find it visually strange to see a fast moving line on the bottom.

Finally, the performance notes contain a specific compromise added late in the process, which I no longer stand by. In indicating the volume of the work, I included the note "amplify the instrument as necessary in larger spaces (but conservatively!)" in response to knowing the work would be premiered within a cavernous new music cathedral with unpredictable acoustics. Outside of that specific context, these notes may encourage the

wrong musical priorities — reconciling the piece with a pre-selected venue, as opposed to considering the piece, event, and venue as a unified curatorial act. Taken seriously, such a unified approach might imply curating communities as much as concerts, attending to the interrelations of people, places, and activities over a longer term.

The choice of venue was ultimately only one detail among many that made me aware of the *opportunity itself* than what it might *provide*. Far more critical were the short timeline to performance, limited possibilities of interaction beforehand, and an awareness that my not-yet-composed work would sit alongside specific canonic works. These all naturally conditioned my work and attitude towards the defensive; at the same time I was trying to figure out how best to make use of a cello, I was also balancing the promise of the opportunity, appreciating its rarity, with an understanding of it as alienatingly detached from my everyday musical life. I felt a curious, ironic conflict between using the opportunity to *learn* and using it to signal *having learned*.

I have since used the experience as encouragement to think about social contexts where similar learning might take place more continuously and interactively within the experience of a life-long musical learner.[371]

10.3. situating *nodes & signs*

The project *nodes & signs* continues a succession of works concerned with 'splatters' — an umbrella term for clusters of short sounds, irrespective of whether these arise from deterministic processes or stochastic ones like those of *Quintext*'s clouds.

In *nodes & signs*, an after-hours computer lab showcases a graph of sounds, interconnected by various real and hypothetical relationships of signification. These relationships span from material properties ('ceramic') through identification of objects ('mug') to probable contexts for those objects ('kitchen'). From moment to moment, the sounds 'activate',

[371] See John Dewey, *Experience & Education* (1938; repr., Free Press, 2015), ch. 3.

and their activation potentially propagates to neighboring sounds, both within and across computers. Each computer begins with the same graph, but slowly and independently erodes it by adding new relationships and breaking existing ones; the graphs diverge over time, but remain cross-wired between computers.

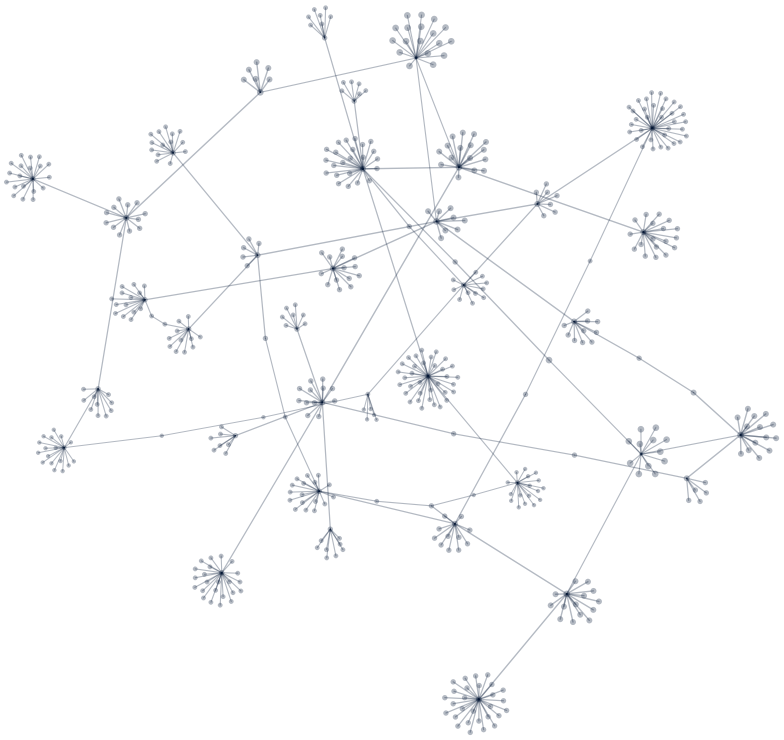

Figure 10.7.: Example graph from *nodes & signs*

10.3.1. on splatters

My interest in splatters, beyond an inexplicable attraction to sputtery sounds, comes from being intrigued by how their surface similarities can originate from a variety of sources and can diverge wildly in their interpretations. The real-world variety of splatters is immense — from toys like dice, marbles, and ping pong balls, to the Geiger counter — giving a lifetime worth of signification potential to explore. From these, I am especially drawn to the auditory equivalent of false cognates; when foley artists use sizzling bacon for the

sound of rain, it makes possible an enriched cinematic experience where onscreen rain, also fake, can be imagined as torrential bacon grease.

