

**BEATBOX: THE POLITICAL ECONOMY OF
THE PROGRAMMABLE DRUM MACHINE**

By Greg J. Smith, B.A., M.Arch

A Thesis Submitted to the School of Graduate Studies in Partial Fulfilment of the
Requirements for the Degree Doctor of Philosophy

McMaster University © Copyright by Greg J. Smith, September 2024

McMaster University DOCTOR OF PHILOSOPHY (2024) Hamilton, Ontario
(Communication Studies & Media Arts)

TITLE: Beatbox: The Political Economy of the Programmable Drum Machine

AUTHOR: Greg J. Smith, B.A. (University of Toronto), M.Arch (University of Toronto)

SUPERVISOR: Dr. Christina Baade

NUMBER OF PAGES: viii, 192

Lay Abstract

In 1978, Roland Corporation introduced the CR-78, the first mass-market programmable drum machine. Allowing players to tap rhythms on drum pads or program them on a step sequencer, the CR-78 brought new aesthetics and affordances to musicians. This dissertation examines how musicians' adoption of drum machines between 1978 and 1985 challenged notions of virtuosity, foreshadowed heightened automation in music production, and reflected trade tensions between the USA and Japan. Applying a 'beat scholarship' methodology informed by platform studies and media archaeology, I conduct three analyses: how Prince was the 'power user' of the Linn Electronics LM-1, how Juan Atkins and Detroit Techno signalled new forms of musical labour, and how Ikuturo Kakehashi haunts the circuits of the Roland TR-808. I argue that the drum machine was (and remains) an 'object in flux,' a touchstone for debates about sonic verisimilitude versus abstraction, and a transformative force for musicians and musical genres.

Abstract

In 1978, Roland Corporation introduced the CR-78, the first mass-market programmable drum machine. Allowing players to tap rhythms on drum pads or program them on a step sequencer, the CR-78 brought new aesthetics and affordances to musicians. It, and other machines that followed, also made drum programming accessible to people who had never picked up a pair of drumsticks. This dissertation examines how musicians' adoption of drum machines between 1978 and 1985 challenged notions of virtuosity, foreshadowed heightened automation in music production, and reflected trade tensions between the United States and Japan. Applying a 'beat scholarship' methodology informed by platform studies and media archaeology, I conduct three major analyses. First, I examine how Prince was the 'power user' of the Linn Electronics LM-1, and read the interface of that drum machine relative to the field of interaction design. Second, I consider the short distance between the factory floor and the studio in the (techno) music of Juan Atkins and the city of Detroit. Third, I meditate on the short production run of the Roland TR-808, the most influential and revered drum machine ever made, and I argue that Roland Corporation founder Ikuturo Kakehashi *haunts* its circuits. I show how the drum machine was (and remains) an 'object in flux,' a touchstone for debates about sonic verisimilitude versus abstraction, and a transformative force for musicians and musical genres. The beat scholarship method I have developed yields a novel way of writing about popular music, music technology, and political economy that is more than the sum of its parts.

Acknowledgements

I owe thanks to many folks for making this work possible. My advisor, Christina Baade, was heroically incisive and empathetic throughout the process; whether she was honing in on a key idea in one of my patchy drafts or coaching me through the grind, she was there for me. Committee members David Ogborn and Louis Niebur provided provocative and thoughtful feedback, and I appreciate their deep expertise and sustained attention. External examiner Theo Cateforis provided thought-provoking and generative questions during my defence, illuminating how threads within this research lead back to foundational conversations in popular music studies and music history. My longtime *HOLO* collaborators, Alexander Scholz and Filip Visnjic, were gracious and patient about my divided attention over the last six years. My insightful peers Alain Mongeau and Golan Levin were supportive in the earliest stages of this project. My family offered unwavering support. And my wife, Jessica Thompson, who is just fabulous in general.

List of figures & photographs

- Fig.i Roland CR-78 ad (1)
- Fig.ii Wurlitzer SideMan ad (5)
- Fig.iii Roger Linn and the LM-1 Drum Computer (26)
- Fig.iv Roland CR-78 (30)
- Fig.v LM-1 Brochure (31)
- Fig.vi LM-1 interface 1 (33)
- Fig.vii LM-1 interface 2 (34)
- Fig.viii Inventing the user diagram “User” (47)
- Fig.ix 2004 Rock & Roll Hall of Fame inductions performance (53)
- Fig.x Andy Warhol's *The Orange Prince* (56)
- Fig.xi Akai MPC60 (62)
- Fig.xii Juan Atkins in his studio (73)
- Fig.xiii Korg MS-10 (74)
- Fig.xiv Juan Atkins on the Cover of *The Wire* (101)
- Fig.xv 808 title sequence screenshots (105)
- Fig.xvi Roland TR-808 (107)
- Fig.xvii Ikutaro Kakehashi (122)
- Fig.xviii TR-808 Service Notes (138)
- Fig.xix TR-808 T-Network Schematic (139)
- Fig.xx TR-808 Bass Drum Circuit (140)
- Fig.xxii TR-808 Snare Drum Circuit (141)
- Fig.xxii TR-808 Hi-Hats Circuit (142)
- Fig.xxiii TR-808 Noise Circuit (143)
- Fig.xxiv 2SC828-RNZ transistor (144)
- Fig.xxv Roland TR-08 (146)
- Fig.xxvi Behringer RD-08 (148)
- Fig.xxvii Missy Elliott “Lose Control” video (154)

Table of Contents

Introduction: Looking for the Perfect Beat	002
The Electronic Drum Machine in Context	007
Key Concerns	010
Methods: Beat Scholarship	012
Positioning Myself in My Research	016
Dissertation Outline	021
Chapter One: Prince, LM-1 Drum Computer Virtuoso	025
Real Drums at Your Fingertips	030
If This is Lust: Prince Vaults into the R&B Charts	036
Prince Gets a New Toy	039
The Pleasure of Buttons, Knobs, and Sliders	040
Reproduction of a New Breed	043
“Heavily Constructed from Programmable Devices”	045
Why Does Everybody Have the Bomb?	050
One Console, 2 Sets of Hands	051
Virtuosity’s Disappearing Act	053
Go Crazy (Punch a Higher Floor)	059
Requiem for an Inventor	062
Chapter Two: From the Factory Floor to the Studio	066
P-Funk Meets Data Processing	073
The Paranoid Style in American Techno: “No UFO’s” & “Future”	079
Three Ways to Talk About Detroit	082
Techno! The New Sound of Detroit?	088
What is the Shelf Life of Shiny Futures? Deep Space (and Beyond)	098
Chapter Three: Haunting the Roland TR-808	106
This is a Ghost Story	110
A Close Reading of 808	112

The Life of Ikutaro Kakehashi	120
Kakehashi's Machines	128
Haunted Circuits	132
A Close Reading of the TR-808 Circuits	138
The 808's Circuits Live On (Kind Of)	144
Kakehashi's Ghost	148
Conclusion: Crate Digging with Missy Elliott	154
Virtuosity, Automation, Political Economy Revisited	156
Key Findings	161
Next Steps: Itinerary for a Beat Scholar	165
Bibliography	167



Scanned by retrosynthads.blogspot.com

No More Waiting for Louie

Louie's a great drummer, and you've been playing together for years, so he must be good. But in all the time you've known him, he's never been on time for practice. So you've always had to wait for him to arrive before you can start to play; and now that you're in the studio that's even more of a problem, because as we all know—nothing can happen without the rhythm track.

Well, now you can spend your waiting time a little more productively by using a Roland Computer-Rhythm. The Compu-Rhythms are two astounding devices that produce accurate and dynamic rhythm tracks that can be used in recording, performing, or just practicing.

Both the CR-68 and the CR-78 provide a variety of rhythms that can be combined and varied over a wide range of tempos—but the real beauty is in their sound. Though the sound is electronically created, it is unbelievably rich—the snare drum



crisply pops and the bass drum punches as if they were heavily compressed.

Two unique features are the Accent control, which gives an added realism to the program tracks, and the Variation control, which produces 11 different drum fills that can be programmed to play at desired intervals.

In addition to all of the other features, the CR-78 Compu-Rhythm contains a micro-computer that allows you to program your own (or Louie's) drum

tracks into the machine by tapping them out on the programmer pad, and a built-in battery keeps them in storage even if you turn the Compu-Rhythm off.

The Compu-Rhythms will find a lot of places in your music—from writing music to laying down click tracks for multi-track recording. They can even provide trigger outputs for external control of synthesizers of digital sequencers.

The Compu-Rhythms may not replace the drummers of the world, but they're going to make it a lot easier to live with their little inconsistencies.

RolandCorp USA, 2401 Saybrook Ave., Los Angeles, CA 90040
(213) 685-5141. Enclose \$1 for a copy of our latest catalog.



Roland
We design the future.

115

Fig.i Roland CR-78 and -68 ad. Source: *International Musician and Recording World* (Nov 1979)

Introduction: Looking for the Perfect Beat

In 1978, Japanese electronic instrument manufacturer Roland Corporation introduced the first programmable drum machine. Dubbed the ‘CompuRhythm’ CR-78, Roland heralded it as “a programmable microcomputer to create your own beats” where the user was “only limited by their imagination.” An ad appearing in the November 1979 issue of *International Musician and Recording World* magazine (Fig.i) was a little coy in describing the device's utility. It showed two members of a band killing time in a rehearsal space, waiting for their habitually late drummer, Louie. One lounged in a chair, playing his guitar. The other reads the newspaper. They both look bored. In the background, a drum kit sits unattended. The accompanying copy describes how drum machines “may not replace the drummers of the world, but they’re going to make it a lot easier to live with their little inconsistencies.” The CR-78 (and the less capable CR-68) were marketed for songwriting, laying down click tracks, and triggering external gear.

When I first saw this ad, I was struck by its nuance. Electronic instruments are often marketed with bold claims about incredible sonic capabilities, ingenious technological innovation, and intuitive user interfaces. Here, Roland hints at a future where drum machines replace percussionists. The subtext: Louie, a drummer with an ironic inability to keep time, has job security *for the time being*. This playful gesture toward human obsolescence is an anxiety associated with all electronic instruments, but it is acute with drum machines.

This project explores the impact of the programmable drum machine on music labour and creativity between 1978 and 1985. My study period begins with the release of the CR-78 and ends as the Golden Age of Rap kicks off (and digital sampling is widely adopted). While it was only eight years, popular music underwent

a rapid transformation during this period. Glam and progressive rock fell by the wayside; new wave and rap were born, each offering new aesthetics and modes of performance, and stars like Michael Jackson, Madonna, and Phil Collins captured global attention. My research examines how drum machines shaped the formation of several genres, paying particular attention to rap, Miami bass, and techno. I explore how Prince and Juan Atkins used drum machines in their early 1980s recordings, and I interrogate the mythology surrounding the Roland TR-808, probably the most revered drum machine ever created.

Profound shifts in music technology coincided with and contributed to the formation of these new genres. Blondie's "Heart of Glass" (1979) previewed coming attractions. Its first four bars featured an infectious clave, conga, and maraca rhythm programmed on the CR-78. That rhythm continues throughout the song, but it's buried in the mix under Clem Burke's drumming. In 1979 it was one of the first worldwide hits to feature a drum machine, and just a few years later drum machine rhythms were not so low in the mix: they took centre stage in Afrika Bambaataa & the Soulsonic Force's "Planet Rock" (1982) and Michael Jackson's "Thriller" (1982). In my dissertation I engage with the music made with drum machines and the political economy of the electronic instrument industry. I examine both spheres because the music made *with* music technology is not separate or distinct from the materials, affordances, or marketing of the machines those songs are programmed on. Additionally, my methods of engaging drum machines are informed by media archaeological and platform studies approaches—the idea that the machines themselves (their interfaces and circuits) are just as worthy of close readings as key songs.

Let's circle back to musical labour—the fate of absentee 'Louie' in the Roland ad, and other drummers. Drum machines did not obsolesce human drummers, but they problematized commonly held assumptions about drums and drummers. Untethered from the traditional drum kit and the cumbersome process of recording it in a studio, electronic percussion offered new sonic aesthetics and new ways of programming rhythm. Machines like the Roland TR-808 (Arthur Baker used its resonant booming bass to make "Planet Rock" sound otherworldly) or the Linn Electronics LM-1 (Quincy Jones used it to undergird the iconic "Thriller" bassline with a devilishly funky cowbell-conga rhythm) offered distinct aesthetics, workflows, and affordances. Rap, techno, house, new wave, and industrial music *crystalized* around the capabilities of electronic instruments. I locate the beginning of these shifts in genre as coinciding with the arrival of the CR-78.

Drum machines are hardware for generating and programming percussion voices. Players tap out beats or program them into a 16-step sequencer—they can build up complex percussion lines, program variations, and mix them live. But drum machines didn't always have this much functionality. In the 1960s and 1970s, crude 'rhythm boxes' were marketed to provide accompaniment for organists and small ensembles. These machines had poor sound and worse interfaces, and players were limited to a fixed bank of genre loops (waltz, bossa nova, rock, etc.). Though intended to provide accompaniment for a solo lounge musician or a small ensemble, they were seldom used in the studio.¹ The earliest rhythm machines were electromechanical, but by the 1960s, they were made with analog circuits. The CR-78 had a crucial technical innovation that all rhythm machines before it lacked: a

¹ An exception: Sly Stone recorded most of the drum lines on *There's a Riot Goin' On* (1971) on the Maestro Rhythm King. Maestro was a subsidiary of Gibson Guitar Corporation and the Rhythm King, which featured 18 preset genre patterns and mute buttons for each drum voice.

microprocessor. The digital microprocessor ushered in the era of *programmable* drum machines, meaning players could create and store their own rhythms.



Fig.ii Wurlitzer SideMan Model 5000 *Popular Mechanics* ad (Nov 1960)

The stakeholders around electronic percussion are numerous. First and foremost, the musical labour of the drummer was problematized long before the programmable drum machines of the 1980s. Fears about human obsolescence surfaced in the United Kingdom in 1967 when the Musicians' Union issued a screed against 'robot drummers,' warning that early rhythm machines like the Wurlitzer SideMan² (Fig.ii) threatened to replace human drummers. As noted by Sarah Angliss, these anxieties about obsolescence were linked to the arrival of sound in cinema in 1927, when the musicians providing live music for film suddenly found themselves out of work (2013, 102). In the pages of *CREEM*, Lester Bangs famously lamented that Kraftwerk's techno-pop was the death of the human gesture and rock's rebellious authenticity, and that the "final solution to the music problem" (1975, 25) could ultimately be to hand control over to the machines "in total passive

² The Wurlitzer SideMan Model 5000 was the *first* commercial rhythm machine. Released in 1959, it was a large cabinet with an electric motor that spun a wheel lined with contact points. As the wheel spun, the contact points were scanned and triggered percussion sounds. It had a total of ten voices.

acquiescence to the cybernetic Inevitable” (3). These lingering anxieties were largely hyperbolic—but a band didn’t necessarily *need* a drummer anymore. Likewise, a producer could pass on hiring an expensive (or temperamental) session musician. A producer recording a major artist at The Hit Factory in New York, a fledgling solo artist recording a multitrack demo in their bedroom studio, any ensemble with a rhythm section—musicians working across all contexts were prompted to rethink their relationship with drums and drummers. Beyond recording and gigging musicians, the drum machine impacted the broader music industry when new labels and distribution networks sprouted around genres that foregrounded electronic instruments.

Rather than promising a comprehensive history of the electronic drum machine, I’ve embraced the messiness of music-making practices, genre formation, and the political economy of electronic instruments. I’ve also developed approaches inspired by media archaeology and platform studies—engaging the functionality and interiority of drum machines—to deepen this analysis. In aggregate, I call this method ‘beat scholarship.’

Beat scholarship reveals and untangles threads that offer contradictory and varying histories of the drum machine. Some of the major threads I engage in my research include notions of virtuosity, the drum machine as a site where musicians worked through the implications of automation, and trans-Pacific tensions between Japanese and American electronic instrument manufacturers. I will outline these threads shortly, but first, I will situate this research in existing literature.

The Electronic Drum Machine in Context

So why have I spent the last five years reading vintage music technology publications and scouring through 1980s interviews with musicians and engineers? The first, and easiest answer to this question is that the programmable drum machine has not been the subject of either doctoral research³ or a monograph. There is a deep body of scholarship on the avant-garde origins of electronic instruments, and the Rhythmicon,⁴ an electromechanical musical instrument Leon Theremin built for composer Henry Cowell in 1932 that was arguably the first drum machine, often appears in these histories. However, early and mid-twentieth century electromechanical and electronic instruments were experimental and frequently prototypes. They were not widely used by working musicians and are the domain of rarefied artists and researchers. My research is specifically interested in mass-market consumer drum machines and the consumer era of electronic instruments kicked off in 1970 with the release of the Minimoog synthesizer by American engineer Bob Moog. The programmable drum machine is a technology that matured shortly *after* the synthesizer, so I argue that any analysis of it is rooted in scholarship on the commercial synthesizer.⁵

However, it is more difficult to parse the drum machine than the synthesizer because it has undergone steadier and more dramatic revisions to its form factor.

Because the 'canonical' synthesizer closely resembles a piano⁶ and hasn't changed

³ Ismael Medina published a Master's dissertation entitled *And The Beat Goes On: The Story of the Drum Machine* out of Cal State Monterey Bay in 2017.

⁴ The Rhythmicon generated rhythm from a series of spinning Nipkow disks. The disks were perforated with different patterns and the device 'scanned' them to generate a fundamental tone and rhythm, and dense layered rhythmic overtones. Its polyrhythmic tone generation was the inspiration for the Subharmonicon, a semi-modular synth released by Moog Music in 2020.

⁵ The Moog story has been chronicled by numerous scholars, including noteworthy monographs by Paul Théberge and the duo of Trevor Pinch and Frank Trocco (1997; 2002), which, respectively, map out the political economy of the electronic instrument industry (situating it relative to other instruments and technologies including the organ and the microprocessor), and tell the story of Bob Moog.

⁶ This is a contentious statement as the burgeoning modular synthesizer scene categorically diverged from the piano form factor and back to the synthesizer's origins in hulking banks of modules

much since electronic instrument standards began to formalize in the 1980s, it is legible to the general public as both an instrument and an object. In comparison, the drum machine is elusive. Drum machine design convention has undergone numerous shifts in the last 40 years, often overlapping and merging with sampler technology and also, particularly in the 1990s and early 2000s, branching into a more accessible groovebox⁷ vernacular aimed at beginners and hobbyists. As director Alexander Dunn's documentary on the Roland TR-808 (2015) exemplifies, a revered individual drum machine can make for a compelling case study, but providing an expansive view of the electronic instrument class is difficult. This is probably why no scholar has produced a drum machine monograph equivalent to what Théberge and Pinch & Trocco did for the synthesizer.

The drum machine *does* appear frequently in music technology and popular music scholarship. Samantha Bennett positions drum machines like the LM-1 alongside other novel early 1980s music technology (2019) but her discussion of the instrument is limited as her project documents broader shifts in music and recording technology. Drum machines have been featured in genre histories by Tricia Rose and Simon Reynolds (1994; 1998), but their respective critical positioning of innovative Black music-making practices and oral histories of genres foreground artists' creative techniques or biographical details more than the tools they use. Finally, and perhaps most directly inspiring my research, the drum machine has received sustained attention from Thomas Brett, whose attentive research on

connected by patch cables. As I state, my research focuses on discrete hardware drum machines rather than modular components. There is an entire alternate version of my research that examines how classic drum machine circuits have propagated across (and been expanded on) in the modular synthesizer world.

⁷ Roland invented the groovebox form factor in 1997 with the MC-303, a digital reimagination of its famous analog bass synthesizer. The device was compact, easy to use, and affordable. The price and portable design caught on and mass-market mini-synths and -drum machines have been a mainstay ever since. An evergreen bad-faith argument by purists is that grooveboxes are 'toylike' and there are hundreds of pages of arguments on synth forums like modwiggler.com and gearspace.com debating the merit of the form factor.

Prince's use of the LM-1 (2020) and his encapsulated history of electronic percussion (2016) have guided me. I also take inspiration from Oliver Wang's examination of the "fake veneer and plastic panelled glory" 1960-70s history of rhythm machines (2014, 225). More recently, Dan Charnas' 2022 monograph on James Dewitt Yancey (aka J Dilla) situates the late American rapper-producer's legacy relative to swing, musical timing, and sampling drum machines.

Stepping back from electronic percussion, reflecting on how traditional drummers frame their duties has informed my thinking about how drummers fit into musical ensembles. Elvin Jones stated that "the role of the drummer is primarily to keep time" (Bruford 2018, 99) and Gareth Dylan Smith complicates that prerogative by underscoring that drummers are simultaneously expected to lead *and* follow other musicians (2016, 91-2). Delving into the psychology of drumming, Bill Bruford poetically encapsulates creativity in drumming as "making it [rhythm] work and making it matter" (2018, 27). With these characterizations in mind, I further reflect on the poor, hapless, and *absent* drummer in the Roland CR-78 ad, and how he is abjectly failing on all fronts.

I received Matt Brennan's *Kick It: A Social History of the Drum Kit* (2020) as a revelation. Published at approximately the moment my dissertation proposal was coming together, Brennan's monograph expertly tells the history of the drummer and the trap drum kit, noting both their simultaneous "marginalization and centrality" in popular music (7). In his introduction, Brennan notes how drummers have been the butt of jokes since (at least) the mid-1960s and, in some sense, I feel the way drum machines were discounted and dismissed in the 1980s echoes this broader sidelining of percussion and percussionists. In his final chapter, Brennan addresses multitrack recording, Black music innovation including sound system culture, early

disco and rap DJ conventions, and Kraftwerk's use of electronic drums; he concludes by noting the drum kit is "not just a physical object or a performance practice" but "a symbol (encompassing both physical and virtual forms)" (317).

Key Concerns

Following the lead of Brennan, Brett, Wang, Rose, and Reynolds, I define the drum machine as an instrument class that spans the hardware, e-drums, software, and VST plug-ins for Digital Audio Workstations across a spectrum of professional and amateur recording studios; this notion has even trickled down to the realm of mobile apps—an idle commuter can tap out beats on a 'drum machine' while they kill time between stations. Drum machines started in the studio, but now they are everywhere.

This returns me to the three major strands of my research—virtuosity, automation, and political economy—which I will now outline.

Virtuosity: The functionality of drum machines necessitates a reconsideration of virtuosity. A player of a traditional drum kit has different ways to express themselves, with a particular playing style emerging from a combination of rhythm composition, stick control, and swing; these characteristics do not map to drum machine usage particularly well as programming beats into a step sequencer or hand drumming individual drum voices onto pads (to layer and build more complex rhythms) does not require the same dexterity and adjusting the swing of a rhythm is not quite as artful as a drummer playing in the pocket. One of the ideas that emerges in my research is that the idea of an electronic instrument 'operator' is fundamentally different than a drummer playing a drum kit. While referring to the synthesizer's prominence in new wave, Theo Cateforis' assertion that electronic instruments

“reconciled what it meant to *work* at one’s instrument” (2011, 181) certainly applies to the drum machine. The drum machine’s step sequencer, granular tone, and timbre-shaping abilities, and how it allows players to program rhythms asynchronously, open up new ways to gauge who is a more or less capable player and what virtuosic playing entails.

Automation: Beyond the necessary rethinking of virtuosity, the drum machine is a site where musicians worked through the implications of the broader shift toward automation and also a symbol *of* that automation. Samantha Bennett describes a fork in the road that emerged in late 1970s recording when artists were suddenly confronted with a choice between “live, acoustic and electric instrument performances and those featuring music heavily ‘constructed’ from programmable devices.” (2019, 19). What better exemplar of programmability than the drum machine? A device that displaces the requisite manual dexterity and human-metronome-like rhythm and lowers the bar of entry to figuring out a rudimentary interface and cracking open a manual. A device that “bears no resemblance to traditional drums and drumming practice” (Théberge 1997, 3), and brings a whole new host of aesthetic and social questions with it. As mentioned earlier, bands no longer *needed* drummers, and recording percussion in the studio no longer *required* a session musician. This fundamental shift in attitudes toward drummers is perhaps best summarized by Depeche Mode’s Martin Gore, who could not answer the question ‘What benefit do drum machines provide over a live drummer?’ because he and his bandmates had only ever used drum machines and never felt the need to incorporate a live percussionist. (Doerschuk 1987, 28). The drum machine, alongside the synthesizer and the MIDI interoperability standard, were harbingers of the automation, digitization, and virtualization of music making.

Political Economy: Finally, the last major thread in my research—the most divergent from popular music studies—is examining tensions between American and Japanese industrialization that manifested in the electronic instrument industry. I didn't set out to do political economy when commencing this research, but any serious analysis of the important engineers and manufacturers from this era of electronic instrument design quickly surfaces a fundamental discrepancy between American entrepreneur-engineers like Roger Linn, Bob Moog, Dave Smith, and Tom Oberheim (each with their own scrappy operation) and the Japanese multinationals like Yamaha and Roland that they squared off against. Guess who won? Without exception, American manufacturers were either bankrupted or acquired as they could not compete with their better-capitalized Japanese competitors. So, the story of the drum machine is very much a story of Japanese procurement, engineering, and marketing wizardry that echoes the intense late 1970s competition between American and Japanese auto manufacturers.

Methods: Beat Scholarship

Beat scholarship goes beyond studying the creation and reception of particular drum machines or the songs made with these devices. It is inspired by the research and writing style of a cadre of scholars that Jonathan Sterne describes as the “new organologists.” Speaking to Tricia Rose and Paul Théberge’s aforementioned monographs on rap and the synthesizer and Steve Waksman’s *Instruments of Desire* (2001), which explores the cultural significance of the electric guitar, Sterne enthuses that these scholars push beyond the limits of traditional organology to “provide deeper, richer cultural analyses of instruments” (2007).⁸

⁸ Sterne does not namecheck Dave Tompkins as a new organologist but I would include him in with Rose, Théberge, and Waksman. His chronicle of the fascinating military origins of the vocoder, *How To Wreck a Nice Beach* (2011), deeply impacted me. It's far from an academic monograph, jumping

Directly inspired by these scholars and Sterne's framing of them as 'cultural studies meets organology,' the stories I tell about different drum machines are bigger than the aggregate of engineer biographies and the corporate histories of competing firms. Likewise, I could easily stick to musician biographies and close readings of songs and albums on the popular music studies side, but I juxtapose the personal with political economy. My writing weaves between the perspective of engineers designing drum machines and the artists who play them. I consider the aesthetics of key songs and albums and the trade winds that blow the electronic and digital instrument industry in new directions. Meanwhile, in terms of methods, I analyze key songs and albums, draw on artist biographies, employ media archaeological approaches, and conduct close readings of marketing and technical literature and electronic instrument trade publications.

First, like Daphne Brooks, I believe popular music scholarship can and should be a game of "critical karaoke" (2010). In that article, she describes a different type of popular music studies that is performative, driven by passion, and bounded by constraints. I've strived to approach my topic with a similar earnestness, through figures, genres, and machines I hold in high regard. So, within the framework of my analysis of music technology, I veer into extended close readings of key songs and albums. This is a way to step beyond music technology narratives and delve into the aesthetics that artists craft with various drum machines. Of course, I foreground rhythm in these close readings, but I try to position it in the broader aesthetic universe constructed by each artist I discuss.

across many timelines and fascinating characters, and I point to it as another key example of how authors can be bold and playful when historicizing music technology.

In addition to the “new organologists” (Rose, Théberge, Waksman) my methods are further informed by two groups of writers. On one hand, I draw inspiration from genre historians, including Theo Cateforis, Alice Echols, Kodwo Eshun, Simon Reynolds, and Dan Sicko; the passion, critical eye, and *craft* these scholars bring to constructing narratives about how genres form and what they do aesthetically has informed how I approach writing about techno, rap, Miami bass, and other genres that I broach. On the other, I’ve worked to incorporate authors more focused on the technical aspects of production in my scholarship, including Samantha Bennet, Greg Milner, and Thor Magnusson; their careful delineation of key moments and ruptures in music technology has provided me with vocabulary and frameworks for assessing these technological shifts.

Alongside my close readings of songs and albums, I draw on artist biographies and autobiographical details shared in interviews. Artists are not necessarily the most reliable narrators when engaging biographers or music journalists, but these sources are useful in getting a sense of what artists’ intentions (or experiences) were at particular moments in their careers. While I did not personally interview any of my subjects, I feel surfacing material from biographies and interviews is a way to let them speak for themselves within the context of my scholarship.

I approach my topic through a media archaeological approach that “extend[s] the idea of an archive into actual machines and circuits” (Parikka 2012, 83). As Ian Bogost and Nick Monfort noted, when analyzing new media artifacts, content analysis is not enough, and any rigorous consideration of a media technology should move beyond reception and address ‘deeper’ materialities, including interface and code (2009, 146-50). This (more) technical approach to engaging media studies has

directly informed the subject and framing for two of my chapters, which centre on the *interface* of the LM-1 and the *circuits* of the TR-808. This approach also informs my (somewhat) non-linear writing style, which is directly inspired by Jussi Parikka’s assertion that media archaeological approaches should “start in the middle” (2012, 5). Any pure chronology of a technology—isolation of a device from machines released before and after—is a fabrication, so embracing the messiness of life (and material culture) is best.

My background is new media art journalism, so I bring a particular curiosity toward material culture to my approach. In new media art the technology being used—facial recognition algorithms, blockchains, sensors—is always strange and new so there is rarely a prescribed way of talking or writing about it. And so much of what artists in this field *do* is critically engage their tools. Informed by my immersion in this culture over the last two decades, media archaeology and platform studies were very influential in the early days of this research when I grappled with approaches on how to engage and historicize specific drum machines and the broader electronic and digital instrument industry.

Finally, drawing on both the political economy and media archaeology approaches. I give a moderate amount of airtime in my research to drum machine marketing material, service manuals, and industry publications. These sources have been invaluable in examining the intended users of these devices and how these machines were marketed to them. The claims made in drum machine ads speak to the intended relationship between an instrument manufacturer and its imagined customers. And the tensions between how these machines work or sound—where they succeed and fall short—relative to these claims is fascinating. I also cite trade publications including *Electronics & Music Maker*, *Keyboard*, and *Sound on Sound*,

where players and enthusiasts review and discuss drum machines. I draw on this material because the passage of decades and the forces of nostalgia have distorted the perception of many of the (now revered) drum machines I discuss. These sources are important because they help me understand how specific drum machines were received during my study period.

Positioning Myself in My Research

As I mentioned, there are no monolithic genres or music technology histories. And there are likewise no unbiased narrators. I must take a moment to locate my own positionality within my research, as factors like race, geography, economic privilege, and sexual orientation have a sizable influence on how an individual encounters music in the world, and how they might frame it culturally. I'm a straight, cisgender white man who grew up in Aurora, a Southern Ontario suburb. My family is upper-middle class, and I enjoyed a fair amount of economic privilege in my youth.

I came of age in the 1990s and self-selected my way into music nerdism. Despite being a bumbling pianist and third clarinet player in elementary school music class, I developed a taste for new sounds in my teenage years. I subscribed to the Columbia Record Club⁹ and enjoyed scouring the catalogue to place orders; it was interesting that brief blurbs on artists or albums could open up new sonic worlds. In 1989, I batch-ordered about 75% of the albums in the freshly-minted rap category and received a selection of albums from artists including Boogie Down Productions, DJ Jazzy Jeff & the Fresh Prince, Eric B. & Rakim, Public Enemy, 3rd Bass, and Tone Loc. Some of those artists were middling, while others were legends in the making—I only had my thirteen-year-old ears to help me figure out which was which.

⁹ Note for any Gen Z readers: The Columbia Music club was a mail order cassette and compact disc service. Just like Netflix used to mail folks DVDs, mail order physical media was a thing in the 1980s.

Probably about five million white kids from North American suburbs can say this, but Public Enemy changed my life. *It Takes a Nation of Millions to Hold Us Back* (1988) sounded different than everything else in the world to me. Between the realness of Chuck D's Lyrics and the technical genius of The Bomb Squad production team, I immersed myself in a dense sound collage of social critique and media criticism, antiracist resistance, and a raft load of James Brown samples at thirteen. I bought *Fear of a Black Planet* (1990) the day it came out, and from my first listen, I was convinced I had found the future of music. In hindsight, it was not a fair comparison to make, but the pop and mixed-genre music of that era—Wilson Phillips, Madonna, Bell Biv DeVoe—seemed like watery pulp in comparison.

The Columbia Music Club begat a love for alt weeklies and college radio. I was a religious listener of CIUT and CKLN, the stations for the University of Toronto and (then) Ryerson University. Each had schedules peppered with shows programmed by underground DJs (many queer and from all corners of the Black diaspora), and, in particular, I was a devout listener of New Powers and Hard Drive. The former was an industrial and experimental electronic show hosted by Chris Twomey,¹⁰ and the latter was a house show hosted by James St. Bass. These two DJs further expanded my sonic universe and provided me with a list of artists and labels that served as on-ramps to Toronto record stores like Modulations, Record Peddler, and Rotate This. Even though I was only sixteen, my subscription to Bay Area counterculture magazine *MONDO 2000* had put the rave scene on my radar as a cultural touchstone, and the increasingly adventurous music I was listening to—Orbital, Kenny Larkin, Plastikman, Nine Inch Nails, Vapourspace—foreshadowed

¹⁰ By the late 1990s I was buying records direct from distributors through Chris Twomey. I'd go to his house in Little Italy and it was filled with piles of hundreds of CDs and records. The last time I saw him was at MUTEK when Coil headlined in 2003, I bought him a double scotch and we swayed wordlessly by a speaker tower.

nightlife adventures. I was an anti-social gawky kid, and dance parties were the unlikeliest place for me to end up. But in the fall of 1993, I went to my first rave—at the CN Tower, no less—and was exposed to Chicago and progressive house and jungle live, and the bass was the loudest and most real thing I had ever encountered. I was hooked instantly and voraciously consumed everything I could learn about or listen to from this world. I headed to underground parties downtown almost every weekend for the remainder of high school. Barely anyone there knew who I was in my high school, and I didn't care. I graduated with a 73% average—my attention and passion were *elsewhere*.

The rave scene was a revelation. I remember walking into a 1994 party called “Lost in the Jungle” hosted by the promoter Delerium. It was a community centre with a hardwood floor filled with rows of weird kids dancing maniacally. The sub-bass made the hair on the back of my neck stand up. I could taste the sweat and cigarette smoke, and British ex-pat MCs were toasting the DJ and crowd as if they were demented talk show hosts. Raves were amazingly inclusive, and I often found myself dancing beside a gaggle of drag queens, club kids, weird hippies, weekend warrior bankers and lawyers, tweakers of all shapes and sizes. Nobody was even out at my high school, and I would walk into a rave bathroom to a bunch of smiling queens doing lines. The hedonism and visceralness of these parties made my suburban high school reality even more boring. Every week was a new adventure, a new dance floor, and new friends—as a newbie, I had no way of knowing this was peak times for the Toronto scene. It quickly commercialized. Bigger events pandered to bigger and dumber crowds, so I dug deeper to discover a new insurgent sound: techno. This time, I arrived as a scene blossomed. In 1994-95, I heard artists like Dan Bell, Richie Hawtin, Mike Dunn and Armando at grungy warehouses all over Southern Ontario. I

saw Jeff Mills DJ in a cornfield near Windsor. I partied in the Packard Building in Detroit. Techno is where I cultivated my aesthetics. The stripped-down, computer-y sounds of artists like Rob Hood and Octave One picked up where the Bomb Squad left off—once again, I felt like I was listening to the future.

Perhaps inevitably, I got into DJing. That entailed learning how to count to 16 and hanging out in record stores with weird patriarchal pecking orders. I wasn't great at schmoozing my way up the nightlife food chain. Still, circa 1998, I loved taking a stack of new vinyl from my favourite store, Speed Records, to a listening station and immersing myself in new sounds from Detroit, Tokyo, London, and whatever else was on the menu that week. As a dedicated bedroom DJ, I explored the art form's roots in hip-hop.¹¹ Techno, in particular, had a school of mixing that came out of battle DJing, with beat juggles, scratching, and backspins amping up the presence of the gesture and the materiality of vinyl in the mix; this opposed how consensus mixing of house and techno aimed for the seamless fusion of two tracks into a steady throbbing pulse. I liked the accident and the rupture, the mistakes. I bought two copies of all my favourite techno records and navigated around the bars, hopping on and off beat, playing with phase effects, and experimenting with the new patterns I could make from the kick, snare, and hats. In hindsight, this was my entry into percussion.

My halcyon days were short-lived. I knew those druggy mid-'90s dance floors were special, but I didn't understand how fleeting their authenticity and novelty was. In 2000, I began organizing an experimental club night called Clonk with my good friend Neil Wernik. Neil made (and still makes) dub techno; he seemed to know every electronic musician and frequently encouraged me to explore production. I

¹¹ Chalk that up to the role Terminator X played in Public Enemy. *He doesn't say much, he speaks with his hands.*

began drawing connections between the minimalist aesthetics I gleaned from techno to visual art and architecture. Seduced by the abstract geometries of deconstructivist architects like Peter Eisenman and Morphosis (and the impenetrable theory surrounding their work), I removed myself from the scene I came up in and moved to Los Angeles to study architecture in 2001. The memories and my record collection stuck with me, and I carried that energy into my 20s and 30s. I dabbled with sample-based production in Ableton Live (avoiding learning music theory at all costs) alongside my architectural studies throughout the 2000s.

Flash forward another decade. I'm at the 2017 edition of the MUTEK festival and listening to Robert Henke play live. I am extremely bored. As a key voice on the influential Chain Reaction label, Henke and creative partner (and now Ableton CEO) Gerhard Behles helped create another one of those sounds that felt like it was beamed from the future into my headphones. And two decades later I was bored with where Henke had taken that sound. I realized the music hadn't changed—I had. I knew I couldn't take my lifelong appreciation of electronic music any further without developing a better material understanding of synthesizers. I had many producer friends in the '90s and '00s and sporadically had access to the Micromoog, Roland TR-606, The Octave Cat, and other vintage synths. Still, production always seemed like something for other people. I didn't have ambitions to release music, I just wanted to understand how to make and modulate timbres, to learn how Low-Frequency Oscillators (LFOs) and arpeggiators worked. When I returned from Montreal, I promptly ordered a Korg Minilogue synthesizer and an MFB Tanzmaus drum machine and began making noise of my own.

Dissertation Outline

Now that I have shared how I came to this research, I want to provide a roadmap of coming attractions. Broadly speaking, the three chapters of my dissertation address the interface, the studio, and the circuit. Each of these three sites gives me different avenues for analyzing my subject. My chapters centre important drum machine models from my study period, musicians with a particularly deep engagement of music technology, and the engineers and companies behind the devices. Tensions between the technical, economic, and expressive aspects of music making animate the resulting discussions.

In my first chapter, I delve into the interface of the Linn Electronics LM-1 drum machine. Released by Linn Electronics in 1980, it was an innovative machine that took advantage of nascent digital sampling technology to provide sound sequencing and shaping capabilities for standard drum kit voices. Its kick, snare, hats, toms, and other voices were all 8-bit samples of real session musicians whose waveforms Roger Linn painstakingly edited given the strict memory limitations. The machine had an innovative sequencer and provided an interface for swing, to nudge the groove just ahead of or behind the beat to emulate a player in the pocket. The device was prohibitively expensive and only marquee musicians could afford it: like Prince.

I argue that Prince, who recorded a rapid succession of albums on the LM-1 between 1980-84, was the 'reflexive user' or 'user-to-be' of Linn's drum machine (Bardini and Horvath 1995). This terminology is derived from research into the early days of personal computing tracking how programmers, ethnographers, and marketers had to imagine who personal computer users would be and sell that narrative to the public. Prince was a virtuoso on numerous instruments, and I use the LM-1 and its clunky interface to trouble more traditional notes of virtuosity that rely

on dexterity and gesture. I tell the story of the LM-1, and its ambition to put “real drums at your fingertips,” but I also examine reflexive back-and-forth between engineers and musicians and consider the drum machine interface as the site where these different actors converge.

My second chapter focuses on the studio, specifically the musical labour that happens in them. I critically interrogate many of the earliest oral histories and theorizations of Detroit techno (Eshun 1998; Reynolds 1998; Sicko 1999; Williams 2001) in a sense to understand how 'futurity' is built into the narratives around and sonic aesthetics of the genre. Centring Juan Atkins, one of the three founding artists of the genre, I conduct close readings of his early work as part of the duo Cybotron in 1980-82, key EPs that he released as a solo artist on his Metroplex imprint between 1984 and 1988, and his debut solo album *Deep Space*, released in 1995. I focus on how he uses and engages electronic instruments during this period, drawing on archival interviews.

Parallel to my examination of Atkins, I consider the broader story of labour in Detroit. Techno, as a genre, is inseparable from Detroit's fabled rise and fall from a mid-century economic powerhouse that was the “arsenal of democracy” to its sustained decline from the 1960s onward. Techno is machine music from the city where both cars and the assembly line were perfected—narratives about progress and nostalgia for more productive pasts are baked into the genre. But this is not a simple story of a boomtown gone bust: Detroit's Big Three declined due to an inability to keep up with innovations by Japanese automakers, including Honda and Toyota. The story of Detroit techno is very much a story about Japanese manufacturing. I draw on Detroit histories (Boyd 2017; Clark 2018; Jay and Conklin 2020) and scholarship on Japanese globalization (Iwabuchi 2002; McKevitt 2017) to

examine and trouble these narratives of progress and locate them in the studio and recordings of one of the founders of techno.

My third and final chapter focuses on the circuits of the Roland TR-808, probably the most famous drum machine ever created. Produced by the Japanese firm Roland Corporation, the 808 was released at a pivotal moment in the electronic instrument, shortly before the MIDI interoperability standard and the first digital synthesizer were released. It was not warmly received by musicians, and only 12,000 units were produced before it was discontinued in 1983. However, rap and Miami bass producers seized on its deep resonant bass drum, noisy snare, and robotic handclap, and its sounds became enshrined in these genres. The 808's voices are now among the most beloved and recognized in electronic percussion and are ubiquitous across contemporary pop, rap, and dance music.

I conduct a close reading of the 2015 documentary *808* by director Alexander Dunn to interrogate and trouble the mythology that has emerged around the TR-808. Drawing on theorizations of ghosts and spectres (Derrida 1994; Gordon 1997; Fisher 2014), I consider the relative *absence* of Roland founder Ikutaro Kakehashi in Dunn's film and his general lack of name recognition compared to American engineers like Bob Moog. My intervention here is to reconcile the biography of Kakehashi and his genius in both instrument design and building Roland to reconsider how we might hear and listen to these ubiquitous drum voices.

This is not a comprehensive history of the drum machine. It's an ambitious, fragmented one that uses a few musicians, machines, and genres to re-cast the story of a subset of electronic instruments. Beyond shining light on a class of electronic instruments often overshadowed by the synthesizer, my research reveals a much broader story about shifting early-1980s technological norms and how the

drum machine opens up new ways to listen to popular music. It also provides insight into electronic percussion's role in genre formation (Juan Atkins helping establish techno) and artists *resisting* genre (Prince's refusal to be pigeonholed as an R&B or funk musician).