This ambiguity of reference appears often in my music for sound alone, where impulses bridge sounds of disparate origins. In *impulse response space*, for instance, I articulate rhythmic grids of impulses with a variety of everyday sounds, some delayed and softened to evoke the early reflections of an unlikely acoustic space.[372] These articulations eventually broaden and accumulate, producing shifting resonances of glassware that engulf the grids. *splatter, articulate, recurse*, meanwhile, projects human intervention onto simple statistical distributions.[373] After an exposition of grain clouds, which the seed the work's recursive process, each successive section reveals more of the originating sounds — and their performative origins — towards a nocturne (of sorts) in the final section.

Through constructing these works, I enjoyed observing the non-equivalence of splatters produced through equivalent means — especially prominent against the backdrop of their 'off-the-shelf' formal processes. Given their relatively low density of events,[374] a splatter's statistical description does little to account for how it might be experienced in a musical context. From the same distribution, one splatter might afford being heard as a 'rhythm', while another might tend towards 'gesture' or 'morphology'. Further, when sounds collide, their interactions can span from the musically serendipitous to the egregious, owing to the peculiarities of masking, phasing, and more.

These unpredictabilities give space for developing and applying a curatorial ear. Within *filter, glisten*, I renounced the 'didactic' formal processes of the other works to follow through on some of these opportunities. Intrigued by the possibility of an auditory parallel to the 'Sorites paradox', I worked with splatters across a wider range of densities — asking, in part, *when does a rhythm become a slosh?* Further, to exaggerate those moments of coinci-

372 this 'articulation' takes place through an idiosyncratic, amplitude-dependent convolution algorithm.
373 the distribution of sounds in time in any given section is determined by treating the previous section's output as a probability density function.
374 essentially, their 'non-ergodicity'.

dence between sounds, I gave myself license to apply processing well beyond my normal custom.

The resulting work entertains a semiotic play on 'filtering', understood through both aquatic and signal processing metaphors. The work's splatters are composed of tens of thousands of acoustic slivers, produced by subjecting source files to band-splitting filters.[375] These slivers, once reassembled, form the droplets and sloshes of the final work, and give rise to the fragmentary, unintentional melodies throughout.[376]

Where each of these works uses software to approach splatters stochastically, another set of works constructs splatters through instructions given to performers. *mise en place*, described earlier, uses interleaved sections of unison carrot biting to regulate forward progress in the work; until the performers non-verbally agree that they have bit in unison, they are stuck in an endless loop producing carroty splatters. Somewhat more refined, the acoustic sextet *in & distinguished from* uses hierarchies of cueing and delayed response between performers to highlight the intense demands in chamber music to balance individual agency with ensemble togetherness — rhythmic and otherwise. Figure 10.8 shows a representative part, which gives only a performer's immediate context, leaving them to make sense of the part situated in rehearsal.

[375] for the band splitting, I used a variant on the Linkwitz-Riley filter. Using an automated process, I split the source sounds into a defined number of bands — from eight at the coarsest to hundreds at the finest. From the untold gigabytes of resulting audio files, I manually removed any slivers I found objectionable.

[376] the work is presented in three versions, lasting three, seven, and nine minutes. These share the same underlying material, but differ in their editorial priorities. The three-minute version, for instance, uses a condensed form to emphasize the gestures and melodies latent within the material; by contrast, the nine-minute version prioritizes a gradual unfolding, guiding a listener with entraining pulses.

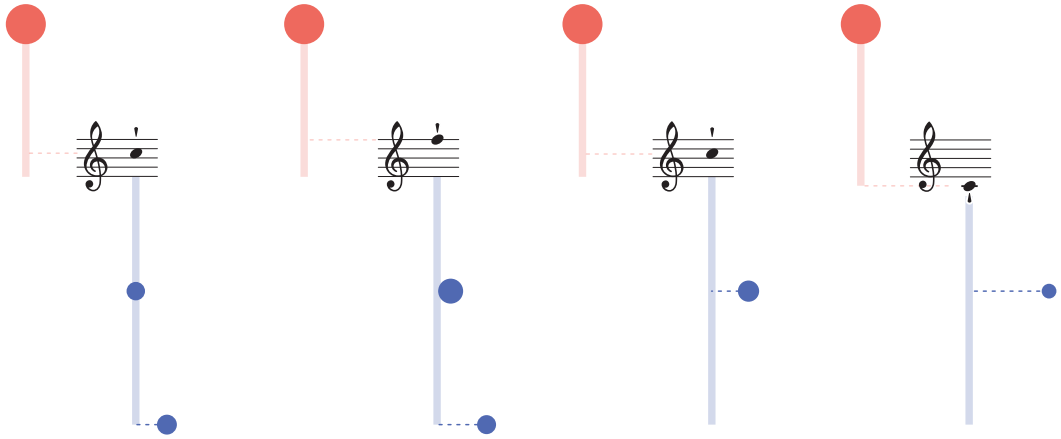

Figure 10.8.: Excerpt from the flute part of *in & distinguished from*

The work *splatter study (on social networking)* extends and generalizes this approach, replacing its fixed instrumentation and pre-given materials with a set of instructions (see Figure 10.9). These instructions, when followed closely, give rise to a complex morphing network of cause-and-effect relationships between friends, involving splatters, cycles, and events of no further consequence. This network slowly disperses at a pace dictated by individuals' own interest and tolerance; as people opt out, the network of remaining participants increasingly approaches a simple mindless call and response.

splatter study (on social networking)

form a circle of eight or more friends. the more the merrier!

independently pick:
- a short sound, ideally just an attack
- a long sound
- a length of time, less than two seconds
- a person in the circle, your "buddy"

whenever your buddy makes their short sound, wait the duration you've picked, then make your short sound. also feel free to make your short sound whenever the moment is right.

if you get bored with your contribution, or want to get out of a loop, you may:
- ignore your buddy's next sound, then rejoin with a different short sound, or
- pick a new buddy and a new short sound, or
- make your long sound, then exit the circle.

if your buddy exits the circle, inwardly mourn their loss, then pick a new one.

Figure 10.9.: Score for *splatter study (on social networking)*

Accompanying the work is a small book, containing a very small subset of the possible relationships between individuals in the work expressed as directed graphs. These invert the relationship of the graphs to sound; where a listener of *splatter study* might infer the underlying graph from its sonic effects, *A Catalogue…* presents the graphs directly for imagined sound. The cover, reproduced in Figure 10.10, gives some sense of how seriously I was taking the materiality of the work.

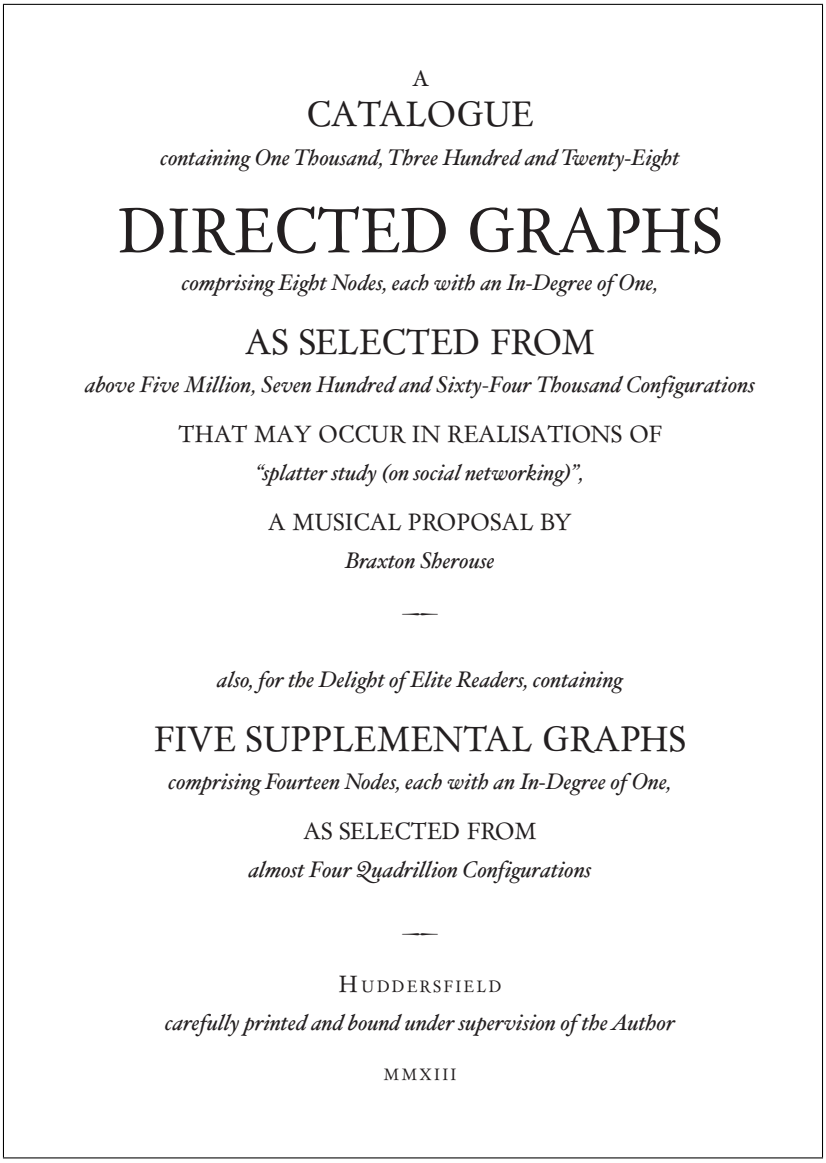

Figure 10.10.: Cover of *A Catalogue…*

The composition of both *splatter study* and *A Catalogue…* was supported by a simple application for visualizing graphs. `cyclic graph generator`, shown in Figure 10.11, helped address my underlying questions about how the instructions might lead to the work's form — especially important since the number of participants impacts the proportion of musicians involved in cycles. This helped me identify eight as an ideal number of friends, balancing the diversity of graph shapes with the consequences of the worst-case scenarios.[377]

[377] here, the limit cases are the singly-linked list (the musicians play 'telephone') and the n-ary tree (everybody is directly dependent on the same person).