Through this synthesis of media archaeological, political economy, and close readings of popular music, I surface four key findings in my research. First, I demonstrate how the programmable drum machine was (and still is) an 'object in flux' due to shifting design norms, technical standards, and user expectations. The rapid technological shifts in the 1980s and the move toward digital technology and digital sampling, in particular, prevented the drum machine from consolidating into a recognizable form factor. Secondly, the earliest programmable drum machines sparked debates about what electronic drums 'should sound like.' This argument continues to this day, but interestingly, in the 1980s, when drum machines were first widely adopted, there was a desire for electronic drums to sound like their acoustic counterparts. In contrast, contemporary pop is full of abstract electronic-sounding percussion that bears little resemblance to the sounds made by a traditional trap drum kit. Thirdly, I demonstrate how the drum machine was transformative, not just for the musicians who used it but for the existing genres doing likewise and nascent genres where its sound was foundational. Finally, since all research projects are a search for a novel method, I demonstrate how the beat scholarship methodology I outlined earlier can be used to listen closely, read deeply, and question the histories of popular music I've inherited.

Chapter One: Prince, LM-1 Drum Computer Virtuoso

A pair of hands moves across the interface to get their bearing. The right index finger hits 'record,' the button emits a satisfying click, and a metronome begins ticking; the left hand instinctively turns the tempo knob clockwise, speeding it up, 110, 120, 130 BPM. The right index finger taps a kick pattern on the button bank on the lower right of the machine, one two three four, a 4/4 dance beat. An accent snare, some wispy closed hi-hats, the snare is too loud, the kick needs more oomph, a quick adjustment to the fader bank gets the mix closer to where it should be—but it needs some swing. Let's mark those inflections with handclaps, bap bap-bap, bap bap-bap. Another accent: a bright tambourine jangle—like a metallic caress emanating from inside the machine. Okay, let's change it up, just have to copy the pattern to ... wait, how do I do that? A never-opened instruction manual for the drum machine resided in its original packaging, somewhere in an adjacent room.

Five minutes later, after a quick consultation with maintenance tech Don Batts, the jamming resumed. Okay, copy the first breakdown, make it denser, capped with a flurry of double-time toms on top of the kick: dun dun dun dun dun dun dun dun. Carnal! This will make 'em sweat. All that's needed now is a syrupy Oberheim lead and some bass twang. The musician sits back, kicks his legs up on the table, and nods to the rhythm. "That took less than ten minutes. I think I'm falling in love."

The musician depicted in the above (imaginary and romanticized) vignette is Prince Rogers Nelson, one of the most revered pop stars of the twentieth century. A mid-1970s Minneapolis funk scene band leader and wunderkind turned production wizard, Prince strutted into global stardom in the early 1980s with his fifth and sixth studio albums *1999* (1982) and *Purple Rain* (1984) and remained iconic through his untimely death in 2016. He has been described as having an uncanny “feel for any

instrument he touched” (Brett 2020, 244), as being animated by a swirling mixture of carnality and spiritual yearning (Pollard 1989), and as purveying a radical inclusivity “based on new racial, sexual, gender, and material possibilities” (Ramos 2014, 443). This range of affective framings speak to the fact Prince functions as a cipher for any number of readings of the music industry. Myth, sexuality, race, technology, autonomy, virtuosity—his oeuvre and career trajectory are immensely generative.¹² It’s primarily but not exclusively the last of those topics—virtuosity—that I will discuss in this chapter. While famed for his searing guitar solos, acrobatic falsetto, and evocative synth pads and atmospherics, I will not focus on any of these instruments here: in this chapter I will argue Prince’s use of the drum machine forces us to rewrite (or at least reconsider) notions of musical virtuosity.



Fig.iii Roger Linn and the LM-1 Drum Computer

The interface described in my opening vignette belonged to the Linn Electronics LM-1 Drum Computer (Fig.iii). Prince was *the* (or *one of the*) first user(s)

¹² I've drawn on a number of sources on Prince's biography here, the key ones are his posthumous memoirs (2019), analyses of his studio practice (Brown 2010; Tudahl 2018), his rarely granted interviews (Miller 1983; Abdurraqib 2019), and commentary on his star power and aesthetics (Pollard III 1989; Matos 2004; Hawkins and Niblock 2011; Ramos 2014).

of the LM-1, a device with deep programmability and distinct timbres that inspired him to dive headlong into its singular “sonic potentials, limitations, and creative script” (Brett 2020, 257) fundamentally shaping his aesthetic between 1981 and 1984. While electronic percussion and drum machines had been available for more than a decade, 1978-82 marked the arrival of the first *programmable* drum machines, and a sea change in sonic fidelity. Encouraged by how new drum machines ascended beyond the “fake veneer and plastic panelled glory” (Wang 2014, 225) of earlier, crude ‘rhythm boxes,’¹³ Prince was an early adopter of the programmable drum machines. He was a member of the cross-genre community that include Phil Collins (who used the Roland CR-78 on “In the Air Tonight,” 1981), Cybotron (the Boss DR-55 on “Alleys of your Mind,” 1981), Marvin Gaye (the Roland TR-808 on “Sexual Healing,” 1982), and Run-DMC (the Oberheim DMX on “Sucker M.C.’s (Krush-Groove 1),” 1983).

In this chapter I will read the LM-1 Drum Computer through Prince’s creative work and, conversely, use the device to frame him as a subject. Putting a specific drum machine into conversation with a specific musician foregrounds the device’s functionality and sonic capabilities and forces me to delve into its material qualities. Here, I am guided by Ian Bogost and Nick Montfort’s advocacy of a platform studies approach: their claims that twenty-first century media studies needs to go ‘deeper’ than content reception and address the interface, form/function, code, and platform of the media/medium being studied (2009). This positioning is further informed by media archaeological methods, which embrace the mess of materiality and “start in

¹³ There is a categorical distinction between drum machines and earlier rhythm boxes. As will be clarified later, the introduction of microprocessors into electronic percussion circa 1978 marked a shift to programmable devices—by the mid-1980s deeply programmable sampler/drum machines were widely used. Approximately 1960-78, electronic percussion was generally limited to loop players with crude functionality, low sonic fidelity, and their palette was constrained to genre-based rhythm loops (e.g. Rock I, Rock II). Wang (2014) provides an overview of the drum machine’s clunky ancestors.

the middle” of technological histories by engaging a selected artifact’s idiosyncrasies, contradictions, and eccentricities—the rough edges that get smoothed over during periodization (Parika 2012, 5).

As informed by the above, I look to the LM-1 console as a surface that reflects and mediates Prince’s talent and as a key site of emergence of electronic percussion in early 1980s studio practice. Beyond conducting close readings of songs like “Private Joy,” “Sexuality,” “1999,” and “Let’s Go Crazy,” which delineate a path through Prince’s 1981-4 discography, precisely when his revered ‘Minneapolis Sound’ crystalized, I will analyze the very knobs, buttons, and sliders—the LM-1 interface—that shaped that sound’s rhythmic foundation. While my close readings of these songs tease out connections between the device’s sonic character and Prince’s aesthetic, I largely defer to Thomas Brett’s meticulous *Popular Music and Society* article (2020) on that topic. Here, I broaden the scope to consider the LM-1 creator Roger Linn, the early 1980s electronic instrument industry that catalyzed his design, and the sloganeering that advertised the drum machine bearing his name. This scope enables me to fuse scholarship by Paul Théberge and others on the tensions between invention versus innovation in electronic instrument design and marketing (1997) with more recent calls in platform studies to move beyond hardware to identifying its various actors and considering how they “play unique roles in larger systems” (Arsenault 2017, 7).

My analysis does not constrain itself to the electronic instrument industry. Rather, in order to understand the programmable drum machine, and, crucially, to *differentiate* it from its electronic sibling the synthesizer, I look to the rhetoric of computing and its accompanying subject ‘the user’—a figure hatched by Silicon Valley interaction designers during the emergence of the personal computer industry.

After all, Linn Electronics marketed the LM-1 as a ‘Drum Computer’ and Linn Electronics competitors Roland employed similar rhetoric as early as 1978. My analysis takes the so-called ‘programmability’ of the drum machine quite literally, by looking to Xerox PARC as the site of the social construction of the personal computer user (Bardini and Horvath 1995). Moving beyond a conventional popular music or cultural studies framing of Prince, I “triangulate” between users, computing, and economics (Eriksson et al. 2019) to depict a drum machine *user*, who is distinct from the *player* of other instruments.

While I relish articulating the user as a generalized subject, I am mindful of Aubrey Anable’s feminist critique of platform studies, where she problematizes the totalizing logic that the black box of a technical object is deciphered by a “penetrating” scholarly gaze. Anable argues against Bogost and Montford’s rigid media strata, and urges for flexibility (and fleshiness), recasting platforms as “curiously porous, queerly promiscuous, and radically leaky” (2018 138-9). Anable warns that focusing “too myopically” on platforms runs the risk of under examining “the complicated differences and relationships between technologies as things and bodies as things,” and minimizing important markers like race, class, and ethnicity (136). Prince is a perfect subject to place between these binaries of convention and desire: a biracial man, genre fluid, thumbing his nose at heteronormativity.

Prince resists generalization, and any examination of the LM-1 in his hands must be as invested in fleshing out an erotics of the drum machine as the obligatory technical teardown. In my analysis, I move back and forth between close readings of songs that marked transitional moments in Prince’s recording practice, and tracing the inception and ideology of the LM-1 interface. Ultimately, I argue Prince is an

unruly subject who confounds and contradicts the expectations of the white male engineer ‘inventor’ who designed the LM-1 in the first place.

Real Drums at Your Fingertips

Throughout the 1970s, genres were converging, colliding, and everyday life in the studio was changing. Much of that change was driven by analog synthesizers like the Minimoog and the ARP 2600, which had moved from fringe to zeitgeist and offered a playground of sound shaping and timbre-generating possibilities. Used by artists as diverse as Kraftwerk, Stevie Wonder, Keith Emerson, Herbie Hancock, and Tangerine Dream, analog sound synthesis had flowered into a sonic renaissance and made its mark from pop to jazz. By the end of the decade, new *digital* electronic instruments were introduced, such as the Fairlight CMI, whose early implementation of sampling had the potential to further disrupt music making practice.



Fig.iv Roland CR-78 (1978)

While there had been a surge in synthesizer innovations in the 1970s, the design of drum machines lagged considerably. Los Angeles guitarist Roger Linn was attuned to this discrepancy, and also dissatisfied with analog synthesis’ crude emulation of drum hits. Listening closely to the sonic character of state-of-the-art electronic percussion circa 1978 illustrates this point nicely. While the Roland CR-78 had an incredibly innovative interface (Fig.iv) that allowed rudimentary

user-programming of up to four drum loops,¹⁴ its signature metallic beat sounded like a can opener piercing a tin lid. The third iteration of the The Synare PS (Percussion Synthesizer) released in 1977 could make incredibly funky disco toms, but they were more akin to the *PEW* of a laser than *actual* toms.¹⁵ *Real drums* were dynamic, and *real drummers* had something that no machine could emulate: a feathery touch, fallibility, swing. Linn thought synthesizing percussion sounds was misguided.



Fig.v Linn Electronics LM-1 Brochure

After years of technical development, carting a jumble of electronics in a box¹⁶ to L.A. studios—accumulating a rolodex of potential customers in the process. Linn released the LM-1 Drum Computer in 1980. It took inspiration from, and considerably surpassed, the crude programmability of Roland's CR-78, but verisimilitude was the feature highlighted in the sales pitch. The LM-1 was marketed under the tagline:

“Real Drums at Your Fingertips” (Fig.v). Both halves of the slogan warrant scrutiny,

¹⁴ The ‘CR’ in CR-78 is for CompuRhythm. While Dave Smith's Prophet synthesizer line had featured microprocessors for a few years by 1978, the CR-78 was the first drum machine to feature one. Microprocessors would be a mainstay in future models by Roland.

¹⁵ Technically, *Star Wars* sound designer Ben Burtt created the Storm Trooper blaster sound by striking an antenna tower guy wire with a hammer, but R2D2's warbles were programmed on an ARP-2600.

¹⁶ Linn has remained a prominent designer of and commenter on electronic instruments. A fixture in the music technology news circuit, he regularly comments on the LM-1's development and influence—I've drawn on several interviews from him in the last decade in this chapter.

and offer insight into the differences between analog drum machines like the Roland CR-78 and Synare PS and the LM-1.

First, the “Real Drums.” Linn’s design was innovative because it eschewed analog drum synthesis. Like their synthesizer brethren, 1970s drum machines relied on analog circuitry’s architecture of transistors, resistors, and capacitors to create the rudimentary building blocks of sound—blocky square waves, smooth sines, jagged sawtooths—whose frequencies were sculpted with filters, and then shaped, temporally, within envelopes. To model a snare, a sine tone in the midrange was splashed with white noise and fed through an envelope with a steep attack and longer release, yielding a metallic *HISS* that snapped then dissipated. A dull kick could be modelled in pinch with a lower octave tone, a low-pass filter cutting mid- and high frequencies, and then a short sustain and release. Subtractive synthesis’ grammar was technical, but the fundamentals could be picked up quickly, and the Minimoog made that learning curve seem less daunting by dressing subtractive synthesis up in a familiar interface: a conventional piano keyboard (Théberge 1997; Pinch and Trocco 2002). Linn was not a fan of how percussion sounds created with analog synthesis were crude, abstract, and bore only nominal relationship to the sounds of a trap drum kit. Taking a recordist, rather than synthesist’s, approach, he invited his housemate, Art Wood (how fortuitous to live with an accomplished session drummer as a housemate!), to record one-hits at 8-bit resolution, 27kHz samples. Like the Fairlight CMI, the LM-1, with its library of samples, signalled a shift from electronic instruments toward digital ones (Magnusson 2009; 2017).

The “At Your Fingertips” in the LM-1 tagline was just as important as the claims of fidelity, and it marked another departure from analog drum machine convention. While devices like the CR-78 had interesting interfaces with granular

control, they took a cerebral approach to drumming. Instead of making individual sounds, the user either mixed and matched generic loops (waltz, samba, rock 1, etc.), muted or added extra voices, and shaped the timbre of the sound. It was possible to program drum loops from scratch, but this was done with a clunky peripheral device, the user experience of which was about as improvisational as one could get. The LM-1 put 12 drum pads in front of the player, so they could tap out beats—mix and match voices—to a metronome and build loops. It reduced an entire drum kit down to a moderately-sized console. In an interview with Kim Bjørn, Linn retroactively explained that he wanted the device to “encourage real-time beat entry with audio feedback and limited reliance on numerical displays” (2017, 213). Linn designed the device to be tactile and intuitive.



Fig.vi Right (mixer & drum pad) side of the LM-1 interface

The LM-1 had many innovative features beyond its drum pads. Each of its twelve percussion voices had a fader and panning knob, so the volume and position of each voice in the stereo field could be adjusted; the right side of the device (Fig.vi) was essentially a mixer, and a drum mix could be roughed out and piped right out to the main mixing board. Each voice could be detuned with knobs at the back of the device.



Fig.vii Left (program & swing) side of the LM-1 interface

The centre-left of the LM-1 console (Fig.vii) was dedicated to pattern creation, and, via the push-button interface, the player could navigate a 100-patch program memory; chain strings of patterns together into songs; and introduce fills, flams, and dynamics into individual patterns. Beyond sonic verisimilitude, the device's central innovation was the implementation of quantization and swing. With quantization, an unskilled or sloppy player could tap in a rhythm and 'snap to grid' (e.g. to 1/6th note resolution, or 1/32nd triplet). With swing, a straight groove could be loosened up. Linn had spent years thinking about the math of swing and settled on a simple formula: percentage-based delay on even 8th or 16th notes. This *slight* variance 'humanized' a rhythm and mimicked how an expert drummer would play in the pocket.

"Real Drums at Your Fingertips" was more than sloganeering—it was a mission statement. With the LM-1 Linn threw the gauntlet down and challenged the stiff rhythms, clunky interfaces, and tinny sound of anachronistic 1960-70s rhythm boxes (Wang 2014). In aggregate, the LM-1's features challenged the notion of what a drum machine could be. Its sampled one-hits were high fidelity, its interface allowed an order of magnitude more granular control when compared to competing devices like the CR-78 or the Boss DR-55, and the per-voice outputs made recording a breeze.

The LM-1 feature set had dramatic implications for musical labour: its sampled one-hits displaced both the stone-cold groove of the faceless session drummer and the flailing limbs of the bombastic progressive rock drummer. The spectre of deskilling had been foreshadowed decades earlier, notably when the UK Musicians Union sounded an alarm over the menace of ‘robot drummers’ in the 1960s (Angliss 2013, 100). And while these anxieties were prompted by the earliest and crudest mass market rhythm machines like the Wurlitzer Sideman, the unions argued it was only a matter of time before the drummers of the world were waiting in line to cash unemployment cheques alongside deskilled factory workers.

These fears were of course overstated, and fit into a broader history of concerns that automation threatened musicians’ livelihood and agency. But Linn’s mixer and per-voice outs did signal changing tides for musical labour: while the gigging drummer with serious improvisational chops was unthreatened by the LM-1, life in the studio would soon change forever. Anyone who has ever gone through the excruciating process of miking and recording drums immediately recognized the efficiency of a drum machine hardwired to the mixing board: plug it in, get your levels right, hit record. More subtly, the LM-1 and the machines that followed it eroded the primacy of the producer, that engineer slash Svengali who shepherded bands through the recording and *authored* their sound.¹⁷ In the right hands, the LM-1 facilitated a new type of artist taking centre stage, one who didn’t need a producer.

Back to Prince, his digits tapping out a kick-snare backbeat on the LM-1 pads, spicing it up with a funky clap pattern—from muscle memory. Real drums at *his* fingertips.

¹⁷ Late 1970s and early ‘80’s producers that have popped up in my research and on my playlists while writing include Mike Chapman, Nile Rodgers, Jimmy Jam and Terry Lewis, and Quincy Jones.

If This is Lust: Prince Vaults into the R&B Charts

“Hai-ahhh.” Three years earlier the purple one announced his arrival to the world with two syllables delivered with karate chop gusto, his cry followed by a half-second pause, and then an invitation: *“Hey, lover, I got sugarcane.”* “Soft and Wet” was the lead single for Prince’s debut *For You* (1978). After making waves locally in his early bands Grand Central/Champagne (1973-6), he was taken under the wing of local producers Pepe Willie and Chris Moon. The latter was so impressed with Prince that he more or less handed his keys to the studio to the teenager and showed him the ropes of his 8-channel mixing console. Prince stayed over weekends, sleeping on the studio floor, and Moon likened him to “an octopus, because there were hands all over the place.” (Brown 2010, 25). The resulting demos attracted the attention of local advertising agent Owen Husney, who was so gobsmacked by Prince’s talent that he shuttered a lucrative advertising business to manage him. After some misfires in New York, Husney got Prince in the studio with engineer David Rivkin to record a demo comprised of “Baby,” “Soft & Wet,” and “Make it Through the Storm” to shop to CBS, A&M, and Warner Brothers—Prince inked a three-album deal with the latter in June 1977 (30-2).

This wasn’t just *any* deal. Lenny Waronker, A&R head at WB, had a panel of producers with resumes spanning Van Halen to the Doobie Brothers vet Prince’s recording and mixing chops, and an unprecedented arrangement was negotiated: at just eighteen, Prince would be the first artist in the history of *any* major label allowed to produce his debut; the only caveat was that WB wanted producer Tommy Vicari on hand for consultation and to monitor progress. Vicari was listed as executive producer on *For You*, but a more accurate attribution could be found in Prince’s posthumous memoirs, where a picture of the producer curled up on the couch during

recording was labelled: “Tommy, in his usual position” (Prince 2019, 129). Aside from two co-songwriting credits for Chris Moon—a demo throwback—the metadata for most tracks read, “Produced, arranged, composed, and performed by Prince.”

While Prince’s ascent in the music industry was meteoric, his early childhood was full of detours. Born in 1958, Prince’s namesake was his moonlighting jazz musician father, and his early world was shaped by music and his parent’s clashing personalities. His first aural recollection was his father’s playing, and he cultivated a vernacular of embodied intrigue with his mother who winked at him. “A wink meant something covert was going on. Something special that only those who were in on it could attest,” he wrote years later (79). His memoirs also recount a spate of mysterious seizures, which stopped, eventually, but he retroactively attributed them to enduring what he called the “normalady” of everyday life (94). Beyond his father’s artistry, he caught his first glimpses of the studio by happenstance when babysitting for local DJ Jerry ‘Motormouth’ Mac, and described laying eyes on a guitar amp for the first time as a near-sacred experience: “[it] would become more important 2 my life than a stove” (98).

In 1968, when Prince was 10, his parents separated. While he understood that the union of his free spirit mother and his workaday father was ill-fated, he attributed the fracture to the fact his father was “too serious” about music (Hunt 1980). For three years, Prince lived primarily with his mother, who grew increasingly resentful of *his* burgeoning interest in music; he moved on to stints with his father, and then a rotating cycle of living arrangements with friends and (extended) family over the next decade. For better and worse, this led to Prince finding refuge in his artistry and imagination.¹⁸

¹⁸ I share an overview of my sources in the first footnote—they were all helpful—but I really draw on Prince’s posthumous memoir *The Beautiful Ones* (2019) when describing his early years. While the impact of his father’s love for music and his parent’s failed marriage looms large in Prince mythology,

Relationship volatility followed Prince into his musical collaborations. He made a name for himself as bandleader and songwriter for Grand Central and Champagne while coming up in Minneapolis, but he began parting ways with musical collaborators when he set his sights on getting signed. A declaration of independence, he played every part in *For You*—twenty-five instruments in all: acoustic and electric guitar, wind instruments, bass, drums and finger cymbals, his beloved Oberheim and other synths including a Moog and ARP String (Brown, 35). This was a notable achievement for any musician on any album, but it was even more impressive on a debut.