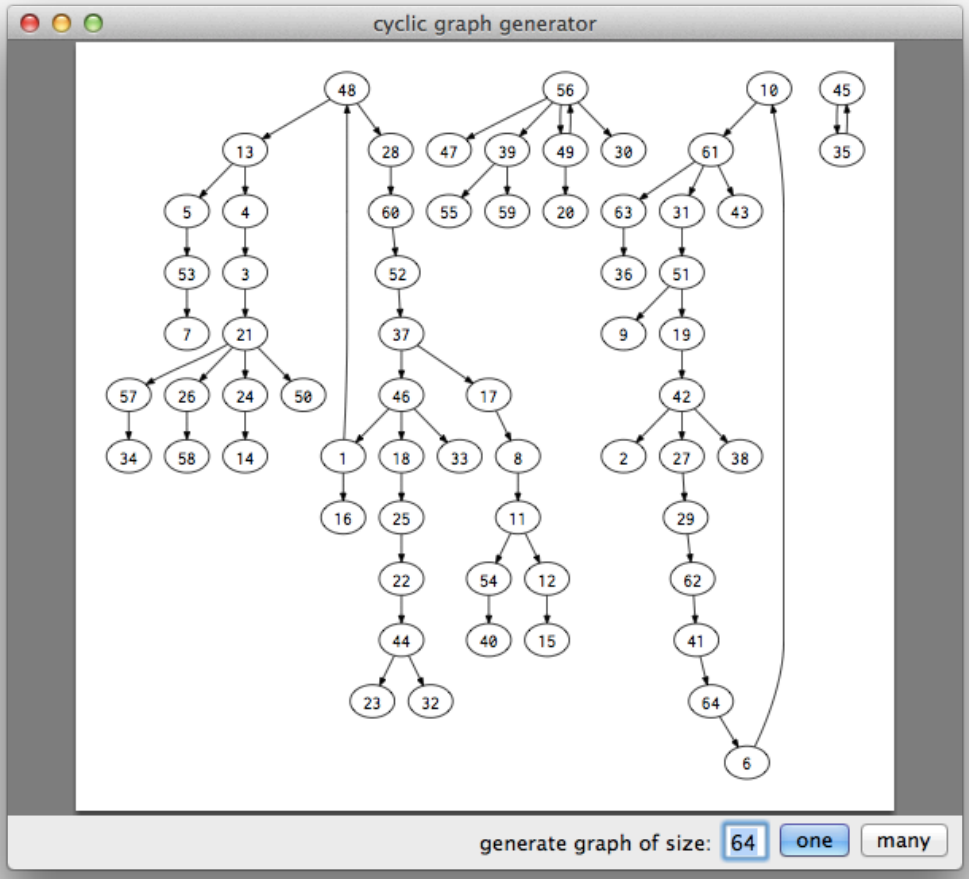

Figure 10.11.: Screenshot of `cyclic graph generator`

10.3.2. from opportunity to performance

nodes & signs began as an exercise in reconciling aspects of the fixed media works, in their approach to sound and signification, with the behaviors in *splatter study* and *in & distinguished from*, which make relationships of causation audible. This possibility had been lurking in the background for a while — *in & distinguished from*, despite taking the form of an acoustic sextet, was composed as a sort of algorithmic computer music, involving developing software and curating its output. To shift from dabbling to actually producing a work, though, I needed a clearer idea of how the idea might manifest in a meaningful

experience for other people; for *nodes & signs*, such a push came from encountering a quote by Brian Eno:

> I walked past a rather posh house in my area with a great big huge screen on the wall and a dinner party going on [...] The screen on the wall was black because nobody's going to watch television when they're having a dinner party. Here we have this wonderful, fantastic opportunity for having something really beautiful going on, but instead there's just a big dead black hole on the wall. That was when I determined that I was somehow going to occupy that piece of territory.[378]

While I had no specific interest in colonizing upper-class dinner parties, I found compelling the idea that blank screens, prominently placed, and with their own associated uses, could represent an opportunity for art. At that time, I would routinely walk by two handsomely-outfitted computer labs in Huddersfield, and started noticing how often they were vacant in the evenings. Maybe Huddersfield could lend me their 'rather posh house'?

More than just a space, empty computer labs also carry strong associations for me, having administered several labs at different educational institutions. I have internalized the peculiar rhythm of lab deployment, which balances short, intensive periods of thought with long stretches of repetitive labor and waiting. Labs also offer the strange delight of seeing the quirky 'personalities' of mass-produced consumer goods intended to be identical — that one computer starts slower than the rest, has a bit of a pink tinge, or an overeager fan. But I clearly have something for empty venues in general — I have strong memories of concert halls, libraries, classrooms, and computer labs outside of their regular operating hours.

I started working towards a software-based sequel to *splatter study*, beginning a single-computer version which I would progressively expand into a complete lab piece. Developing this software unfolded in parallel to curating the sounds and determining their relationships. I settled on visualizing the relationships of the sounds through a force-directed graph, in large part because these evoked various phenomena from the natural world, from

[378] Dustin Driver, "Brian Eno: Let There Be Light", 2012, `https://dustindriver.com/apple/apple-pro-eno.pdf`.

dandelions to tumbleweeds. I also found it attractive to watch the system strive for and eventually attain equilibrium. Figure 10.12 shows the resting state of the graph of sounds in the single computer version.

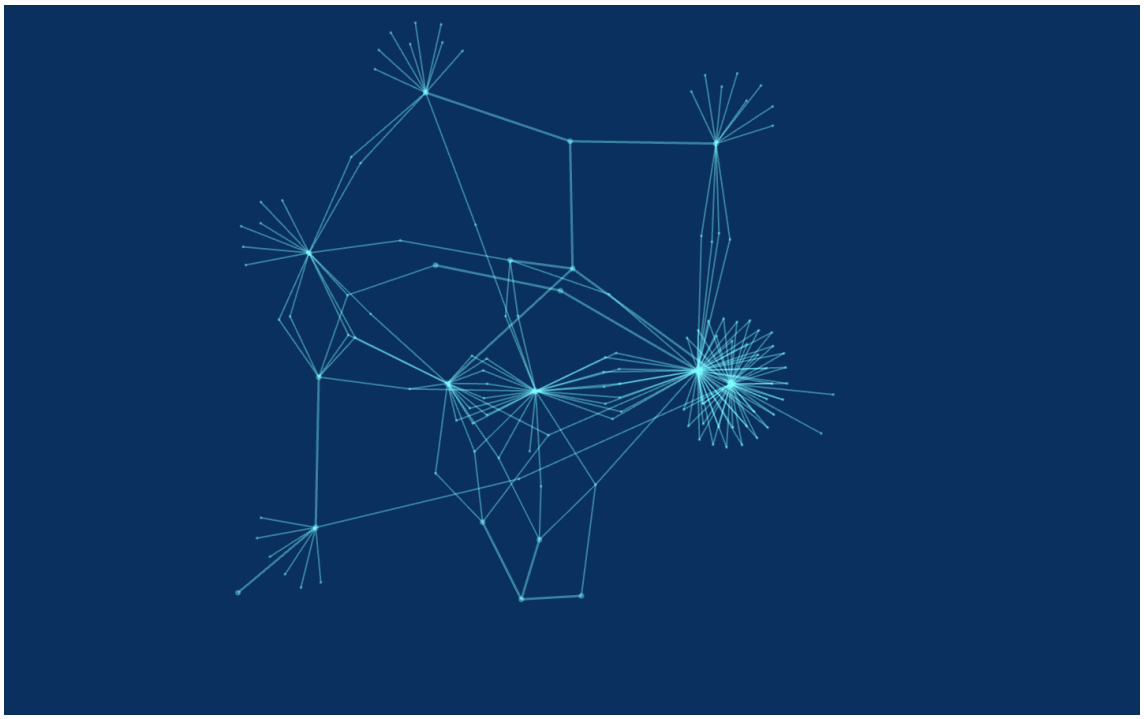

Figure 10.12.: Screenshot of *nodes & signs* for single computer

The activation of sounds, and their propagation to surrounding sounds, involved selecting and tuning algorithms towards results I found aesthetically desirable. In the end, each sound has an associated 'cost', and each activation receives a fixed 'budget'; any budget remaining after a sound is activated spreads to neighboring sounds. This propagation algorithm balances depth-first and breadth-first activations, and balances the selection of neighboring sounds using a simple statistical feedback algorithm;[379] all of these choices work against the lumpiness associated with a naive random selection. Figure 10.13 shows the software's high-level controls, hidden during a performance.

[379] Larry Polansky, Alex Barnett, and Michael Winter, "A Few More Words About James Tenney: Dissonant Counterpoint and Statistical Feedback", *Journal of Mathematics and Music* 5, no. 2 (July 2011): 63–82.

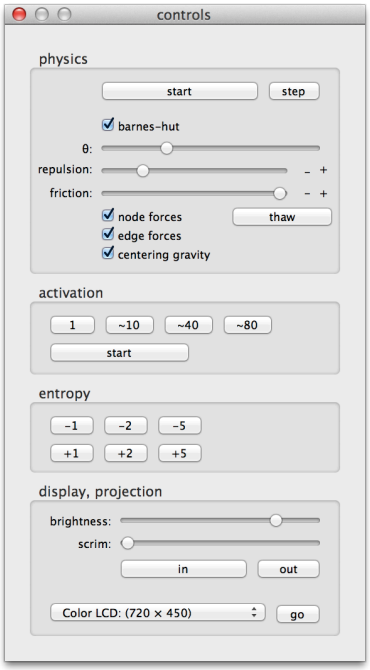

Figure 10.13.: Controls in *nodes & signs* for single computer

I first presented the single computer version during a set at Ostrava Days. With the software very much a work in progress, and me still learning how to make music with it, the performance took on a deliberately pedagogical form — introducing the graph in its pristine state, activating it with various intensities, then slowly ramping up the entropy until any semblance to the original was eroded away.