It only takes a few bars of the lead single, “Soft and Wet,” and its opening phat synth melody and rubber bass to announce that a new talent had arrived. The mix is full of ornate flourishes, and no two bridges or choruses are alike. Dozens of vocal parts; a mid-song genre slide from R&B into a full-on disco; and one-off majestic pads, funky accents, and solos pepper the song. Prince’s description of bedroom pleasures may not have been fully formed, but there could be no doubt about his talent as an instrumentalist. Just the same, the song somehow simultaneously feels overly manicured and sloppy. The “Soft and Wet” he describes is about pressing flesh, but it’s also echoed by the sound design. This is particularly evident in the song’s final bars, where the syrupy lead is followed by a big vocal finish. Here, Prince sounds like an Olympic gymnast sticking a landing; he’s vaulted onto the world stage with aplomb but his composure falters—he flashes the judges a goofy smile. Even if the finish feels canned, the lyrics speak volumes. *“If this is lust, then I must confess I feel it every day.”* It’s devotion and dedication rather than

the earnest insights on his childhood in his memoirs provides a much clearer view of his (conflicted) feelings for his parents than any of his lyrics, or biographies penned by music journalists.

proficiency that he's signalling.

Prince Gets a New Toy

It's August 1981 and Prince has just programmed the syncopated rhythm that undergirds "Private Joy," a single included on his fourth album *Controversy*, released that fall. The kick-snare pattern is unremarkable, and the twangy bassline Prince layers on top of it does a lot of lifting in establishing the groove. While the low end is unassuming and whisps along, it's the mids that animate the ode to self-pleasure, make it gyrate. Handclaps and hi-hats add embellishment—lustre. And then there's the toms; while crudely textured and cartoonish in timbre, they contribute something intangible to the mix. Something new.

Prince's falsetto coos breathlessly, celebrating his lover with shameless devotion. "*My little secret, my private joy / I could never let another play with my toy.*" Smokey Robinson in tone, NC-17 in tenor, it's a paean to pleasure and exclusivity but between Prince and whom? Prince speaks to and of a woman, but wry double entendres suggest another reading; when one brags of 'strangling Valentino' the options are either jealous homicide or spirited self-service—our protagonist seems more inclined to the latter.

In mixing the aliased handclap, tambourine, and tom timbres with the saccharine Oberheim 4 lead, Prince had a eureka moment. While this particular session was recorded in Sunset Sound Studios in Los Angeles, "Private Joy" marks a critical moment in forming what the music press called 'the Minneapolis Sound.' The sound was more uptempo than traditional funk, featured synths instead of horn parts, and employed more heavily processed or drum-machine-derived percussion sounds. In the early '80s, the term was ubiquitous in the music press when

describing Prince's overall finesse as a producer, mixer, and all-around synth and electronic percussion wizard, as well as recordings by The Time, Vanity 6, Sheila E., Jimmy Jam & Terry Lewis and other producers hailing from The Twin Cities. Roy Kay describes Prince's take on the sound "as a deterritorialization and critique of the historical, social, racial, and cultural categories that constituted his youth" (2022, 216), which speaks to Minneapolis' status as a multicultural melting pot. Valourizing Minneapolis as exotic, the Minneapolis Sound nomenclature created a permission structure for East and West Coast tastemakers to celebrate the Upper Midwest—a region they'd typically describe as flyover.

The subject of the carnal pleasures foregrounded in "Private Joy" is worth dwelling on. "You're my little lover, Orgasmatron / Only I know, only I know baby, what turns you on." 'Reliable sexbot' is the overt reading (see also: Darling Nicki and her enviable vibrator collection), but what if Prince is not speaking about the machinic but simply about his machine? His LM-1. That gives new licence to any reading of his heavy breathing and enthusiasm. He is undoubtedly singing about a muse, but perhaps it is one that is literally rather than figuratively turned on.

The Pleasure of Buttons, Knobs, and Sliders

Interaction design is concerned with control and affordances: *rich user experiences*, in contemporary vernacular. The design subfield emerged from human-computer interaction (HCI), a reflection of the technocrats and managerial class who had access to computers in the postwar period. HCI bubbled up in the 1950-'60s *after* the early days of feminized operators, punch cards, and Alan Turing's evocative hypothesis that one day a computer could 'pass' as human. These waypoints plotted a course to a new phase of computing, one that could be

summed-up in a single acronym: IBM.

International Business Machines signaled the propagation of computing from research and military contexts toward business and everyday life. Vannevar Bush, who looked beyond the wartime applications he oversaw, dreamed of benign information retrieval. His memex, which he detailed in “As We May Think,” an essay published in *The Atlantic* in 1945, was a hypothetical device that fused desk and archive, a *navigable* archive in which a researcher sat at a control station and played Ariadne, physically ‘linking’ their way across documents. A thread of this concept was later picked up by Ted Nelson (Xanadu) and Tim Berners Lee (HTML and the World Wide Web). Bush envisioned the outsourcing of memory to machines.

Bush’s imagined interactions became more tangible in the 1960s research of Ivan Sutherland and Douglas Engelbart, “interface heroes” (Laurel 1989) who respectively prototyped computer-assisted drawing and augmented reality, and the graphic user interface and video conferencing. Their prototypes were where ‘the rubber hit the road’ for ideas only *described* by Bush, and each anticipated interactions and interfaces for their novel—acutely embodied—rethinking of the computer-operator interface.

However, early thinking around the ‘human’ in human-computer interaction was crude, as illustrated by J.C.R. Licklider’s 1960 HCI manifesto “Man-Computer Symbiosis.” In it, the psychologist and computer scientist schematized humans as “noisy, narrow band devices” with “nervous systems [that] have very many parallel and simultaneously active channels.” (2003 [1960] 76). Hardly a profound humanist, Licklider’s mechanistic reading of human fallibility framed interaction as an engineering problem—something to be solved, or *optimized*. This cybernetics-era rhetoric of bodies, senses, and systems bleeding into one another was echoed in

Marshall McLuhan's framing of electronic media as "an extension of the human nervous system" (1964).

This generalized thinking about the body and technology permeated the early days of synthesizer design, with Robert Moog and Don Buchla laying out competing visions for what a 'synthesizer' should be. Following in the footsteps of other electronic instrument inventors—like Thaddeus Cahill (the Telharmonium), Leon Theremin (the instrument bearing his name, the Rhythmicon), Hugh Le Caine (the Electronic Sackbut), and Herbert Belar and Harry Olson (the RCA Mark II Sound Synthesizer, aka 'Victor')¹⁹—Moog and Buchla's 1960s designs were hulking masses of modular components, blinking lights, and tangled patch cables. Literally manifesting signal routing and processing paths, there was no 'design' to speak of—just engineering. The aesthetic was far more mainframe than musical instrument. Their designs diverged in 1970: Moog integrated a 3.5 octave piano keyboard into the Minimoog—the first mass-market synthesizer—offering a familiar interface for a would-be player to experiment with timbre within tonal convention. Buchla, a purist, saw the synthesizer as a break from both acoustic instruments and the Western tradition, and defiantly rejected the keyboard and oscillators that followed the volt-per-octave standard (Pinch 2002, 10), putting his 'systems' far enough outside the realm of familiarity that they were limited to niche audiences. Like the Hammond organ before it, the Minimoog was a "nexus of past, present, and future" (Théberge 1997, 46) that created an archetypal form factor for future innovation.

¹⁹ Using Théberge's invention versus innovation distinction, as far as electronic instruments go there was *only* invention before the Minimoog. It took the Minimoog to have electronic instruments (more adventurous than organs) establish a foothold in the market, making corporatized innovation possible. In many ways, the 1970-1985 electronic instrument market was marked the gradual decline of 'inventors' and the rise of multinational (often Japanese) corporations who engaged in what Théberge characterizes as "transectorial innovation." See his discussion, on the microprocessor in particular (1997, 58).

That the Minimoog made inroads with musicians at the same time the scope of computing widened is not a coincidence. The 1970s was the decade that computers and ‘high’ technology began to expand beyond research, defence, and corporate applications. If IBM’s ascent prompted HCI beyond specialists, it was the intervention of designers that helped computing take its next step beyond the “rarefied domain of programmers and kit-builders” toward “casual or discretionary” users (Katz 2015, 107).

Reproduction of a New Breed

“Sexuality” was *Controversy*’s second single, released shortly after the breakout eponymous hit. With it, Prince amped up the tempo and textures that animated “Private Joy,” yielding a raw machine rhythm. An infectious groove even by Prince standards, “Sexuality” foregrounded his interest in new wave—and moved him further into uncharted territory, distinct from the R&B sonic tableau of his first two albums. “Sexuality” hinges on a noisy snare, one of Prince’s greatest; an epic *SNAP* authoritative enough to challenge Devo’s infamous whip crack, which had so resoundingly lashed the popular imagination. But beyond the noisy snare, it’s the timbres of the central, distorted, driving tom rhythm that take centre stage here. The percussion programming just *ripples* with energy, the palette gluing together the best of a conventional kit (kick, cymbal, side stick accents) with wild tom textures that sound like Tupperware percussion. In his first *Rolling Stone* interview Prince revealed his first instrument (and drum kit) was a “box full of newspapers” (Miller 1983)—perhaps the tom pattern represented Prince coming full circle.

“I’m talking about a revolution we got to organize / we don’t need no segregation, we don’t need no race.” Delivered with the fervour of a preacher (or

overzealous aerobics instructor), Prince calls for full-on rebellion. Not particularly subtle, it is perhaps unsurprising that critics homed in on the *lack* of a discernible polemic rather than the song's innovative rhythmic timbres. Robert Christgau's lukewarm *Village Voice* review unflatteringly described Prince as a "rather confused young fellow" (1981). If the politics were fuzzy the anti-conformity mandate was at least clear. "This is your life," Prince cries, offering his perennial promise: liberate your body and your mind will follow.

Tracking the jump from "Private Joy" to "Sexuality," it's clear Prince was experiencing an embodied liberation of his own. Compelled by the timbres and workflow of the LM-1, he heavily invested in the device, and it quickly became a sketchpad, with which he streamlined his songwriting process. Thomas Brett's meticulous scholarship on Prince's use of the LM-1 distills the artist's relationship with the drum machine down to four central tenets: a deep engagement with its sonic potential and limitations, idiomatic programming, fast and continuous workflow, and the integration of the device into the broader studio—a network of technologies and practices (2020, 257-8). While all these elements are important for understanding the role the device played, I highlight the "fast and continuous workflow" as central. For Prince, it was why the LM-1 was a revelation: its intuitive interface. After refining, revising, and re-recording his demos *ad infinitum* to get signed, and then running himself into the ground to record dozens of parts in *For You* and his eponymous sophomore album, Prince knew he wanted to work faster, and record *rawer*. Speaking to *Ebony* in the mid-1980s, he described *Dirty Mind* in acutely visceral terms: "If I could put my bloodstream on vinyl, then this is what it would be" (Norment 1986). That album's percussion was received by *New Musical Express* as "a taut rhythm team of skipping bass and metallic pepper-shot drums" (Carr 1980)—an

idiosyncratic foundation for Prince's falsetto and synth stylings. "Private Joy," "Sexuality," and *Controversy's* title cut (and let's not forget the delightfully weird "Annie Christian" and "Jack U Off") signalled Prince had found a new toy—a receptacle for his blood and sweat.

"Heavily Constructed from Programmable Devices"

As noted by Samantha Bennet, popular music recording practices in the late 1970s and early '80s recording practices underwent a shift from capturing performances toward music "heavily constructed from programmable devices" (2019, 8). So did how producers programmed: as chronicled by Bennet, Paul Théberge (1997) and others, the early 1980s saw the release of the MIDI interoperability standard, the rollout of digital synthesis, and the introduction of sampling, all of which profoundly influenced music making practices. It's worth noting that the onset of this music technology renaissance coincided with some genres fading (disco, prog rock) and others bubbling up (new wave, rap), with the newcomers heavily drawing on the aesthetics, affordances, and constraints of these new instruments. The profound shift is encapsulated in Bruce Springsteen's output during this era; *Nebraska* was recorded within the democratized affordances of a Tascam PortaStudio 4-track recorder, and then in 1984—two short years later—*Born in the U.S.A.* became patient zero for the compact disc, its sound "frozen in pristine digital form" (Milner 2009, 189).

In his analysis of the LM-1, Brett notes how Prince "understood the equipment as links with a larger music production system" (258). The drum machine had its own workflow but it wasn't an island: it and other pieces of gear—synthesizers, pedals, mixers, recording media—were nodes in a larger, interconnected system. It is in this

interconnection that I centre Prince's acute understanding of the studio as a space where his prowess as a multi-instrumentalist takes a backseat to his ability to intuit new and innovative applications for music technology and electronic instruments. Building on Brett, I argue that Prince's deep engagement of the LM-1—both its sonic aesthetics and programming workflow—*anticipates* the widespread adoption and incorporation of electronic percussion into 1980s popular music. While Prince's multi-instrumentalist virtuosity provides a means to read his early albums, it's his aptitude as a *user* of the LM-1 rather than a *player* of two dozen instruments that served as accelerant for his songwriting process, allowing him to work more instinctively. If the 1980s marked the moment the audience for computing expanded beyond the "kit builders and programmers" described by Katz (2015), it was musicians like Prince that demonstrated the drum machine was an effective, usable, *desirable* tool that belonged in the studio of every musician. Here I lean into this idea of 'Prince as user' and situate him in the trajectory of computer and synthesizer adoption that I described earlier. In an effort to move beyond conversations of virtuosity, I turn to interaction design to open up a broader conversation about the relation between players and their instruments.

Though divergent in how they prioritize our senses, instincts, and capacities, the varied schools of interaction design converge around the centrality of designer-user relationship. If HCI framed the world as humans and machines, interaction design swaps out the machine with the designer, who anticipates the needs of the would-be user. Don Norman writes of a user coming to a designed object for the first time as "discovering what it does, how it works, and what operations are possible" (2013 [1988], 10). The designer is a *mediating* figure, whose work lessens the cognitive load for the end-user. And, as far as music

technology goes, Thor Magnusson encapsulates the process neatly as “the tool is designed, its affordances and constraints are outlined, and the user’s actions are predicted and delineated into the interface and interaction design” (2019, 53).

The leap from the subjectless HCI to user-centred design did not occur overnight: it was necessitated by computation’s expansion beyond specialty domains. If IBM was the poster child for the mainframe era, Xerox PARC gestated the personal computer user. No single site contributed more to the incubation of user-centred design than the Palo Alto R&D facility Xerox set up in 1970. Until that point, the document reproduction company had been solely focused on photocopiers, but heading into the 1970s there were storm clouds on the horizon with IBM’s rapid expansion into all corners of business. In an attempt to open up new markets, the company poured funds into envisioning the office of the future and bankrolled a cadre of ethnographers and computer scientists in hopes of outflanking IBM and other competitors. Within a decade, both the desktop computer and numerous computing paradigms that underpinned it—the mouse, the GUI, WYSIWYG, ethernet—were developed or refined at PARC, but the most enduring invention to emerge during its halcyon days was the notion of ‘the user.’

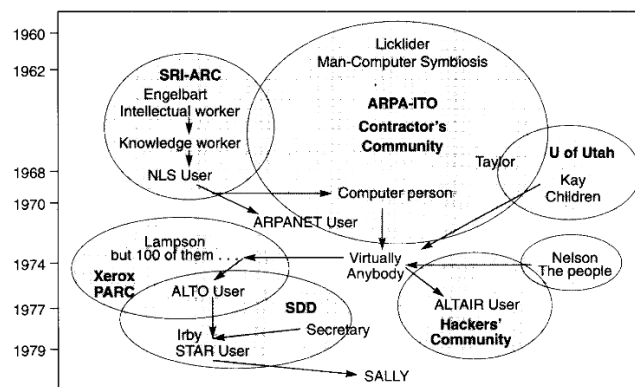


Fig.viii Inventing the user, from “The Social Construction of the Personal Computer User” (57)

In “The Social Construction of the Personal Computer User” (1995) Bardini and Horvath map the PARC-era seismic shifts in computer science, which transitioned from envisioning the user as a vague 1960s military-industrial complex and skunkworks R&D subject to a middle-class woman named Sally in 1979 (Fig.viii). Bardini and Horvath’s analysis builds on the notion of the lead user, an early user of a product that presents “strong needs” and is “familiar with conditions which lie in the future for most others” (Von Hippel 1986, 791). Extending the anticipation implied in the ‘lead’ user concept, they describe the personal computer user as having agency when they emerge in the 1980s, but also position that agency relative to the efforts of the computer scientists, interaction designers, and marketers that developed personal computing hardware and software applications for the general public—GUI conventions and input devices, spreadsheets for home accounting and productivity software, etc.—and communicated their use. To reflect the complexity and bidirectional nature of this relationship, Bardini and Horvath coin the term “reflexive user,” a subject that starts in the mind’s eye of the designer, who was eventually replaced by the *real* user, after the personal computer was out in the world and had developed a budding market and culture. The reflexive user is first enacted as “mental representation” and “a sketch of a strategic plan” (1995, 42)—“created” where no explicit user already exists (65).

In dwelling on the tension between an idealized user who starts as a design personae and ends as a public, I introduce Prince as a figure to complicate and confound the tidy bidirectional flows of influence and imagination bridging designer and user. As one of the first users of the LM-1 Prince brings *more* to the device’s interface than Linn could have anticipated. Surely Linn expected serious drummers to take an interest in his machine (it was received with open arms by Ultravox’s

percussionist, Warren Cann), but the Linn Electronics marketing department flew a flag of sonic fidelity over the LM-1 to entice would-be users. The sounds that Prince coaxed out of the device were a rebuttal to this messaging, and this is perhaps best exemplified by his detuned tom sounds. Significantly abstracted, their wonky sonic quality derives more of its provenance from the aliased low resolution of 8-bit sampling than Art Wood's original drum hits; his detuning of the LM-1's tambourine and cross stick voices was similarly transformative. Similarly, Prince's dense drum programming—the tom flurries, the intricate flams—often eclipsed what a human player could accomplish.

Bardini and Horvath's discussion of the reflexive user describes a subject that explores the outer limits of what a tool is capable of. These explorers are "highly unstable," and as product development winds down their role fades and they "eventually disappear ... to be actualized in a separate living entity, the real user" (42). Prince does fit relatively neatly into each of these characterizations: on one hand he experimented, and on the other that experimentation demonstrated the role of the drum machine in the studio of musicians (the 'real' users). However, he transcended any "mental representation" Linn had of who the LM-1 user was or could be. Linn has talked about how surprised (and delighted) he was by Prince's use of LM-1, commenting specifically on the detuning, speculating, "I think he was able to hear what the correct sound should be in his head. The one that was interesting and complemented his music well" (Johnson 2017). In that same interview, he laments Prince's 2016 death, because he was never able to hear him experiment with The LinnStrument, an advanced interface that takes advantage of recent developments in the MIDI standard to enable greater musical expression from electronic instruments. Linn says "I think he would have valued" his design. But the

subtext is clearly that Linn regrets not having the chance to hear what Prince could do with his design.

Why Does Everybody Have the Bomb?

“Don’t Worry, I won’t hurt you, I only want you to have some fun.” This time the timbral distortion is applied to Prince’s voice. The pitched-down disclaimer opening to “1999” makes an overture to the listener and nails the early ’80s affective zeitgeist—one part nuclear proliferation anxiety, two parts hedonism. In *Controversy*, Prince advised Roanld Reagan to “talk to Russia (before it’s too late)” while a firefight and explosions crackled and boomed in the background, accompanied by machine gun snare rolls and leaden kicks. By 1982, the minute hand on the Doomsday clock had ticked forward to 11:59, but instead of cowering from red dawn, Prince welcomed purple sky.

“2000 zero zero, party over, oops, out of time.” Judgement day and the afterlife are always close at hand for Prince, but “1999” receives Y2K annihilation with a dance line. The sound design is tightly calibrated, the noisy cymbal crashes with a long decay—pent-up twentieth-century tension releasing from a steam valve—a noise snare, fuzz cowbells, and wonky claps fill out the mix. The drum kit may be melting in white heat, but the beat goes on; the reverb on the percussion is amped up a bit, every hit an exclamation point followed by silence. *“But life is just a party, and parties weren’t meant to last,”* sings Dez Dickerson—sighing, surrendering. *“So if I gotta die I’m going to listen to my body tonight”* Prince howls jubilantly. A one-word chorus “party!” repeats over and over, the syllables jumbling into one another, smearing, and sounding eerily like “heartache.” Loose (human) hand claps keep time until the LM-1 takes over to sound the final countdown.

“Mommy, why does everybody have the bomb?” Lisa Coleman’s voice is pitched-up, not more-than-human but less-than-adult; faced with oblivion, why not revert to childlike innocence? The December 31st festivities described were 17 years away when “1999” was recorded. Enshrined in the 1980s party canon, the song offered a flip meditation on nuclear proliferation and a glimpse of the then-distant twenty-first century. In a CNN interview years later, Prince describes the song as a rebuttal to cynicism toward futurity. “I knew there were going to be rough times for the earth, because this system is based in entropy ... I just wanted to write something that gave hope” (*Larry King*, 1999). An alt-timeline, “1999” warned and revelled, and endorsed faith as a way to find joy and pleasure while living under the shadow of Mutually Assured Destruction.

One Console, 2 Sets of Hands

While more concerned with delineating the world through his signature lens of lust and faith, Prince parsed the technologized early 1980s subject in his own way: he embodied it. While he signalled multi-instrumentalist virtuosity and mastery of R&B and funk convention on *For You* and *Prince*, it was the maturation of his sound through streamlining his recording and electronic instrument utilization—production acumen—that pushed his sound beyond generic expectations. Here, I return to Prince’s hands, and my romanticized vignette of him tapping out the tom and clap patterns that undergird “Private Joy”—articulating new timbres, textures, and timings. Now, I evoke a similarly tight crop of another set of hands, working on a related problem.