Back in Huddersfield, I started to fit the work to the lab. First came a 'parallel version', with each of the workstations running the same software autonomously, without any communication between them. This made for incredibly dull music, but allowed me to get comfortable working with the space. It also involved building some small 'operations' tools for centralized control over the screen brightness and volume, to stop and start it, and to distribute updated versions. At this point, the appearance of the piece can be seen in Figure 10.14.

Figure 10.14.: *nodes & signs* for computer lab

In the final stages, I allowed activations to span between computers, and adjusted the musical density to compensate. Before sharing it with people, I considered whether (and how) the piece should respond to their interaction; in a sense, grappling with whether participation also implies co-construction. On the one hand, I wanted to invite people to get closer to the computers somehow, since the experience of sitting at a computer differs considerably from standing at a distance. On the other, I had skepticism that someone, given the opportunity to simply click and hear a sound, would be able to find any depth in the piece. Following that line of thinking, attendees of the first lab opening engaged with 'placebo interactions', their efforts leading to visual activations of the graph, propagating across the computers, but without affecting the sound one bit.

10.3.3. reflections

Where *inflection study* puts a listener in direct contact with a musician and their cello, a listener of *nodes & signs* sits or stands among several dozen expensive glowing computers. From that standpoint alone, it is worth critically assessing whether the work transcends

its highly-technologized presence. While making the work, I thought of its aesthetics as oppositional to the technological frame, and therefore making a playful, provocative commentary on it; I am far less convinced now.

At the least, from seeing more and more force-directed graphs over the intervening years, I have shifted from seeing *through* them to their contents, to instead simply *seeing them* as presets. While I can dissipate some of my embarrassment by noting that new 'infoviz' software libraries have since made these graphs trivial to create, supporting their ubiquity, it could just as well be that I have become more attentive to these graphs in the world from having used them in the piece. From that perspective, it seems likely that I adopted as a defining aesthetic feature of the work a common property design object.

Similarly, my construction of the graph on the basis of potential sonic *meanings* was an intentional response to the then-common approach of positioning sounds in 'timbre spaces'. My impression was that timbre maps, while incredibly useful, too often substituted for musical judgement, and therefore contributed to the overstated importance of the sound of sounds in music. While I thought my approach could point towards a more perceptually-oriented, semiotically rich experience for human listeners, feedback from several attendees made it clear that this point was lost. Among other comments, people suggested that I could replace my manual tagging with automatic classifications of crowd-sourced sounds off of the internet — then I'd "really have something".

Finally, *nodes & signs* directed a significant proportion of my time and attention towards computers, and especially, towards developing and tweaking software for them. From that perspective, what began as an Eno-encouraged optimism for the medium eventually gave way to an impatient slog; by the end, I was relieved to go sit in a piano practice room and play some *Mikrokosmos*.

Ultimately, my understanding of the lab piece continues to oscillate between two alternatives: in one, I have made sensitive use of the unlikely venue of a computer lab to host a musical encounter; in another, I have simply made a screensaver.

10.4. technological tendencies

Having introduced some of my works in the previous sections, this section gives more context on the various roles computing played in their construction.

Here, a deep irony of the project emerges: by making my computational ambivalence central to the thesis, it all but forced a discussion of technical details that I would otherwise simply suppress. This is because I very rarely find that knowing more about an artwork's associated software enriches my aesthetic experience; more often, these details rewrite my experience into a simple categorization and comparison with similarly-constructed works.

While software details may not be essential for understanding or appreciating the works, they are integral to discussing the underlying *practice*. So, I share the following remarks as a percussionist might discuss their mallet selection — as choices essential to, but not primarily constitutive of, the resulting music.

10.4.1. approach, avoidance, alignment

Behind the scenes, my practice plays out an approach-avoidance conflict regarding computing, owing to decades of technological and cultural change, as well as my own concurrent growth. To the former, I take rather personally how personal computing has shifted from serving as a hobbyist activity within local communities to enabling a runaway global 'surveillance capitalism'. I am now convinced that computers underpin or exacerbate many of the most contentious global issues of our lifetimes — far from the idealized visions of many computing pioneers. To the latter, after decades working with computers, the magic I once felt in getting them to *do something* has dissipated considerably. I now wish for more of my life to exist outside of the glow, steeping instead in less mediated sensations. Sometimes, I've learned, carefully dropped rice will do just the trick.[380]

[380] thinking here of Michael Pisaro and Greg Stuart's *Ricefall (2)*.

I therefore consider music making as an opportunity to problematize computing as a cultural phenomenon, rather than to evangelize it or merely evade it. Within my music, this manifests in various ways, but principally through attempting to align the presence of computing with an understanding of the work's content. This means that making music for me involves bringing the intended meanings of a work, its medium and manner of presentation, and its methods of construction all into alignment, none of which are taken as pre-given.

Within many of my works, computing has no visible presence at all, playing at most a supporting role in the work's construction. The two works with kitchen sink instrumentation, for example — *mise en place* and *splatter study* — use computing's absence to facilitate its critique, addressing the contemporary topics of gestural control of computer music and of social media, respectively. The instrumental works such as *inflection study*, meanwhile, adopt the focal practices of traditional acoustic music performance, even when they were constructed with the assistance of software.

The works for sound alone such as *filter, glisten*, while making use of digital audio as their medium, are intended to be experienced in listening contexts where a listener resides on the inside of the immersive gap, and can therefore enjoy an indexical listening rather than a 'technological listening'. Where these works involve conspicuous signal processing, the techniques used are purposefully idiosyncratic, and have some sort of metaphorical integration with the work's overall concept.

It is quite rare that a computer makes a visible appearance in my music. When a laptop serves as a live score in *dawidziuquet*, this is a pragmatic solution to make the work performable with no rehearsal. Given its association with a special occasion, I simply ignore the experience of a non-participant observer; they can join in or wait a few minutes for it to pass. Finally, *nodes & signs* represents my most conspicuous display of technology yet, and as discussed, leaves me uncomfortable.

10.4.2. studies, domain specificity

While in some ways these works cover a wide musical terrain — at least from resonant carrot biting to resonant cello plucking — they all share a tendency towards single-concept works of a relatively modest scope. As such, they could all be considered 'studies', even when I don't explicitly label them as such. In a world of 'masterworks', I am happy to approach music making in this way, encouraged by a long history of other musicians' studies, many of which I enjoy far more than their 'proper' works.

Treating music in this way also affords a corresponding approach in the related software. Within the metaphors of the fireside chat, all the software in this project is 'sand mandala' at best, never 'village'. The software is *disposable*, built only to address a short-term need, having no 'users' other than myself, and correspondingly having no expectations on distribution or maintenance. It is also *domain specific*, in that it uses musical representations idiosyncratic to specific works, rather than ones intended for broader use or relevance.

Adopting this approach has direct implications for 'quality' and preservation. Compared to the standards I uphold in my work life, these programs are no paragons of professionalism, with almost no test coverage, no specification, plenty of misleadingly named structures, and often using ad-hoc language bindings to bridge otherwise incompatible programming environments. Similarly, for a hypothetical 'user', the 'happy path' is especially narrow: the tools can do exactly what I needed them for, and likely little else.

While these choices reflect a deliberate pragmatism at the time the software was produced, assembling these once-discarded programs into a 'portfolio' raises additional points for discussion. At the least, the whole notion of 'disposability' runs counter to an assumed desire for preservation in the digital age. Contemporary debates around the expected lifetimes of data, such as the 'right to be forgotten', show that these questions grow only more complex as the years pass.

Preparing the programs for submission also required revisiting them in ways I typically would not otherwise; instead of simply allowing the software to 'rot', I made pragmatic updates to the code, compensating for various deprecations that occurred in the interim. Hopefully the self-consciousness I felt in revisiting this code after years gives some truth to my claims of continual learning!

10.4.3. platform as 'preset'

Finally, since I develop my music and its corresponding software in parallel, I often encounter similar questions around reinvention and reuse simultaneously in both media. Their surface-level differences give way to deeper patterns of interconnection, linking an embrace or rejection of historical musical precedent with the accretion and subtraction of software construction; digging for musical radishes and deciding when to reuse or rebuild software libraries; the emergent 'presets' of a musical genre and those of a technical platform.

A 'platform', beyond simply referring to a given manufacturer's hardware architecture or operating system, can encompass more generally the complete set of external dependencies necessary to run a piece of software. Expressing platform in this way — as an instance of abstraction — reveals the irony of 'cross-platform' development: that the very frameworks that abstract away the multiplicity of lower-level platforms *become* a platform themselves. Selecting from these platforms for music making involves not only deciding which of the pre-existing accreted technologies best serve a given need, but also committing to assimilations that may well later reveal themselves as a technological presence.

This helps to frame my 'non-use' of computer music programming environments. At one extreme, when these environments actually contain within them the means for making whatever I have set out to, the sheer rarity of this encourages me to doubt whether what I wanted to do is valuable after all, or whether it is simply redundant with the universe. It is far more common that what I would like to create is misaligned with the affordances of

these environments, at which point I make use of general-purpose programming languages as a matter of principle and habit. Rather than trying to overcome a mismatch *within* such an environment, I would prefer to face the learning experiences that come from subtracting a bit too far, requiring me to reinvent 'square wheels'.

Some of the wheels are delightfully square indeed! As the sole user of my software, I make use of the latitude this affords for experimentation. For instance, some of the included software flouts 'best practices' for real-time audio performance, unapologetically replacing the usual meticulousness around audio callback 'hygiene' with a carefree disregard. In exchange for the associated hazards, this has allowed me to experiment with new programming languages.[381]

Software, too, can be a domain for attempt.