In 1979 Roger Linn was in the midst of the sound shaping that would translate the percussion one-hit recordings he collected from housemate Art Wood to the

LM-1's digital samples. Due to his inexperience in engineering, but also because he liked what he heard when he ignored the rules, Linn inadequately low-pass filtered his recordings contrary to Nyquist-frequency orthodoxy for the 27 kHz samples he was constructing. He *should* have filtered all frequencies above 13.5 kHz out of the samples, but he felt the resulting samples were “dull” and lifeless, so he kept some of the higher frequencies because: “the distortion had the ‘sizzle’ of real drums” (Milner 2009, 313). Keeping the aliased sizzle was Linn's aesthetic decision, but it took Prince's detuning the LM-1 voices—the tupperware toms, wonky claps, the jagged aliased noise snare—to *manifest* its possibilities.

The proximity of these two sets of hands, ostensibly hovering over the same machine—a bundle of assumptions about how percussion is programmed and how drum voices are shaped, how rhythm works—is the all-important hyphen in the designer-user relationship. Bardini and Horvath, in describing the subject construction that produced the ‘person’ in personal computing, close that analysis by noting that it is only once an invention is out in the world that “the real users come into the game to validate the winner's representative of themselves,” and that this “real user” is a “verification of the strongest claim” for who or what that subject can be (1995, 63). Although they make room for the agency of the user, they position that subjecthood relative to the designer's intent; this claim seems to disempower the user. While the notion of the user with limited agency is perhaps tenable for consumer electronics, does the same logic hold for electronic or digital instruments, which are ‘played’ not ‘operated’?

Prince boasted that he may have had “the first Linn” and that he recorded “Private Joy” on a prototype of the LM-1 (Brown 2010, 62). That claim may be dubious given the song's summer 1981 recording date, but taken at face value,

using Bardini and Horvath’s nomenclature: Prince was *the* reflexive user of the LM-1. As chronicled by Brett (2020), the device became a central preoccupation—a songwriting sketchpad—that functioned as an armature on which Prince refined and then streamlined the Minneapolis Sound.



Fig.ix Tom Petty, Dhani Harrison, and Prince at the 2004 Rock & Roll Hall of Fame Inductions

Virtuosity’s Disappearing Act

One of the most iconic moments in early twenty-first century popular music is Prince’s performance at the 2004 Rock and Roll Hall of Fame induction ceremony (Fig.ix). Along with Tom Petty, Jeff Lynne, and Steve Winwood, Prince played an affective rendition of “My Guitar Gently Weeps,” honouring George Harrison, who had recently died. Even within an ensemble of guitar heroes, Prince stole the show with a searing solo. His peers’ expressions are priceless and register outright awe over Prince’s playing²⁰; and if his dextrous fingerwork and quivering tones weren’t enough, he ends the song by throwing his guitar up in the air and striding confidently off stage. As if immune to gravity, the guitar just *ascends* and counterintuitively never falls back to earth—magic. Tom Petty’s drummer, Steve Ferrone, captured the

²⁰ The late Beatles’ son Dhani Harrison, in particular. He beams a 200 Watt smile while Prince is shredding, driving home the point that something very special was happening onstage.

resulting bewilderment: “everybody wonders where that guitar went, and I gotta tell you, I was on the stage, and I wonder where it went, too” (Kinos-Goodin 2017).

In truth, the disappearing guitar act was a sleight-of-camera trick. In close-up, it appeared that Prince threw the guitar upward to the heavens—the way his arms moved and the angle of the ascending guitar suggests as much. A wider camera angle reveals he merely tossed the guitar up *and forward* to the first row of the audience into the waiting arms of a trusted guitar tech. Regardless of the veracity of the guitar throw, the solo became the subject of lore, particularly after Prince’s untimely passing in spring 2016.

This now-legendary moment encapsulates Prince’s virtuosity, which extends far beyond the guitar. One could equally point at his piercing falsetto, mastery of the piano and synthesizer, or his dexterity on the drum kit. It’s knowledge and experience derived from the latter that he capitalized on when he immersed himself in the LM-1 from 1981-4, when recording *Controversy*, *1999*, and *Purple Rain*; then, as is the case in most trysts and infatuations, he moved on. I single out this early 1980s period in Prince’s discography as being ripe for an intervention, a space to reconsider Prince’s talent, and virtuosity writ large. To do so, I will draw on Steve Waksman’s canonical consideration of the electric guitar (1999), specifically his analysis of Jimi Hendrix—a handy foil for Prince on several fronts.

Waksman uses Hendrix as a prybar to force open conversations and genre, race, and performativity; in Hendrix’s hands the electric guitar was a “literal and symbolic instrument” for “transgressing musical and racial boundaries” (180). He dwells on the projection of Hendrix’s sexuality through the potent combination of sonic innovation and gesture—seamlessness between player and axe, a “fusion of man and machine.” Waksman’s close reading of the performance of the “Star

Spangled Banner” paints Hendrix as orchestrating melody, volume, feedback and distortion—“shades of noise”— with sardonic lyrical interjections; he also notes a distinction between a 1969 Los Angeles Forum performance of the anthem with the guitarist’s iconic Woodstock performance (171-3). That the latter, performed for the *archetypal* (predominantly) white ’60s counterculture audience, was muted lyrically and tempered sonically is duly noted.

Prince was no stranger to having his virtuosity conflated with his sex appeal. His salacious lyrics and personae were irresistible bait for journalists, and he toyed with those who were foolish enough to ask facile questions about lust. In his first *Rolling Stone* cover feature (1983), Debby Miller quipped, “So Kraftwerk made *The Man-Machine*? This is the Man Sex Machine,” juxtaposing her subject’s “androgynous look” and “sex-mad lyrics” with the sterility of synth pop’s Teutonic progenitors. Highlighting a dash of James Brown fiendishness, she questions whether those qualities make Prince “scariest to white audiences than Mr. T?” Read generously, she’s positioning her subject as transgressing genre norms, but the correlation between Blackness and anxiety is overt.

Miller’s characterization warrants analysis though, as she’s not just speaking of Prince’s sex appeal and racial ambiguity—she’s qualifying his masculinity. And the reading is: *confused*? First we have Kraftwerk, harbingers of the “the ultra whiteness of an automatic, sequenced future” (Eshun 1998, 100); teutonic, asexual, students of Stockhausen, forever disassociating from the human in favour of a robot other. Then, James Brown, decidedly *not* asexual, drenched in sweat and desire, the embodied personification of rhythm; elevating the beat “to near mythic proportions” (Reinecke 2009, 610) through a tactical mix of tyrannical band leader practices and unparalleled dance moves. The lustful, hardest working man in show business meets

the sterility of Krautrock’s motorik pulse, and the formidable (apparently threatening) physique of the menacing-but-lovable enforcer in a fictional group of ragtag mercenaries. Miller’s quip is vague, the equivalent of throwing sand in the reader’s eyes—a distraction from the fact she can’t quite get a fix on her subject.



Fig.x Andy Warhol, *The Orange Prince* series (1984)

Just as his biracial identity complicates his relationship to Blackness, Prince’s take on masculinity defies characterization (Fig.x). Lyrically and in performance he’s a Lothario, but he puts women in control in the bedroom *and* at the mixing board—just ask sound engineer and producer Susan Rogers. Sasha Geffen has described this flexibility as “a liquid space where Prince could not only desire women but adopt those features at the same time” (2020, 111). Sartorially, his dandy aesthetic pushes outside the comfort zones of funk, soul, R&B convention and “the rigid constructs of heterosexuality” (Hawkins and Niblock [2011] 2016, 242). It builds on the glam masculinity of David Bowie and Marc Bolan, which alluded to the possibility of queerness and resisted cultural norms that “suppress innate androgyny in favor of supposedly stable masculine and feminine identities” (Auslander 2006). Prince’s masculinity is *bewildering*. To quote Nic John Ramos, discovering Prince’s libidnal performance of gender is to be left wondering “*what’s this guy’s plan?*” (2014, 443).

This indecipherability echoes how Eric Clapton, Mike Bloomfield, Pete Townshend—threatened white male guitarists—are left reeling by Hendrix’s virality slash virtuosity (Waksman 1999, 192-203). Invoking Fanon, Waksman frames Hendrix as growing increasingly frustrated by the scrutiny of the consumptive gaze of his white audience, ultimately yearning to be “heard, not seen; listened to, not watched” (205).

It is this desire for invisibility despite flourishing under the scrutiny of stardom that ties Hendrix and Prince together. While both artists cultivated a larger-than-life stage presence and capitalized on their sexuality, they sought refuge and introversion in the studio. Hendrix frequently used the phrase “electric church” (Richman 1969, 74) to describe the boundless possibilities of manipulating sound in the studio, and this open-ended exploration is the *opposite* of how the amplified electric guitar centres its player within a band or ensemble *in the moment*. Prince’s ability to play upwards of two dozen instruments separates him from Hendrix, though, and this spread in aptitude results in divergent thinking about how virtuosity is mobilized. Hendrix pushed *an* instrument to its limits and brought that knowledge about the malleability of sound back to the studio. Prince was a human multi-track recorder, attuned to how myriad musical gestures—strings, keys, percussion—could be arranged across the audio spectrum and arrays of channels, and he possessed a keen understanding of how they sit in a mix. In the late 1970s he told the *Minneapolis Tribune* the misstep most multi-instrumentalists make when recording is inconsistent intensity: “you have to pretend each time that this is going to be your only track and that you’re the only guy who’s going to play that instrument” (Prince 2019, 153). The listener can *hear* this confidence fully realized in the hundreds of sonic flourishes across *For You* and *Prince*. The problem was that this level of

attention was not sustainable—economically or physically; Prince nearly broke both the bank and his body recording his first two albums.

Prince pushing himself to near oblivion lines up with traditional notions of virtuosity, which Jane Ginsborg has defined as an innate gift honed through practice and a combination of “excess and exceptionality” (Ginsborg 2018, 455). Indeed, scholarship on nineteenth-century pianist Franz Liszt and violinist Niccoló Paganini defines virtuosity as interpretive and technical mastery “typically involving speed, accuracy, and power” (Doran 2020, 11) and inspiring rhetoric espousing “the epic nature of human agency” (Palmer 1998, 342). However, Prince furiously playing all his parts in the studio, away from prying eyes, doesn’t align with the spectacle of Liszt, Paganini, or Hendrix in front of an entranced audience. Moreover, Prince tapping rhythms on the LM-1, however brilliant they were, is even more inscrutable and veiled than these esteemed benchmarks of mastery. What Prince did with the LM-1 sits outside these more traditional notions of instrumental virtuosity.

The Anthropologist Anya Royce describes virtuosity as “the masque of nonchalance” (2004, 18), and, with that blasé characterization in mind, I return to and linger on the image of the miraculous ascending guitar that concluded Prince’s memorable 2004 Rock and Roll Hall of Fame induction ceremony performance. That sequence—shredding, disavowing, disappearing—is a cipher for understanding the elusiveness of Prince Rogers Nelson. The spectacle of his stagecraft and charisma, his impassioned solo, a single moment encapsulating a career-long trick he had played on his audience—suggesting that the height of his powers was peerless virtuosity. Susan Rogers, his engineer for *Purple Rain* through *The Black Album* (1983-7), balked at the notion that Prince was a perfectionist, stating “he was that fluent on so many instruments that we could go super-fast. There was no perfection

involved” (Crane 2017). By the mid-1980s his superpower was efficiency, not virtuosity. How else can a musician record 42 studio, 4 live, and 17 video albums in their career, and leave a vault of unreleased music substantial enough to require an archivist-executor. The mandate for self-determination was there from the beginning, inked into his precedent-setting Warner Brothers deal. Prince knew that both authenticity and autonomy were forged in the studio. In a 1981 interview with *New York Rocker* he inferred that artists reliant on outside producers had made Faustian bargains. “What happens if that cat dies? There goes your sound.” (Schwartz 2019 [1981], 21). While Prince came to this realization early in his career, it wasn’t until his sixth album that he fully embraced its implications.

Go Crazy (Punch a Higher Floor)

“Dearly beloved / We are gathered here today / To get through this thing called life.” First a religious rite, then rapture—that’s the order of operations in “Let’s Go Crazy.” The song opens with Prince describing an afterworld of eternal light over Matt Fink’s church organ chords—he urges the listener to let that light illuminate their navigation of *this world*. A chugging backbeat kicks in—one of Prince’s more authoritative LM-1 bass drum kicks, signalling that he means business—which is animated by flurried cross sticks and infectious synth and bass lines. Lyrically, Prince tackles faith, meaning, morality, *all of it*, espousing ecstatic hedonism to ward off materialism, mundanity, and the menace of Satan’s debasement; famously, the word ‘Satan’ could not be used for fear of banishment from the airwaves, so here Lucifer is reconstituted as a descending elevator. “*Let’s go crazy / let’s go nuts,*” Prince calls for release and surrender, “punching-up” a higher floor rather than accepting predestination; “*go ... crazy,*” Lisa Coleman and Wendy Melvoin harmonize their

response. One of Prince's most inspired blurrings of "mana and taboo," and "the sacred and the profane" (Pollard 1989, 139; Till 2010, 153), he simultaneously projects 'redeem thyself' preacher and 'pull yourself up by the bootstraps' life coach energy. The song crescendos with a blues walkup that fuses a guitar solo for the ages, a piercing synth tone, and an extended drum fill, terminating with Prince hoarsely screaming "*take me away.*"

"Let's Go Crazy" opened Prince's concert film *Purple Rain* in 1984, and its mock sermon introduced him to a global congregation. *1999* had sold upwards of three million copies, but its reception paled in comparison to *Purple Rain* as either a commercial success (*Purple Rain*'s lead singles "When Doves Cry" and then "Let's Go Crazy" were Prince's first #1 hits) or as a pop culture breakout moment. The film's potent combination of new wave aesthetics, a fully-matured Minneapolis Sound (that had seen five albums' worth of development) that now made compelling overtures to the stadium rock crowd and white radio in middle America, and Prince's oozing charisma and transgressive star quality catapulted him into an elite echelon of pop stars alongside Madonna, Michael Jackson, and Bruce Springsteen.

The opening sermon in "Let's Go Crazy" leads with alienation and loneliness, but Prince offers solace: "*take a look around / at least you got friends.*" While this fits the song's narrative of reckless abandon, it also acknowledges a shift in the artist's headspace. Prince's debut and sophomore albums showcased him as a wunderkind, an inspired one-man-band that burned through (and burned out) many of his earliest musical collaborators; *Dirty Mind* saw him expand beyond R&B and funk generic expectation, and *Controversy* and *1999* were both heavily indebted to the arrival of the LM-1. When he first tapped out the "Private Joy" tom pattern in 1981, the device served as both (songwriting) sketchpad and (get recording quickly) launchpad; *1999*

also saw new faces within his band, shifting to Dez Dickerson (guitar), Brown Mark (bass), Bobby Z. (drums and percussion), Dr. Fink (keyboards), and, crucially, Lisa Coleman (keyboards). While recording 1999 with the ensemble, which became The Revolution, Prince glowed: “I personally love this band more than any other group I’ve played with.... everybody knows what they have to do.” He warmed to Coleman in particular, praising her as a “master of colour in her harmonics.” And of her monotone voice: “I could sing off what she had with straight soul” (Brown 2010, 67-8).

Coleman brought the final piece to the puzzle a year later, when her then-girlfriend and longterm collaborator, guitarist Wendy Melvoin, subbed in after Dez Dickerson abruptly quit the band in the lead-up to the recording of *Purple Rain*. Beyond being a gifted guitarist, Melvoin had another talent, which album engineer Susan Rogers described as “coming the furthest I’ve ever seen pulling at Prince out of his shell ... everyone else felt intimidated by him” (79). After five albums and about twice as many personnel changes, Prince trusted his collaborators and opened up the recording process to them. Rather than just summoning musicians to the studio at 2AM to record a part, or jamming out variations of a song prototyped on the LM-1 (or in Prince’s head), recording became collaborative, rehearsals became *generative*. Prince had embraced a streamlined sketch-to-recording workflow in the early 1980s, and, when appearing on MTV for the first time in 1985, he gushed about taking it to the next level, stating, “it goes even quicker now that the girls help me—the girls meaning Wendy and Lisa.” (Fagnoli 1985). Unlike the claims of auteurship of his first five albums, *Purple Rain*’s liner notes read “produced, arranged, composed and performed by Prince and the Revolution.”

Requiem for an Inventor

While the LM-1's percussion voices were momentarily so integral to 1980s pop they were “foregrounded in mixes to unusual degrees” (Bennett 2019, 400) in hits like “Thriller,” its \$5,000 USD (\$16,500 inflation adjusted) price point ensured there was limited audience beyond the initial 500 units. Prince, along with the Human League, Quincy Jones, and other producers put its punchy sound on the map and it was everywhere—briefly.



Fig.xi The Roger Linn-designed Akai MPC60

After a chance encounter and some advice from Roland founder Ikutaro Kakehashi—the entrepreneur and engineer behind the TR-808 and the subject of my third chapter—Linn set to work on a new instrument to create new revenue streams. Linn Electronics followed the LM-1 with the LinnDrum in 1982. Considerably more affordable than the LM-1, this device was a commercial success (although Prince was not a fan and greatly preferred the original), but, like so many other American outfits, Linn Electronics lost its way in the choppy waters that followed the launch of the Yamaha DX7 and the MIDI interoperability standard in 1983. The company shuttered in 1986, after a stillborn MIDI peripheral device design bankrupted the

company, suffering the same fate that befell so many American boutique inventors as Japanese multinationals took centre stage. Linn went to work for one, Akai, acting as lead designer for the Akai MPC60 sampler (1988, Fig.xi), with its iconic 4x4 drum pad on which much of rap's golden age music was tapped out, an interface convention that remains ubiquitous through to present day sampler and drum machine design.²¹ In recent interviews, Linn has positioned the LM-1 as an opening statement in a career-long argument for prioritizing musical expression over feature creep in electronic instruments. He looks back to the immediacy of the LM-1's 2x9 drum pad arrangement as facilitating the recording of musical ideas "without technology getting in the way" (Bjørn 2017, 213). Even decades later, he remains frustrated with the fact that drum pads are still functionally "on/off switches," which do not facilitate the sophisticated rolls or voice muting that a dexterous player can employ on a trap drum kit (Russell 2019).

In introducing this chapter, I stated that the LM-1 caused a rethinking (if not a rewriting) of our thinking around virtuosity. By putting the affordances of a machine in dialogue with the idiosyncrasies of an artist, a very specific conversation emerges. In the middle ground between Prince's quest for autonomy and the granular control and ease of recording offered by the LM-1, something catalyzed, changing both his aesthetic and workflow during a formative moment in his legendary career. What strikes me about the LM-1, when considered as a harbinger of the more recognizable drum machines that followed (the Roland 808, the SP-12, etc.), is the chasm between Linn's creation and its crude rhythm machine predecessors. To quote Warren Cann, in his LM-1 review for *Electronics & Music Maker*, "the Linn is so far ahead of anything else in its field at the moment that it's just not worth drawing

²¹ Linn's MPC60 design is as deserving of a platform studies-informed historicization as the LM-1.

comparisons.” Cann was savvy, and he incisively focused on the *programmability* of the device, stating that it would “breed new players and new techniques” (Cann 1981, 29). The “at your fingertips,” was the important part of the LM-1 marketing slogan, he argued.

As chronicled in detail by Paul Théberge (1997), the synthesizer industry that emerged in the 1970s and flourished in the 1980s ran on rails placed by another industry: electric organ manufacturers. Both the familiar form factor, and the primacy of the piano in the Western tradition, eased the burden of communicating the synthesizer’s abstract sound shaping paradigms in order to develop a market. There is no such legacy to point at when trying to triangulate between the users, technology, and economics of the programmable drum machine. The LM-1 and other black boxes like it emerged just after white, male, progressive rock drummers lorded over popular music, extolling a “primal, powerful, virtuosic, exhibitionist” style (Brennan 2020, 228). The gap between the larger-than-life bombast of a John Bonham and the gestureless, steady bass pulse of Kraftwerk, Giorgio Moroder, Run-DMC, or Prince, couldn’t be more pronounced. But Prince troubles that comparison because he arrived at the LM-1 not only an accomplished drummer, but an accomplished player of, well, *everything*. It follows that he brought his virtuosity to the LM-1 pads, but what did he take away from the device? That is the question I have attempted to answer here.

This chapter began with a vignette imagining Prince tapping out his first patterns on the LM-1—his hands poised over the console. Later, I drew attention to the time lapse by which both Prince and Linn lingered over the same surface, bringing their attention, care, and passion, meeting in a middle ground, between designer and user. Adopting Bardini and Horvath’s nomenclature, I positioned Prince

as the LM-1 “user to be,” a player that not only pushed at the edges of how a device could be used, but *how it could sound*.

Returning to the buttons, knobs, and sliders of LM-1 I am reminded of Paul Dourish’s observations about the arc of interaction design. He notes, “it has been a long transition from interaction with computers using a soldering iron to interacting using a mouse. It has been neither smooth nor planned” (2004, 13). He concludes that the “perceptions of the roles that computers will play in our lives” is hopelessly entangled in the materiality of circuits and the modalities of computation. In trying to encapsulate what Prince, as a proxy for musicians on a whole, took away from the LM-1 and the programmable drum machine writ large, I gesture to a 2009 fan argument about ‘what was the LM-1’ and ‘what was drummer Bobby P’ on Prince.org, an online fan forum. The user funkyhead started a thread titled “Help - Who Drums on Lets Go Crazy?” earnestly wondering who was responsible for the beat. A user promptly replied “...it was a live studio recording at the [First Street] Warehouse,” suggesting any LM-1 voices were triggered from drum hits. But then another replied, “On the *Purple Rain* tour, about all Bobby did was hit cymbals.” The truth is, both claims about where the duties of drummer, machine, and bandleader start and end are accurate.

Chapter Two: From the Factory Floor to the Studio

Saturday May 25th, 2001. The subterranean space is sufficiently bunker-like to warrant being called the ‘underground stage’; not much of the waning sun penetrates its depths. I’m in Detroit, under the shadow of the Renaissance Center—opened by Ford in 1977, usurped by General Motors two decades later—for the inaugural Detroit Electronic Music Festival (DEMF). Outside the bunker planted in Hart Plaza, the Isamu Noguchi-designed Horace E. Dodge and Son Memorial Fountain jets water: a metal superstructure over a granite pool with hundreds of lights accenting its textures and materials.

The matrix of purple specular reflections glinting off the curvature of an eccentric metal form feels on point, given that Warp Record experimentalists Autechre are about to play. There are about 2,000 people crammed into the cavernous space and a palatable *mood* courses through the room. Not just anticipation that the UK duo of Sean Booth and Rob Brown, who emerged in the early 1990s with melodies and timbres heavily informed by Detroit techno, are going to play a live set drawing from their challenging new record *Confield*. It feels like we’re on the cusp of a sea change for techno and electronic music.

On one hand, it’s thrilling to be in Detroit: Motor City finally grants its homegrown techno producers the heroes’ welcome they deserve. Detroit producers have been getting accolades worldwide since the late 1980s—but now they finally get to headline a city-wide festival stateside. Autechre are just one act in a ‘who’s who’ roster of global electronic musicians, many inventors and innovators in their own right, including Laurent Garnier, Carl Cox, LTJ Bukem, and Jazzanova here to pay homage to Detroit. More than a million people are expected over the course of

the weekend and Ford even signed on as sponsors. Is the cold shoulder North Americans have long given to electronic music finally beginning to thaw?

Autechre opens with a long, wavering tone. It's only semi-audible over the sustained cheering. Fluttering hi-hats and an ominous bass growl, then a rich synth line is added to the mix—doused in delay and distortion. The crowd moves with the bass and Autechre does what they do best: explode song structure, fire complex percussion salvos, timestretch samples beyond recognition. Generally, the soundscape gestures forward into a speculative future—obtuse synth abstraction, otherworldly textures. But *every so often* a rudimentary beat drops into the mix for a few bars that is straight out of a 1980s Einstürzende Neubauten or Mantronix B-side. As quickly as the reference for old school heads appears, it's gone.

While weaving through the crowd, I happen upon a pocket of middle-aged Latino and Black men who are stop-start gliding across the dance floor. Elder breakdancers with salt and pepper stubble, their tracksuits and vintage kicks most definitely not of this decade. They pop, lock, and machinate, humanize the jagged timbres, seamlessly processing complex rhythms in real time.

Autechre in Detroit. Techno in Hart Plaza. That crowd. I don't think I was being idealistic at the time when I felt Detroit is finally acknowledging the genre it inspired: its progeny. Those breakdancers weren't just moving in the moment, they were transmitting decades of embodied knowledge. Like Morse code, each forearm hit and chest pop spelled out entire rhythm and drum pattern genealogies, each freeze dot-dashed vitae of past dance floors traversed, EPs absorbed. Watching their (seemingly) effortless movements—they were chewing up and spitting out everything Autechre was throwing at them—a combination of confirmation bias and youthful bluster led me to believe DEMF marked techno's *arrival*. I was dead wrong.

By the turn of the millennium, journalists and critics had been heralding electronic music as the next big thing for two decades. The incorporation of new technologies and equipment (both high-end and mid-low end) into 1980s studios impacted composition and arrangement techniques so much that new forms (e.g. the widespread propagation of the 12" remix) and genres emerged (Bennett 2019, 53). The UK acid house craze that ignited the Second Summer of Love in 1988 is one such narrative arc; and the rave scene that followed it provided a template for nightlife and electronic music appreciation that could be replicated in cities worldwide. What started in warehouses moved to clubs, and at DEMF I assumed that, because Detroit techno was positioned near the centre of electronic dance music's cambrian explosion, its place was assured. But unlike Motown, Detroit's most famous musical export, techno is nebulous and inscrutable—it had a complicated relationship with recognition and recognizability from day one. In contrast, Motown remains firmly lodged in middle class consciousness, providing aural wallpaper for brunches and insurance ads, forever asserting an idyllic vision of Black identity and prosperity in service of a "crossover agenda" (Flory 2017). Detroit's musical legacy has been further sustained by the intensely precise but *seemingly* loose-sampled rhythms of J Dilla, providing a blueprint for new rhythmic configurations in beat music, rap, and commercial pop writ large (Charnas 2022). Detroit techno never permeated public consciousness in the same way. The question of whether it was forgotten, erased, or simply obsolesced is my focus here.

In the following pages I will trace shifts in music production between 1982 and 1995. That span covers the 1978-1985 timeline that bounds *most* of this thesis, but here the discussion extends into the 1990s. Focusing on one city, one genre, and one musician—Detroit techno, Juan Atkins—I will map genre formation within

techno, how new music technology facilitates those developments, and the evolution of listening to and distributing independent electronic music. Given my broader focus on drum machines, the emphasis on rhythm and the meticulous sound design of percussion voices in techno makes it a productive case study; and compared to adjacent genres like rap and disco, it remains underexamined.

My analysis centres Detroit techno, a driving form of Black American electronic dance music. The ‘Detroit’ in Detroit techno is important because that particular metropolitan area is not only a defined geographic area but an *aura* that permeates electronic dance music, even if that presence is indiscernible to many contemporary listeners. Featuring a four-on-the-floor rhythm similar to house, techno’s affective and aesthetic sensibilities are wildly different from 1980s dance music made in New York and Chicago. House is warm, jubilant, and affirming; techno is often cold, dispassionate, and leans into the dehumanizing aspects of technology. Both genres share funk as an ancestor and animating force, but there the similarities end. As noted by Atkins’ collaborator, Derrick May, “house still has its heart in 70s disco, we don’t have any of that respect for the past, it’s strictly future music” (Cosgrove 1988).

The ‘strictly future music’ part of May’s claim did and continues to do a lot of heavy lifting. For better and worse, the rhetoric of futurity has encircled and perhaps ensnared Detroit techno since its inception. As a city, Detroit is also tied to technological progress—or at least it used to be. During the first half of the twentieth century, the city experienced an economic renaissance that accompanied the rapid growth of the American auto industry. Cars rolled off Ford, General Motors, and Chrysler assembly lines, and because of gains made by the labour movement, many of the very workers who sweated to assemble those vehicles also snapped them up.

Seemingly a virtuous cycle, like many fables about prosperity and upward mobility, the gains were not evenly distributed across racial lines. When the boom ended by the 1970s, all that remained was strife, segregation, and a growing population of workers displaced by increasing automation and decreasing profits. The writing was on the wall long before simmering tensions about housing segregation, racist policing, and (lack of) economic opportunity boiled over in the 1967 riots. In a few short decades, Detroit went from being the city that was emblematic of *the future* of production to a stinging reminder of how much it had fallen short. Both Detroit (as a city) and techno (as a genre) pose a vexing question about the passage of time: what happens when an expected shiny future—prosperity, equality—never arrives?

I could focus on any of a few dozen Detroit techno musicians, but I centre Juan Atkins. This analysis could just as easily scrutinize the signature moody strings of releases on Derrick May's Transmat imprint to tell techno's story. Or decode Underground Resistance—a mostly anonymous collective of musicians that pushed back hard against the commodification of electronic music in the early 1990s. Or chronicle Detroit's preeminent globetrotting DJ Jeff Mills, who has served as an ambassador for techno on dance floors worldwide and become an avatar for futurity in his own right. I centre Atkins because he was as close to a 'first' techno musician as there is. His recordings in the electro rock duo (later trio) Cybotron pre-date techno; their 1983 album *Enter* roughed out moods and motifs that later producers would build on. After leaving the group in 1985, Atkins, Derrick May, and Kevin Saunderson began releasing singles on their respective labels. Their collective efforts with these 1985-88 singles would be later recognized as the first techno records, but unlike May and Saunderson, Atkins would later try to reconcile techno's

association with the single/EP with the album format.²² Second, I centre Atkins because the notions of futurity so central to the genre emanate from him. Indeed, Cybotron was ground zero for techno's central aesthetic preoccupation of futurity.

In analyzing Atkins and May's dubious claim that techno is "strictly future music" I draw on sources ranging from popular music studies, political economy, Black and labour studies, and histories of Detroit. The American futurist Alvin Toffler is important to any history of the genre because early techno producers framed themselves with rhetoric that echoed Toffler's 'techno rebel' figure. Taken from Toffler's *The Third Wave* (1981 [1980]), the phrase describes pragmatic early adopters of emerging technologies who are "neither bomb throwers nor luddites" and asking "hard questions about the kind of future they want" (150-1). Toffler positions techno rebels as "agents" of a third cultural revolution (the shift to knowledge work), which was displacing the 'second wave' (industrialization). Atkins' appropriations and transformations of the techno rebel archetype became a dominant frame for understanding the genre in the 1990s when they were adopted by the European music press. They were also more seriously analyzed by music writers including Kodo Eshun, Simon Reynolds, Dan Sicko, and Ben Williams.

A number of theorists inform my analysis of techno's founding mythology. Svetlana Boym's *The Future of Nostalgia* (2001) was an invaluable counterpoint to the Toffleresque futurity rhetoric that is so prominent in scholarship and journalism about techno. In encapsulating pertinent Detroit history, I use a simple framing mechanism proposed by Mark Jay and Philip Conklin in their monograph, *A People's History of Detroit* (2020), and Katherine McKittrick's "Plantation Futures" (2013) helped me read the city as spatialized trauma. Beyond these sources, I draw from

²² This is a contestable claim as Kevin Saunderson's group Inner City *did* release influential albums (see *Big Fun / Paradise* (1988)). However, they were squarely house music, not techno.

economic and labour histories of Detroit and the West by Daniel J. Clark (2018) and Christopher Frey (2019) to reconcile how shifts in economic production played out in Michigan, and the work of Koichi Iwabuchi (2002) and Andrew McKeivitt (2017) was invaluable in understanding the role Japan played in globalization.

The above sources inform my threading of Detroit's economic decline and synchronous emergence and 'rise' of techno. That the genre took root as the auto industry cratered is notable. Deemed the 'Belleville Three' for their suburban origins, techno originators Atkins, May, and Saunderson contributed to and drew from a vibrant local party scene with a soundtrack of American funk, R&B, new wave, and British synth pop and italo disco, fusing those sounds and their divergences of race and geography to create a new form of dance music. Much of the novelty in their sound was inspired by and responding to the central role of automation in Detroit—an automation that ultimately displaced rather than liberated workers.

Drawing on this central thread of automation, I will conduct close readings of Juan Atkins' discography between 1982 and 1995 to map the emergence and evolution of techno. I examine songs from his self-released debut singles and 1982 Cybotron album *Enter* (with Rik '3070' Davis); the 1985-6 releases on his Metroplex imprint, which are recognized as canonizing Techno's preoccupation with futurity, urban decline, and its central 4/4 beat convention (Sicko 1999; Williams 2001); his contribution to the 1988 Virgin Records compilation *Techno! The New Dance Sound of Detroit*; and Atkins' first solo album, *Deep Space*, released in 1995, which underscored both homegrown and transatlantic alliances. Within this twelve-year window, techno emerged, sustained the careers of a local network of Detroit producers, and served as a touchstone for European electronic music production, and became a part of the global electronic music economy it helped inspire. Within

these close readings, I pay particular attention to the places where rhetorics of futurity emerge, and how they morph and transform in later reiterations. I also examine the liner notes to *Techno! The New Dance Sound of Detroit*, which have had an outsized influence on the framing of the genre.

Finally, I analyze how Atkins' mode of studio production and releasing music evolved during this time period. This involves tracing the transition from his early work in an ensemble releasing through a label, to shifting into releasing vinyl EPs on his own label, to the debut solo album he released on the European R&S Records in 1995.



Fig.xii Juan Atkins in his studio (photo: Matthew Vosburg for *Music Technology* Dec 1988)

P-Funk Meets Data Processing

Juan Atkins was born in Detroit in 1962 (Fig.xii). The son of a concert promoter for soul and jazz acts, including Barry White and Norman Connors, Atkins spent his pre-teen years with “a bass guitar more or less permanently slung around his neck” (Brewster and Broughton 2011, 299) in the rhythm section of a funk garage band. After getting into trouble in his early teens, Atkins moved to the predominantly white suburban community of Belleville to live with his father in the mid-1970s.

Suddenly isolated, introspective Atkins ratcheted up his voracious consumption of science fiction novels and film. He also gravitated toward musicians exploring Black futurity, honing in on the sonic fluidity of Parliament-Funkadelic. Noting that their “double band” structure allowed the ensemble to foreground a horn sound in one configuration and guitar solos in another, Atkins made a mental note to cultivate the same flexibility in the band he would form one day (Shallcross 1997, 19). Misinterpreting liner notes to a Giorgio Moroder album, Atkins thought he needed to learn data processing to sequence electronic music (Williams 2001, 157). The wildly incorrect assumption inspired him to enrol in a high school ‘future studies’ course where he learned about American futurist Alvin Toffler, whose *The Third Wave* (1970) had sold millions. The book evangelized for a nascent post-industrial economy, animated by a “techno-rebel” class, who were simultaneously elite technocrats and advocates for more sustainable and equitable futures (149-54). Atkins went all-in on Toffler’s vision not only as an ideology but also as a framework for sonic aesthetics. Mentored by queer dance floor mainstay DJ Ken Collier, he and peer Derrick May formed Deep Space, a “conceptual disco” DJ unit that reigned over Belleville’s high school party scene circa 1980 (Sicko 1999 [2010], 32).



Fig.xiii The Korg MS-10

In 1980 Atkins bought his first synthesizer, the Korg MS-10 (Fig.xiii). The little black box would become synonymous with heavy sub bass and gnarly screaming leads. A paragon of simplicity, the MS-10 had one oscillator, one envelope generator, a lowpass filter, and modular functionality for signal routing. Atkins learned synthesis fundamentals on it and was composing entire tracks with it in no time, embracing the limitation of bouncing EQ'd recordings of individual lead and white- and pink-noise-derived drum voices on a pair of Kenwood cassette decks (Trask 1988, 39).

Once he completed high school, Atkins' geographic range expanded: Deep Space made inroads in Detroit's party scene while he studied at Washtenaw Community College. There, he met Richard '3070' Davis, a "reserved, isolated, weird" (Gray 1992, 35) Vietnam veteran ten years his senior, whose wartime and subsequent Veterans Health Administration system experiences engendered a deep cynicism toward American imperialism.²³ Davis was the *right kind* of weird: a fellow Toffler acolyte with an interest in electronic music, he had a well-outfitted studio with kit including an ARP Odyssey, the Boss DR55 Dr. Rhythm drum machine, and a Roland RS09 string machine. Atkins' played Davis some of his early demos and a collaboration ensued. The pair developed a Toffleresque lexicon of futuristic ideas and one of their portmanteaus yielded a moniker: Cybotron—cyborg combined with cyclotron (Reynolds 2013 [1998], 9).

Cybotron's debut, "Alleys of Your Mind," was self-released as a 7" single on the duo's Deep Space records in 1981. The titular single juxtaposes a phat funk bassline with morose robotic vocals about being cerebrally out of sorts: "*alleys of*

²³ Beyond distrusting the establishment, Rik Davis found equal lack of solace in counterculture. Returning to the U.S. in 1969 he was revulsed when "I saw the hippies and the Beach Boys side with their friend Charles Manson" a hypocrisy that left him feeling "everything I had been taught or believed was just a ridiculous lie" (Rubin 2016).

your mind / paranoia right behind / alleys of your mind / out of sync, out of rhyme.”

While dour and plodding, the funk-new wave fusion was noteworthy. They’d taken Gary Numan metallic sheen and undergirded it with basslines drawing from the George Clinton-Zapp continuum.²⁴ The B-side “Cosmic Raindance” was innovative as well, layering swelling, expressive keys over a simple and infectious rhythm consisting of a diminutive kick, characterful noise snare, and descending bassline. The duo followed with another 7”, “Cosmic Cars,” in 1982, which layers a plink-plonk central synth line with austere strings, a bubbling secondary synth line, and tongue-in-cheek lyrics about space cars. Again, the B-side shines, with Davis delivering an angsty screed about conformity, snarling, *“life is a line, take a number ... take your place”* under electric guitar riffs contributed by John ‘Jon 5’ Housely.²⁵ With support from legendary local tastemaker WJLB radio DJ Electrifying Mojo in Detroit, “Cosmic Cars” became a regional hit—Cybotron sold 25,000 copies. The buzz attracted Fantasy records, which signed the group to an album deal.

Their debut *Enter* followed in 1983, combining the songs from the two singles and five new tracks. Liberally mixing synth pop, new wave, and prog rock influences, it presented a bold, if uneven vision, marked by experimental synth sounds, electro rhythms, sleek futurism, and sociopolitical commentary. Outside of techno and electro histories, *Enter* is eclipsed by its lead single “Clear” in which Atkins and Davis offered their most lucid vision yet of the futurity they had been formulating in “Alleys of your Mind” and “Cosmic Cars.” Affectively, the mood on the earlier songs was,

²⁴ Released by Detroit producers in 1981 within weeks of each other, whether Cybotron’s “Alleys of Your Mind” or A Number of Names’ “Sharevari” was the ‘first’ techno track has been the subject of debate. Regardless of provenance, Dan Sicko was pragmatic when noting it was the latter that had more impact on the high school party scene Deep Space was active in (1999 [2010], 28).

²⁵ A late addition to Cybotron, the fact John Housley was white complicates the image of the band as a Black act. Famously, when Cybotron first got on the Detroit Airwaves local listeners assumed they were white and European (Reynolds [1998] 2013, 9). Atkins was never particularly interested in dwelling on race within Cybotron, stating that he and Davis “knew we were Black ... [and] in America. There was nothing to talk about, those were our circumstances” (Brewster and Broughton 2011, 302).

respectively, dreary and sophomoric, but the ascending tones and sleek textures of “Clear” were iconic—and its rigid electro beat moved the dance floor.

“*Ready, one-two-three-four.*” A count-in followed by a dramatic white noise swoosh. A moody string stab sounds as a punchy and calibrated electro beat kicks in. And then two synth lines for the ages: a textured staccato bassline and shimmering ascending tones. The mix lives up to the song’s titular promise.

The drums on “Clear” were programmed with what Atkins would proudly describe decades later as “the first 808 in Michigan” (Metlay and Reid 2022, 23). Curiously, he and Davis did *not* take advantage of the resonant kick for which the Roland TR-808 came to be revered. The kick in “Clear” is precise, not overstated—a steep attack, not much decay; the noise snare has more presence in the mix—a much longer decay; and there’s a skittering closed hi-hat pattern in the background. Atkins collects dividends on the hours he spent bouncing individual drum voices and mixing frequencies on his cassette decks.

The central synth line is an ascending arpeggio. Its delicate tones shimmer, while it flutters upward endlessly. A decade later, Europeans would be fascinated by how Detroit techno’s moody strings and synth lines encapsulated grit, futurity, and hope. The kernel of it all, and that central affective quality, originates in this simple infectious arpeggio. In bridge sequences ascending chords are added and amp up the drama. The disaffected “Clear” utterance that sounds regularly is spoken by Rik Davis. Its monotone, processed enough to sound unhuman, and choruses are a call and response sequence between a pair of pitch-shifted versions of his voice: “*clear all this space (clear all this space) / clear today (clear today) clear your mind (clear your mind) / clear (clear) behind*” A great reset is implied—removal, renewal, and agency, and this gesture is—irony of all ironies—opaquely described. Is it urban

renewal or just some random access memory getting wiped? The listener must draw their own conclusions about what year zero entails.

A streamlined remix of “Clear” by Jose ‘Animal’ Diaz became a top 20 hit on Billboard’s Black Singles chart, airing nationally. While the lead single’s “bass-driven, stripped-down groove that relied on grating textures and an air of abstract menace” (Williams 2001, 157) innovated and gained attention for the duo, tensions between Atkins and Davis came to a head. The gap between “Clear” and its B-side “Industrial Lies” signalled a growing rift between the collaborators. Atkins wanted to lean into futurity, and discard Jon 5 and the rock overtures; Davis wanted to foreground social commentary and felt constrained by focusing on the dance floor (Rubin 2016).

Although the duo split up in 1985, their preoccupations with Toffleresque futurity continued to resonate in both Atkins’ solo work, and that of collaborators May and Saunderson. In the following decade this rhetoric was adopted by music journalists and scholars including Reynolds, Eshun, Sicko, and Williams in their contrasting efforts to encapsulate techno’s origin story in the 1990s and early 2000s. Reynolds describes Detroit techno musicians as “rejecting luddite strategies” and using electronic and digital instruments as sites of “empowerment and resistance” against the corporatism that spawned them (2013 [1998], 11)²⁶; Sicko called his monograph *Techno Rebels* (1999), embracing the rebellion nomenclature, but, curiously, downplayed the techno-futurity rhetoric, instead offering a libertarian reading of the genre as having “less to do with futurism ... than with the power of individual and personal visions of utopia” (11).

The most sophisticated integration of Toffler’s ideas into techno’s generic framing can be found in Williams’ “Black Secret Technology” (2001), where he

²⁶ DeForrest Brown Jr. picks up on this thread in his 2022 monograph, describing how Atkins and company innovate sonically without being “restricted or defined” by their kit (2019).

deploys some of the futurist's more astute predictions to situate the political economy of the Detroit auto industry. He uses Toffler's anticipation of knowledge work and telecommuting to contextualize "new forms of global outsourcing" as the undoing of Detroit's "heavily localized market" (157). Williams also uses the techno rebel figure to position the Underground Resistance production crew (who received wide recognition in the early 1990s) as extending Atkins' "fascination with Toffler's *Third Wave* one step further" and looking beyond Detroit's flailing industrial productivity to recast the city as "an alternate Silicon Valley in which the robots have downed their tools at the conveyor belts, taken to the datawaves, and begun transmitting communiques of subversion worldwide" (167).