[381] some of the submitted software uses the D programming language, an unlikely candidate for professional audio programming since it previously mandated use of garbage collection as a means to ensure memory safety. In the past few years, a `@nogc` attribute has been introduced, making it more possible to construct real-time systems. See, for instance, the Dplug project: `https://github.com/AuburnSounds/Dplug`.

V.

[fade out]

11. a parting glass

The previous chapters introduced 'computational ambivalence', supported by a variety of interrelated exhibits: a 'field guide', two case studies of historical works, and reflections on two strands of my own music. While these exhibits each congregate around my practical perspective, they point outwards towards musical concerns of relevance to many musicians. I hope this attempt, while humble, encourages others to share their experiences of computing beyond the false dichotomy of embrace and avoidance.

Since giving shape to the project meant pushing a number of important concerns out of scope, I want to discuss a handful of these as areas worthy of further work.

Throughout the chapters, there is some initial, incomplete thinking around the relationship of computational ambivalence to the social construction of computing and experimental music as gendered. The case studies get closest to making this explicit, by emphasizing a musical and social sensitivity in these composers' works too easily steamrolled by masculine stereotypes around science, technology, and rationality. If these elite men thwart the masculine norms often invoked in their remembrance, it raises the question who *would* satisfy these norms; perhaps we're all ambivalent. While I hesitated to build up this line of argumentation directly in the document, since it deserves a focused exposition by a better-informed author, I have sprinkled some of its constituent evidence throughout.

Also left unaddressed is how computational ambivalence might inform the creation of new music and music technology, as opposed to merely helping to explain pre-existing music. Many of the cited texts are oriented towards such action, making them promising starting

points for pursuing a music computing otherwise. While purposefully excluded from this document, some related possibilities have been unfolding in my work life, through which I continually experience how humanities scholarship on technology can inform early-stage work on new attempts.

Finally, it is worth addressing the periodic despondency evident in the text around the topic of musical community. Of all the presets, this is the one I continue to find most elusive, and which accounts for the several year gap since my last finished work. To give purpose to finishing projects, I need to confront my current sense of musical isolation. I am aware, though, that needing, finding, and forging community may well be a theme of musical experimentalism as a whole; I will now find a way to set down roots, encouraged by the many cacti who have come before.

12. accompanying portfolio

Alongside this thesis text, a digital portfolio contains the referenced music and software for your listening, viewing, and compiling. A selection of these materials are available on my personal website;[382] a pointing hand calls these out below, with the additional aim of disclosing their prior publication. ☜

For reasons of academic hygiene, the portfolio distinguishes between materials included as a part of the thesis submission, considered integral to it, and those materials merely provided for context.

12.1. submitted

12.1.1. case studies

Quintext:

- `Cloud Explorer` and `Spline Explorer` applications
- retrograde comparison diagrams for both movements
- convergence diagram for Parabolas and Hyperbolas

Theraps:

- `Thermograph` native and web applications

[382] `http://www.braxtech.com/`

- "Listening Score and Notation Nitpicking Guide"
- `thermal`-encoded versions of the score
- `thermal` TextMate bundle for source code highlighting

12.1.2. music

dawidziuquet:

- `dawidziuquet` live score application
- software scripts used in the compositional process
- a representative reading by the Edges Ensemble

filter, glisten:

- three versions of the work, lasting three, seven, and nine minutes[383] ☜

inflection study (pizz. gliss. lullaby?):

- score ☜
- recording of a performances by Séverine Ballon ☜
- recording of a performance by Matthias Lorenz
- prototypical performance by myself during the working process
- `HandwritingCapture`, `SplineFitter`, and `cello canvas` applications
- representative documents from these applications

mise en place:

- video of a performance by Bird Rat Centipede (Sam Andreae, Linda Jankowska, Rodrigo Constanzo), video by Angela Guyton ☜
- revised score

[383] the three-minute version is also available on *SEAMUS Electro-Acoustic Miniatures 2013: Negative Space*, Society for Electro-Acoustic Music in the United States, SEA-002, CD.

nodes & signs:

- video documentation by Angela Guyton ☜
- `nodes & signs` application
- `Graph Maker` and `lab control` applications

splatter study (on social networking):

- score ☜
- supplemental treatise, "A Catalogue…" ☜
- recordings of two performances by the Edges Ensemble
- video of a performance by Modelo62 ☜
- video of a performance by Infuse, video by Mats Attnäs
- `cyclic graph generator` application

12.2. provided for context

The following materials are included for context, having been referenced within the body of the thesis. These works were completed prior to my enrollment in Huddersfield, and therefore are not intended for evaluation towards fulfillment of the degree.

- *for violin* — score, recording of a reading session by David Sariti
- *impulse response space* — digital audio ☜
- *in & distinguished from* — parts, score, and a recording by Verge Ensemble ☜
- *mise en place* — score
- *splatter, articulate, recurse* — digital audio ☜
- *write, trace* — score, example part, and a studio recording by Voxare Quartet

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