Notably, Eshun ignores Toffler's rhetoric when speaking of the Belleville Three. Arguing for an expansive sonic fiction—Black worldbuilding—Eshun offers an idiosyncratic nomenclature for how techno *works* and what it *does* to bodies.²⁷ He describes how Motor City producers listened with an "import ear," reappropriating the sound design and affective tenor of Kraftwerk and British new wave toward new ends, and explains how techno, acid house, leftfield, and other genres interlock into a "futurerhythmmachine" propelling Black aesthetics forward into the twenty-first century, escaping nostalgia for 1970s soul (1998, 101-3).

The Paranoid Style in American Techno: "No UFO's" & "Future"

In the aftermath of the Cybotron split, Atkins unsuccessfully sought an American label to release his debut solo single. Fantasy records didn't bite—the short-lived electro moment had already passed. Given the lack of interest, Atkins

²⁷ *More Brilliant Than the Sun* (1998) is full of gestures toward posthuman Black embodiment, bubbling up from the aesthetics of the artists Eshun proselytizes. He frames house in post-Cyberpunk terms as a "neurocircuit" (98), the drum kit is replaced by "a push-button percussionist who taps ENTER" (105), and Underground Resistance are described as "a Roland symbiont that uses 303s to heal ... [and] investigates synthetic sound as a lifeform" (125).

self-released “No UFO's” on his own Metroplex imprint in 1985. He later described the label mandate as a “continuation of the more funk, bass, electro-bass tracks” (Brewster and Broughton 2011, 302) from the Cybotron sound. If “Clear” blueprinted techno’s affect and aesthetics, his debut solo single broke ground and began construction.

A white noise swoosh fires and dissipates, followed by a steady kick drum beat and syncopated cowbells. A busy medium tom pattern triggers with heavy handclaps demarcating the backbeat, a rubber bassline and delicate strings fill out the mix. *“Told me it was alright / you said I should not fear / things you haven’t seen before / are coming very near.”* A paranoid Atkins sings about unknown threats. He deadpans a chorus: *“They say there is no hope / they say no UFOs / why is no head hung high / maybe you’ll see them fly.”* The glib delivery is accompanied by a wavering synth line. It bridges into several 8 bar sequences with complex tom breakdowns, some interspersed with chopped up and scrambled phonemes—word salad—from the chorus vocalizations.

In “No UFO’s” Atkins kept Cybotron’s gnarly synth- and basslines, but he dramatically pared back the song structure and discarded the kick-snare electro rhythm, replacing it with a more steadfast four-on-the-floor beat. The song’s drum programming, with its dead simple kick pattern, cascading breakdowns, and exemplary use of the Roland TR-909’s industrial-strength sonic palette, would later be recognized as establishing techno’s central 4/4 beat convention (Sicko 1999 [2010]; Williams 2001). Atkins fully channels Detroit’s guiding assembly line logic into a new sonic aesthetic here. The kick is a chassis on which tom and hi hat patterns are affixed,²⁸ around which the rubber bass, harmonic accents, and permutations of

²⁸ For maximum appreciation of “No UFO's” close listening of the alternate instrumental mix is essential. With the vocal lines and chorus removed you can get a sense of how much is going on in the mix, and how effectively the varied patterns interlock with and overlay one another.

the vocal mix are moulded. The frenetic switching between dense percussion patterns signals the labour of the 909's perennial unseen operator. A pair of disembodied hands *working* the control panel, locking parameters, prototyping an entirely new form of dance music ready-made for mass production in the process.

"They analyze and test us / I hope they do not catch us." Affectively, "No UFO's" does not align with the 'the truth is out there' credo that kept *X-Files* FBI agent Fox Mulder searching for extraterrestrials throughout the 1990s; Atkins evokes the same conspiratorial forces and kept-in-the-dark public, but where is the *there* in his scepticism? Is it cryptic patterns that appeared in a midwestern cornfield, or a streak of light over the I-95? In "Alleys of your Mind" the paranoia was right behind, suddenly it was hovering above.

Ironically, it was the vibrant club scene of a neighbouring city that helped put "No UFO's" on the map in the Northeast. Derrick May delivered an early pressing to DJ Farley Jackmaster Funk, who "made it the biggest record in Chicago" (Brewster and Broughton 2011, 303) when he put Atkins in heavy rotation at the Warehouse. The song glistened with the same futurist sheen, but it was more "streamlined and austere" than Cybotron (Reynolds 2013 [1998], 12). It also moved the crowd in a way that his (mostly) album-oriented former project could not. Atkins had found a formula that worked on one of the world's most pedigreed dance floors—one of the sites where house music was born—and would continue to refine it for the next decade; a generation later a panel of local music journalists listed "No UFO's" as number 18 on a list of the 100 greatest Detroit songs framing it as "Grandmaster Flash, Prince and Depeche Mode reimaged, retooled and compressed" (2007).

"No UFO's" B-side was also noteworthy. On "Future," Atkins reassumed the role of Toffler's harbinger, providing a litany of electronic gadget, media formats, and

industrial progress. *“Techno revolution / and fast technology / enter a computer / robotic factories.”* Atkins’ voice is once again heavily processed, similar to the “No UFO” chorus. If that tone was flip and cynical, here the affect is dire. *“Pocket calculators and TV sets / remote control and microcassettes.”* Rappers in the 1980s used rhymes to map local geographies, share street knowledge, and playfully spar—Atkins lists consumer electronics inventory. A milieu of cathode-ray tubes, spooled tape, and infrared transmissions; the domain of Sony and Memorex. There is no sense of loss or fading tradition, the tape travel direction only turns forward.

The lyrics in “Future” suggest grim inevitability, but Atkins’ sound design is less convincing. Beyond the bassline (a gem, even for Atkins) and driving kick, the percussion voices are janky. A blocky handclap thuds on the back beat, and a whirring sound fires every four bars, lingering in delay trails; the latter conspicuously resembling a piston slap, the noise an engine emits when a piston rocks back and forth when its motion should be strictly vertical. Later in the track a noise snare fizzles, synths squelch, and an instrumental outro breaks down in total malfunction. While the vocals intone, *“changes all around us / the future is here,”* the sound design hints that rollout is not going so smoothly.

Three Ways to Talk About Detroit

From its inception as a New France fur trading post in the early eighteenth century, Detroit has been synonymous with extractive racial capitalism and emancipatory desires. A destination for settlers and migrants, Detroit was integral to the underground railroad, serving as a ‘free state’ destination for northward-bound runaway slaves and a stopover for journeys ending in Southern Ontario. Between 1850 and 1890 the industrial base in the city developed, establishing itself as a Great

Lakes transportation hub and leading manufacturer of pharmaceuticals and tobacco. Arguably, more than any other American city, Detroit has benefitted from (and then suffered because of) automation.

In 1913, Henry Ford's Highland Park auto factory implemented the first assembly line. It streamlined production, and the competitive edge it granted sparked the meteoric rise of the American auto industry. Post-depression frustrations with income inequality and a major shift in labour from agriculture to manufacturing spurred the emergence of the United Auto Workers (UAW), a worker's movement enabled by thousands of wildcat and 'sit down' strikes that halted mid-1930s production, allowing workers to engage in collective bargaining. During the Second World War, Ford and its competitors were integral to Roosevelt's "Great Arsenal Democracy," with Detroit automakers halting car manufacturing between 1942 and 1945 to focus on armament production, with the wartime effort adding 17 million jobs to the economy (Jay and Conklin 2020, 96). The productivity boom continued in the postwar years, with the automobile becoming a key commodity as America "moved to articulate production and consumption in a Fordist shape" (Gilroy 2010, 36).

In response to Detroit's surging productivity, the UAW successfully negotiated for higher wages, forging paths of upward mobility for blue collar workers and expanding America's middle class. During the 1950s and 1960s, the so-called 'golden years' of industrial growth and rising wages, automakers began divesting from Detroit as a base of operations. Between 1947 and 1958, the Big Three opened 23 plants across suburban Michigan—none in Detroit—attracted by "cheap land, low taxes, business-friendly governments, and a relatively docile workforce" (Jay and Conklin 2020, 119). Setting the stage for white flight, this divestment eroded both Detroit's tax base and the UAW's bargaining power. The reliance on the auto

industry that had pumped up Detroit's economy now deflated it, leaving the city centre gutted—or so the story goes.

In *A People's History of Detroit* (2020), Mark Jay and Philip Conklin posit that mythology and creative destruction are productive framing mechanisms for Detroit history. The two forces are at play in the above historical sketch, and we can see how, in tandem, they can be combined to weave the *types* of story that are often told about the city: a spark of industrial innovation, unprecedented economic growth, a fall from grace, and the need to rebuild. This arc looms large in the biographical and generic narratives of the Belleville Three as well, and the waves of techno producers that followed.

Inspired by Jay and Conklin's methods I will present three vignettes of Detroit history that feature these two forces as organizing principles. While doing so I will draw on histories from economists, social geographers, labour theorists, and Black studies scholars. My aim is to characterize the themes that figure prominently in discourse about techno: Detroit as an economic and social failure—a city in need of a comeback, the factory as a site where notions of automation and economic progress were fostered, and the worker as a *subject* of automation. I will then develop these three vignettes in a discussion of automation theory.

1. The Persistent 'Comeback' Narrative

In the introduction to his monograph on his native city, Jerry Herron describes Detroit as “a place where bad times get sent to make them belong to someone else” (1993, 9). This notion of the city as ‘down and out’ aligns with 1980s assessments of the city up to its recent gentrification. Detroit's desire (and need) for a ‘comeback’ was forged in the auto industry in the decade following the 1980-1 recession

because American automakers weren't *just* blindsided by stagflation, they were out marketed, out manufactured, and *out manoeuvred* by Japanese competitors.

Ingeniously countering protectionist tariffs by setting up shop stateside, Honda announced a pilot project to manufacture motorcycles in Ohio in 1979. A success, they scaled up operations and opened the Marysville Auto Plant (MAP) in 1982, bringing 10,000 jobs to the struggling rustbelt, and capturing hearts and minds; photographs of the midwestern workforce were soon used in national campaigns to market the cars to Americans, forever muddying the waters of 'buy American' protectionism (McKevitt 2017, 90-2). These 'transplants' and the daunting sectoral layoffs set the stage for GM's 1983 mission statement of "reorganization, diversification, reindustrialization, or automation" (Ingrassia and White 1995, 73), sloganeering that would later be echoed in Detroit redevelopment efforts.

By the 1990s, after decades of divestment, the post-industrial urban design toolkit of "financial incentives, branding campaigns, and physical redevelopment" cynically swapped social democracy for corporate welfare (Neumann 2016, 2-3). Seeding its twenty-first-century gentrification, Detroit was framed as "a blank slate" where billionaire developers like Mike Ilitch and Dan Gilbert were lauded for "building something where there was nothing" (Jay and Conklin 2020, 40). Detroit's comeback narrative nostalgically dwells on the memories of mid-century prosperity and the economic losses caused by the city's deindustrialization. More recently, it had a second wind following the Great Recession in 2008, when (bleakly) the city became a 'destination' for tech startups, social entrepreneurs, and those looking to buy cheap foreclosed homes.

2. The Factory Produced the Middle Class

Factories are spatial manifestations of labour. First emerging to facilitate textile and cotton production in the eighteenth century, electrification sparked a new class of factories that became the engines of the Second Industrial Revolution. It was Ford's Highland Park facility where the moving assembly line was first implemented in 1913, and the diffusion of electricity enabled numerous innovations: motors (precision machining of parts), electric craneways (loading), lights (greater visibility), and fans (better ventilation). Between 1913 and 1914 the assembly time for a Model T dropped from 12 hours total labour to 1.5 (Frey 2019, 151).

Friedrich Winslow Taylor's analysis of embodied labour as a series of sequential gestures to be "optimized, reprogrammed, distributed, and otherwise mediated" (Liu 2008, 224) also created a *new* worker. In the first half of the eighteenth century, a worker might build an entire widget from scratch, with years of training and a toolkit at their disposal; labourers in the twentieth century performed piecemeal tasks with nominal training and limited discretion about *how* they work. The drudgery of repetitive labour had an immediate deleterious effect on workers, and Ford had to hire 52,000 workers to maintain Highland Park's required workforce of 14,000 (Alpern 1979, 6). The much-lauded \$5 workday Ford introduced in 1914, "widely considered as the moment the manufacturing middle class was born" (Jay and Conklin 2020, 81), was about mitigating turnover.

Economists tell a rosier story about labour in the first half of the twentieth century than labour activists. Simon Kuznets' eponymous ratio measures the percent of income going to the highest-earning households—income inequality. When he first put his theory forward in *American Economic Review* in 1955, he used it to elegantly demonstrate the steep falloff in inequality from the depression into the 1950s,

extrapolating that industrialization created a middle class. This rhetoric took hold in both mid-century economics and the popular imagination at the same time that ‘automation’ as a term began to displace ‘technological unemployment’ (Frey 2019, 180). Kuznets’ correlation *seemed* correct for forty years, until the trifecta of deskilling due to robotization, manufacturing jobs moving overseas, and neoliberal architects like Ronald Reagan and Margaret Thatcher set to work dismantling workers’ rights.

3. The Worker as Subject of Automation

Returning to earth from the dispassionate helicopter view enjoyed by economists, the worker’s perspective on automation is more conflicted. Yes, in hindsight the 1950s and ’60s can be framed as a period where a significant number of blue collar workers (at least if they were white men) obtained the American dream—a nuclear family, a home, a car, job security, a pension—but as observed by historian Daniel J. Clark, “people who worked in auto plants did not live their lives as aggregate statistics or in hindsight” (2018, 11). To embattled 1980s autoworkers, the jobs lost to Japan weren’t coming back, and those that remained were threatened by robotization. GM executives vowed to “automate away from those assholes” in their dramatic 1983 reorganization, pouring \$70 billion into robots and retooling (Ingrassia and White 1994, 33). Ostensibly ‘the assholes’ were the Japanese, but they could just as easily have been cursing the UAW.

For decades, the UAW and automakers shared a mutual optimism that workers and automation could complement one another. The story of automation in the 1950s and 1960s, auto manufacturing’s ‘golden age,’ was one of *enabling* technologies, machines and processes that “make people more productive in

existing tasks” versus replacing technologies that “make jobs and skills redundant” (Frey 2019, 13). One of the biggest proponents of this vision was UAW President Walter P. Reuther, who was quoted in the obituary that marked his untimely death in a 1970 plane crash as predicting “in the future, an auto worker may work only 10 hours at the factory. Culture will become his main preoccupation. Working for a living will be sort of a hobby” (Stetson 1970, 34).

Reuther never lived to see the oil crisis, stagflation, the trade deficit, offshoring, mass layoffs, or U.S. manufacturers mount a (doomed) technological arms race with the Japanese in the 1980s. However, he was prescient about one outcome of labour being tasked to robotic arms and their ilk. In a 1954 factory tour, a manager proudly pointed to new machinery and jokingly asked Reuther, “How are you going to collect union dues from these guys?” Without skipping a beat Reuther answered, “How are you going to get them to buy Fords?” (38).

Techno! The *New Sound of Detroit*?

“Night Drive (Thru-Babylon),” the second release on Metroplex, came out in late 1985. In it, Atkins’ stream-of-consciousness narrates a nocturnal cruise through a tech-noir cityscape; driving with a heavy foot, he gloats that he’s “*tempting fate a little bit.*” Laser toms and the vocoded phrase: “*TIME SPACE TRANSMAT*” cuts through the mix over a punchy electro rhythm and sinister bassline.

A collage of surface and reflection, rubber and asphalt, the figure of the car is central. Whereas jeep beats and slab culture evoke material culture and identity in rap—Kraftwerk’s autobahn was resolutely idyllic—in techno, driving is fraught with tension. From the perspective of the Detroit resident with a memory, shouldn’t it be? The only things the roads out of the city led to were suburban communities like

Pontiac and Flint where manufacturing jobs were relocated. Both automakers and white middle class residents had abandoned Detroit long before the 1967 uprisings.

While “Night Drive (Thru-Babylon)” can be framed as a parable about the exodus of capital from Detroit’s city centre, the song’s enduring resonance lies in the way it captures the resulting bleakness. The world it describes is mostly in the rearview mirror. Atkins’ stream-of-consciousness account of “*contemplating contemptuously, the inferior designs / and the outmoded, underpowered*” is also saying the quiet part out loud about eugenics, Social Darwinism, and technological progress. The desolation described here echoes “Cosmic Cars,” in which he lamented, “*I wish I could escape from this crazy place / fantasy or dream, I’ll take anything.*” In “Night Drive (Thru-Babylon),” Atkins expanded on this framing of Detroit as a *non*-place, with its best years behind it, describing it as “decaying like an ancient city in Europe.” (Ferguson 2010).

Channelling Toni Morrison, Katherine McKittrick describes plantations as “a space that everybody runs from but nobody stops talking about” (2013, 10). In “Plantation Futures” she grapples with how Black descendants of slavery must carry the burden of enslavement without being crushed by it. She describes the antagonist colonial impulse as seeing land with amnesiac eyes, as “‘nowhere’ and inhabited by ‘no one’” (6). And this is how we might frame post-divestment Detroit: a landscape of abandonment. This is not a denigration of the (largely Black) populace that remained after white flight, but an *acknowledgement* of the indifference that capital (and capitalists) exhibited toward them.²⁹

²⁹ My argument is more focused on notions of futurity and production norms than local geographies and community resilience. For a contemporary critical geography reading coming *from* Detroit, see Dora Appel’s incisive analysis of the city’s techno producers as “preserving community in the face of corporate gentrification and land speculation” (2021, 101).

“Night Drive (Thru-Babylon)” ends with Atkins catching a distorted glimpse of himself in the mirror sunglasses of a woman on the street. What aspects of Detroit does the song reflect back to the listener? When scrying its distortions, we might heed the warning of Eshun, who bristled at the idea that ‘the street’ was the go-to-cipher for understanding Black music. Techno, he wrote, “eludes all social responsibility ... accentuating its unreality principle” (1998, -004). Surely Atkins’ nocturnal spin has the affective quality of 1980s-Detroit-by-night dead to rights, but it’s what he’s driving toward, not what he’s driving through, we should be mindful of.³⁰

Techno was a genre without a name until 1988. After the successful UK licensing of a spate of Derrick May and Kevin Saunderson singles (including “Nude Photo” and “The Sound,” both 1987), Kool Kat Records’ Neil Rushton set out to capitalize on the burgeoning interest in Detroit producers in Europe. In a decision he later described as “subliminally connected” to vintage Motown compilations like the *Motor Town Revue, Volume 1* (1963),³¹ which surveyed talent across the label’s roster (Sicko [1999] 2010, 64), Rushton compiled a collection of songs from the Belleville Three and their proteges and acolytes including Eddie ‘Flashin’ Fowlkes, Blake Baxter, and Anthony Shakir. Keen to differentiate Detroit from the house music being made in Chicago and New York, Rushton borrowed a word from the title of Atkins’ contribution, “Techno Music,” and named the compilation *Techno! The New Dance Sound of Detroit*. Techno was a perfect moniker for the fledgling genre: it was a sleek encapsulation of the futurity so important to Atkins, it sounded exotic, and it differentiated the genre from new wave and house. While it *referred* to novelty, ‘The

³⁰ Building on Eshun’s claim that “techno disappears itself from the street, the ghetto, and the hood” (1998, 102), Tobias C. van Veen characterizes the aesthetics of Detroit techno as choosing voluntary exile rather than trying to reflect the city’s bleak urbanism via social realism (2013, 28).

³¹ *The Motor Town Revue* brought together the formidable combination of The Supremes, Marvin Gaye, The Marvelettes, and The Miracles showcasing the depth of Motown’s artist pool. Rushton set out to echo that prolific survey of talent with his techno compilation for Virgin.

New Dance Sound of Detroit' branding of techno reached for the mantle of a 'Motor City sound' that had remained unclaimed since Motown vacated Detroit to more tightly integrate with the abundant media, licensing, and crossover opportunities available in Los Angeles, manifesting Berry Gordon's vision of "using African-American artists to reach audiences outside of traditionally black markets" (Flory 2017, 163).

For the song that inspired the naming of the genre "Techno Music" verges on underwhelming. While it artfully interweaves bass and synth lines and ethereal strings, the mix is uncharacteristically cluttered compared to other Atkins productions from the era. Vocodered speech rigidly articulates "*Tech-no Mu-sik*" over busy toms and handclaps alongside a mid- to high-range characterful resonant synth line, which alternates with a sequence melding an articulated baseline to more vocoders: "*I'm your friend / on your comp-u-ter.*" The song functions as a techno pop proof of concept, but lacks the gravitas of so many of Atkins' other 1980s productions. Other highlights from the compilation include Derrick May's tautological "It Is What It Is," which melds an acid line and orchestral strings in erudite simplicity; Anthony Shakir's richly textured "Sequence 10" is a playful din of bells, toms, shakers, and oddball percussion sounds; and Inner City's "Big Fun" became a breakout house anthem, with chic arpeggiated synth stabs, piano licks, and vocalist Paris Gray's carefree narration of an idealized night out. "*We're having big fun / the party's just begun.*"

The response to "Big Fun" was exuberant and the song instantaneously became a house anthem. Propelled by the single, the compilation was commercially successful, and The Belleville Three were immediately in demand on the burgeoning European DJ circuit. Atkins described the shocking experience of looking out into the crowd of 5,000 at one of his first UK gigs, and simply not believing so many white

kids could be dancing to the records he was playing. “This could never happen in the U.S.,” he thought to himself (Shallcross 1997, 20).

Atkins, May, and Saunderson’s warm reception in post-acid house Europe marked the moment that techno went from being a regional sound to “the new dance sound of Detroit.” And it’s in the liner notes of *Techno! The New Dance Sound of Detroit* where many of the genre’s founding myths were established. In them, a short interview of the trio by UK music journalist Stuart Cosgrove establishes a founding mandate of futurity. The trio position the genre as serendipitous, “a complete mistake,” and as echoing Detroit’s economic decline; this notion of failure is captured in May’s quip that the nascent genre, “Is like Kraftwerk and George Clinton stuck in an elevator.” *Automatons plus mothership plus malfunction equals techno.*

However, May’s evocative quote is almost always truncated when reproduced. The full quote is “[techno is] like George Clinton and Kraftwerk are stuck in an elevator with only a sequencer to keep them company.” Ironically the seemingly central music technology almost always gets left out of the transatlantic conflation.

May further differentiates techno from Chicago house stating, “we don’t have any of that respect for the past, it is strictly future music.” His comment underlines techno’s acute lack of references to soul and disco—its austere sound emerging from synthesized tones and percussion hits. Infamously, Atkins claimed he was “more interested in Ford’s robots than [Berry] Gordy’s music” (Cosgrove 1988), facetiously suggesting that techno owed more to Ford than Motown. Atkins later described this slight of Gordy as a misquote (Shallcross 1997), but correct or not, it was used to prop up Eshun’s description of Cybotron and Model 500 as exemplifying a new mode of Black embodiment, attainable through “cyborging” or “technofying” oneself (1998, 106-7).

In trying to locate the destination of Atkins's "Night Drive (Thru-Babylon)," I return to the three vignettes I laid out earlier, which ripple through techno's mythology: the persistent notion that Detroit was poised for a comeback, the factory as a site where discourses about productivity are produced, and the worker as a subject of automation. Earlier, I sketched how these themes inflect Detroit's history and worker's struggles; now, I will use them to think about techno's aesthetics, 'automation' in music technology, and ruminate on a labour-based framing of techno.

Earlier we established Detroit's 'golden age' of manufacturing was not in fact golden. Labour theorists including Daniel J. Clark, have discussed how much of the 'organizing' within mid-century American labour movements was senior white workers preventing equality (2018, 2)—pulling the ladder up behind them. Once you disavow that there is any golden age to return to, nationalist protectionism notwithstanding, there is nothing tragic about the American auto industry being outperformed by Japanese automakers. So how do we *hear* this economic history in techno? Svetlana Boym's *The Future of Nostalgia* (2001) is helpful. In it, the cultural theorist describes two types of nostalgia: one conservative and regressive, the other open to critical interrogations of the past. The former is 'restorative,' and aims to recapture a past status quo; the latter is 'reflective' and "aware of the gap between identity and resemblance," acknowledging that "the home is in ruins ... [or] renovated and gentrified beyond recognition" (50). That there can be no 'return.'

Although early journalists and music historians were adept at articulating where techno 'came from,' they were less capable of anticipating where the genre might take us—of deciphering its futurity. In another sticky point of reference from the *Techno! The New Dance Sound of Detroit* liner notes, Stuart Cosgrove uses Derrick May's descriptions of urban ruin for dramatic effect. After describing how techno

“reflects” alienation, despair, and unemployment, May quips, “in Britain you have New Order, well our music is the new disorder.” Cosgrove follows that quote with a closing observation: techno’s disruptive innovation was akin to “free form jazz for the computer era” (1988).

Beyond the lack of correlation between wild rhythms in free jazz and the rigidly quantized ones in the upstart genre, one can understand Cosgrove’s desire to use such a hallowed form of Black music to situate techno. ‘Computer jazz’ is not the *worst* aspirational framing of the genre, and one could easily chart interstellar affinities between *Ascension*-era John Coltrane and Sun Ra’s entire oeuvre and techno’s futurity. Likewise, it is commonplace to attempt to situation Motown, which, much like automakers, was another ‘industry’ that abandoned Detroit, as a tradition in whose wake techno follows.³² Both of these evocations *look back*, relying on past genres, however, diminishing what was *legitimately new* in Techno.

When one focuses on changes in industrial production during the 1980s, a model for listening to techno becomes discernible. The genre is not so much the sound of a flailing American manufacturing sector and resulting urban blight as a refrain announcing the shift to a globalized economy of outsourced labour—which, as far as both Detroit and America were concerned, manifested in Japan. Before the late 1970s campaigns to ‘buy American,’ before tariffs on car imports, and before Vincent Chin was mistaken as Japanese and beaten to death by a pair of disenfranchised Michigan autoworkers in 1982, Japanese consumer electronics were adopted in every corner of American life without backlash. In contrast to cars, TVs, VCRs, and the Walkman were “culturally odourless” (Iwabuchi 2002, 28). Sony, Mitsubishi, and Toshiba became household names and this high-tech lexicon is

³² Dan Sicko's characterization is classic brain drain: "Detroit was left without a staging area and its new talent with few choices: fend for yourself or move to one of the coasts." (1999 [2010], 33).

exactly what Atkins intones in “Future”: “*Just take my advice / a brand new day’s upon us.*” With its dominance in the TV and VCR market, Japan quietly claimed sovereignty over the nuclear family’s electric hearth. “*Have no fear / the future is here.*”

The takeover of domestic space was echoed in the studio, with Atkins and his Detroit peers using Japanese gear from their earliest productions onward. In the early 1980s, Roland, Korg, and Yamaha ascended. Beyond creating Atkins’ ‘starter synth,’ the MS-10 (1978) and the Boss ‘Dr. Rhythm’ DR-55 (1980), on which some of Cybotron’s first rhythms were tapped out, the trio of manufacturers released a spate of innovative synthesizers and drum machines. The resonant and bruising sonic palettes of the Roland TR-808 (1980) and -909 (1983) became the archetypal techno drum kits, and Yamaha’s 1983 breakthrough the DX7—the first mass-market digital synth—coupled with the introduction of the MIDI standard marked the moment that digital instruments and digital interoperability captured the cultural imagination (and market share). By mid-decade, Japanese conglomerates like Roland and Yamaha ran American entrepreneurs including Robert Moog, Keith Oberheim, Don Buchla, and Roger Linn out of business, echoing what happened in the auto industry. This was not just a changing of the guard regarding sector dominance, but the beginnings of a transition from electronic to digital instruments that would play out over the next two decades. This shift did not simply “change underlying media functioning”; it changed “musical ideas and practices” as well (Magnusson 2019, 34).

Neither Ford nor Moog were able to compete in global markets. The sense of Japan as a harbinger of this categorical defeat was captured in the Ridley Scott film *Black Rain*, when the central American protagonist is chided by his Japanese host: “now music and movies are all America is good for. *We make the machines, we build*

the future...” (1989). In an instance of delicious irony, Roland’s early 1980s tagline *actually was* “we create the future.” The question that should be extracted from that sloganeering and the fictionalized exchange quoted above is not ‘Who makes the future?’ But ‘Who owns it?’ If ingenious American entrepreneurs were swept aside by Japanese conglomerates, Black American techno producers’ creation of new modes of musical expression (and economic value) with ‘the machines’ was a defiant reclamation of sovereignty. Not sovereignty *for* America, but in spite of it.

I want to dwell on this notion of musical labour further. Returning to the sketch of the factory I made earlier, in which I characterized it as a space where labour gets subdivided into discrete tasks and drained of affect under the watchful eye of management, I draw attention to the perceived spatial and temporal gap between the factory floor and the bedroom studio. Perhaps more than any other, techno is a genre in which this distance is nominal. It’s a mode of music making that consciously erased this distance and made the fledgling 1990s ‘bedroom producer’ possible.³³

This transition extends out of a continuum of developments in which forward-thinking labels and artists used new technologies (and workflows) to rethink musical production and notions of musical productivity. Berry Gordy likened the operation of Motown Records to an assembly line of producers and session musicians—even a ‘quality control’ department—encompassing “all components needed to create and sell its own music” (Flory 2017, 43). Kraftwerk were among the first pop groups to recognize that the studio *was* an instrument, creating a new hybrid musician-sound engineer model of musicianship (Schütte 2020, 35), and later

³³ Techno may have anticipated the bedroom producer, but Donna Haraway saw it coming first. In *A Cyborg Manifesto*, building on economist Richard Gordon’s notion of feminized labour and the ‘homework economy,’ she describes feminized labour as “extremely vulnerable; able to be disassembled, reassembled; exploited as a reserve labour force” (2016 [1985], 38). This reading is prescient in light of the ascent of bedroom producers “from anonymous, often unseen creators to live performers and chart-toppers” (Fintoni 2020, 2) in the twenty-first century.

literally taking their famed Kling Klang studio on the road, “making the spectacle of the music machines a part of their show” (158). In Kingston Jamaica, recording engineer King Tubby mastered the mixing board and analog effects, while pumping out pristine remixes for local sound systems where “all the mutating elements seem to be orbiting one another” (Milner 2010). In 1979, Tubeway Army completed its metamorphosis from its punk rock origins to the first chart-topping new wave band on the heels of "Are 'Friends' Electric?", taking the DIY punk ethos and prototyping a synthesizer-driven aesthetic “short on technique, but long on creative curiosity” (Cateforis 2011, 168). Techno built on all of these developments with a few key distinctions: while Kraftwerk and new wave artists like Gary Numan and Devo playfully transformed themselves into stiff, dehumanized, and androgynous performers that centred white neuroses about technological alienation and redefined notions about “what it meant to work at one’s instrument” (181), techno went a step further and disappeared the figure of the musician altogether. And whereas Kraftwerk underwrote their 1970s studio with a blank cheque, early techno producers made similar contributions to music making practices on consumer-grade gear, sometimes sourced at the pawn shop.³⁴ As noted by De Forrest Brown Jr., Atkins’ humble MS-10 bedroom productions anticipated a new era of democratized music making “when even a nineteen-year-old Black kid in Detroit could dream of the sounds of the future” (2022, 53).

³⁴ The 'digital turn' in music technology brought on by the Yamaha DX7, MIDI, and samplers prompted major retooling in both professional and amateur studios alike in the mid-1980s. Many Detroit and Chicago producers (and their scrappy compatriots overseas) got started with steeply discounted analog synthesizers and drum machines, relegated to pawn shops by more well-heeled studios looking to 'upgrade.'

What is the Shelf Life on Shiny Futures? *Deep Space* (and Beyond)

Although its vacuum is supposed to be silent, *Deep Space* opens with a woosh—a shuttle pushing off from a dock—followed by ascending chords. The lead song, “Milky Way,” resounds with appropriately spacious reverb, and two central synth lines rise to the foreground of the mix. The first is pristine and melodic, its foil arpeggiated, resonant, and gnarly, snaking back and forth across the stereo field. “Orbit” follows, an acid line and driving heavy kick trace a path around a planet or star, accented by a busy hi-hat pattern that is eclipsed by clamouring cymbals; the groove is loose enough that it feels like the kick might skip ahead of itself—careen out of control.

While the 13 solo and collaborative singles Atkins released on his Metroplex imprint between 1985 and 1994 were successful by any metric for measuring independent American dance music, Atkins refrained from returning to the album format until 1995’s *Deep Space*; it took 12 years for Atkins to follow up Cybotron’s *Enter* with his first solo album. Rather than self-release *Deep Space* Atkins took advantage of the burgeoning European electronic music economy—which he helped kickstart—choosing to release the album on the London-based R&S Records. All-in on acid house in the 1980s and European hardcore in the early 1990s, the prolific label primarily focused on European artists—hardcore and trance artists including WestBam and Jam & Spoon, but also experimentalist upstarts including Aphex Twin and Biosphere. It was also a European outlet for notable American artists including Joey Beltram and Fingers Inc., and it even featured some of Atkins’ Detroit peers (Eddie ‘Flashin’ Fowlkes and The Suburban Knight).

Atkins bundled a selection of singles and remixes from his Metroplex catalogue, including “No UFO’s,” “Night Drive (Thru-Babylon),” and “Techno Music”

for release on R&S in 1993. Entitled *Classics*, the compilation capitalized on his growing recognition as part of the bedrock on which European dance floors were built, bringing material marketed to DJs, previously only available on vinyl, to European CD listeners. He followed with *Deep Space* two years later.

In “The Flow,” the third track on *Deep Space*, Atkins’ sci-fi soundscapes are humanized by Aisha Jamal, who sings of love, loss, and surrender, her voice accented by pristine chimes and moody strings. “The Warning” follows, echoing the gallop-rhythm of “Orbit.” A distorted kick, sub-bass pulse heartbeat, and ascending synth line build momentum, which serves as scaffolding for shimmering chimes and a warm lead synth line—Atkins tipping his hat to New York and Chicago. Filtered hi-hats, and a droning bassline makes for a groove that rocks back and forth, and engine-like sounds suggest the shuttle from “Milky Way” has returned and is doing donuts outside the airlock.

While the lyrics to “The Flow” are forgettable—Jamal was perhaps breaking the fourth wall when she sang, “*I found a new route I wanna take it*”—Atkins worked in his comfort zone on the first half of *Deep Space*, co-producing tracks with regular collaborators and tasking François Kevorkian at Axis Studios in New York with mixing duties. For the second half of the album Atkins most definitely ‘took a different route,’ savvily enlisting Mortitz von Oswald to engineer and recording parts of the album in Berlin’s Love Park studios. This partnership tapped the nerve centre of a new German avant garde: von Oswald was the primary force behind the cavernous and reverberating sounds of the Basic Channel and Chain Reaction imprints. The nascent Berlin sound’s relation to techno was best described by Biba Kopf as “an archaeology of techno ... [that] burrows beneath the future-shock debris to work up new geometric shapes from the music’s original architectonic ground plans.” (1996,

19). Atkins' handing the reins to von Oswald to mix, process, and interpret his sound was a profound endorsement.

The album's fifth track and the first mixed by von Oswald, "Astralwerks," acknowledges if not embraces drum 'n' bass rhythms and timbres, merging Detroit tones with filter-swept arpeggiations.³⁵ "Starlight" follows with the smoothest of nocturnal grooves, an immaculately calibrated simple kick-hi-hat pattern and a warm bassline serving to scaffold its heavenly ascending chords. The final three tracks "Last Transport (To Alpha Centauri)," "I Wanna Be There," and "Lightspeed" achieve warmth through precisely mixed bass lines and drum tuning, and rarified synth timbres. Most affectively, Atkins lends his voice with a chorus that assures the listener "*I want to be there / when you return*" over a burbling acid bassline.

Rather than take a career victory lap and replicate the sound he'd developed on Metroplex over the previous decade, Atkins used his solo album to consider and incorporate aesthetic and generic developments since techno emerged as a recognizable genre post-1988. This decision was not received warmly. Eshun, whose sonic fiction treatise *More Brilliant Than the Sun* would lionize Cybotron's productions three years later, opened his review by unflatteringly stating that "Atkins must be feeling like the world's oldest cyborg these days" (1995). *Deep Space* did not even command enough respect to be the sole subject of that review, with Eshun also taking aim at Carl Craig's album, *Landcruising*. Ultimately, Eshun concludes that while techno had "colonized" the UK "so totally" and functioned as an "alphabet, oxygen, and electricity" for European producers, Atkins and Craig's mid-career

³⁵ Atkins' gestures to drum 'n' bass was not simply a case of using the sound design of a chic genre to 'update' techno's sonic palette. It was Belleville Three peer Kevin 'Reese' Saunderson that templated the titular rumbling low end—the *bass* in drum 'n' bass—on his 1988 single "Just Another Chance," where his Casio CZ-5000 bassline became immortalized to subsequent generations of producers as 'Reese Bass.'

experimentation suggested it was time to move on. These *new* Detroit productions, he assessed, were “essential, yes. But boring too” (49).

To add insult to injury, Atkins’ first commercial DJ mix, released four years later in 1999, seemed to garner more attention than his album. Critics on both sides of the Atlantic took potshots at his (lack of) turntable acumen in unengaged reviews for *MixMag* in the UK and *Spin* stateside. In the latter, Rob Michaels flippantly described Atkins’ track mix as a “savvy blend of Detroit horsepower and Teutonic craftsmanship ... [with] all the synergy of a Chrysler-Mercedes merger” (1999, 121).



Fig.xiv Juan Atkins gets *The WIRE* cover treatment in July 1997

Atkins also graced the cover of the July 1997 issue of *The Wire* (Fig.xiv). There, emblazoned under the subhead “motor city magus,” he wore a high collared blue sweater and grey bug-eye sunglasses, head tilted, staring off into the distance. Bathed in future-y blue light, the shades cast a piercing specular reflection, not unlike the one described in the lyrics of “Night Drive (Thru-Babylon)” a decade earlier. In the accompanying profile by Mike Shallcross, *Deep Space* warrants just two paragraphs of discussion. The first describes how the “lascivious vocal electro of ‘The Flow’” and the “desperately lonely splashes of melody on ‘Starlight’” benefit

from von Oswald’s engineering; the second explains “why it took so long” for the Detroit producer to release an album. Atkins answers that the labels he approached were risk averse, and there was a prevailing preconception that techno was “single-oriented” (22).

I close on the chilly reception to Atkins’ solo album for a few reasons. First, it effectively bookends the body of work he began with Cybotron in the 1980s. While my decision effectively excludes two decades of his recording³⁶ from this discussion, it also parcels off thorny discussions of what electronic music became in the first decade of the twenty-first century. Whether the resurfacing of electro sounds and 1980s aesthetics in electroclash, the pulse of Berlin-style minimal techno, or EDM rearing its ugly head—scenes and stylistic shifts occurring across the 2000s—situating techno within these developments is a different project than what I have undertaken here. If we’re being succinct, we might encapsulate techno as a Black, local, and technically innovative mode of music making practice—none of these qualifiers are particularly relevant to these later scenes and sounds.

However, my discussion does not dwell on Detroit’s local-ness, so much as consider how a particular set of economic and social forces engendered a unique vision of futurity.³⁷ Derrick May’s quip about “Kraftwerk and George Clinton trapped in an elevator” seems to have captured mindshare as a concise descriptor of the genre’s aesthetics and calculated bridging of generic and racial lines, but, even if it

³⁶ Perhaps most notably the album *Digital Solutions* (2015), which continues the in-genre spirit of experimentation in *Deep Space*—but this time released under his own Metroplex banner.

³⁷ San Francisco is another city that gestated a futurity tied to marginalized perspectives and populations. In 1981 Patrick Cowley released “Menergy” and “Megatron Man” on Fusion Records. The sleek disco songs picked up where Giorgio Moroder left off sound design-wise, but these shimmering synth lines reflected the city’s vibrant gay nightlife. Moby Dick Records and Fusion were the first “gay-owned, gay-run dance music labels” (Niebur 2022, 116) and the success of Cowley alongside Sylvester and Two Tons O’ Fun opened up the floodgates for global attention and record deals to “several projects that had up to that point been essentially local” (130). This is exactly how things played out in Detroit several years later, where the attention Atkins, May, and Saunderson’s labels received paved the way for subsequent ‘waves’ of producers.

was a misquote, I can't help but linger on Atkins' mangled throwaway comment that he was more interested in robots than Motown. *If only it were true* that techno could make that break from musical tradition that the Belleville Three—full of youthful bluster—suggest is possible in that formative interview.

The mythologies that solidified in those 1988 liner notes were widely echoed in the genre histories that followed a decade later. Reynolds, in the first few pages of his oral history of the rave scene, describes Atkins as a “middle-class kid two generations removed from his grandfather's stint as a Ford line worker” (2013 [1998], 4). This same valorization of blue-collar labour resurfaces decades later when Laurent Fintoni situates beatmaking culture in “the sweat trickling down bodies as they toil away at an assembly line where there is no room for improvisation” (2020, 13). In both cases, labour—both real and imagined—is used as a marker of authenticity.

Earlier I drew attention to the gap between the factory floor and the bedroom studio. Another distance we might measure is the notable affective gap between “No UFO's” and *Deep Space*. In the angsty earlier single, Atkins speaks of spacecraft buzzing downtown Detroit; in the latter album—seemingly at peace with himself—he achieves escape velocity and leaves Earth altogether. Something profound happened between Atkins' mid-1980s prescience and his ‘departure’ a decade later. At a certain point ‘the future’ both spoken of, and represented through new sonic aesthetics, outlived its usefulness in discourses of electronic music. What *didn't* obsolesce was how the genre prototyped new modes of musical productivity, a fact that remains hidden in plain sight.

While the prescience of Atkins and the Belleville Three may remain largely overlooked and under-credited in the post-EDM popular music landscape, one area

where we can see traces of its vital but elusive futurity is in the affect and avatars of the upper echelons of Black women musicians in the early twenty-first century. From Janelle Monáe's time-travelling android alter ego Cindi Mayweather, a "straightforward allegorical reading of Afrodiasporic conditions of otherness" (van Veen 2013, 16) to Beyoncé commencing her 2007 BET Awards performance by emerging from a robotic exoskeleton with a lurching mechanized dance, futurity has gained currency within popular music. Robin James describes Beyoncé's performance (and Rihanna, in her 2007 video for "Umbrella") by invoking the Robo Diva, a neologism coined by music writer Tom Breihan that James characterizes as a figure that defiantly "challenges entrenched aesthetic norms and gender-race politics by asserting her black femininity and technological prowess" (2008, 403). The Robo Diva does this by taking command of her sexuality, asserting agency in the world, and *embodying* techno-futurity. We can see further evidence of this in Beyoncé paying homage to the Black and queer roots of house music in *Renaissance* (2022)—and not just as a *sound* but as hedonistic revelry for her legion of silver-clad fans on its carnival-like accompanying tour. Janelle Monáe, Beyoncé, and Rihanna inhabit the future-imaginary as a form of resistance against being "overdetermined by the safe and clearly neocolonial role society wants to give them" (James 2008, 418). There is a tangible link between the subjectivities implicit in 1980s and '90s techno production and these types of embodiment and projections of futurity that are now palatable (and exciting) for contemporary pop audiences and fandoms. Atkins may indeed be the "world's oldest cyborg," as Kodwo Eshun so unflatteringly described him three decades ago, but he helped prototype artistic orientations whose time may have finally come.

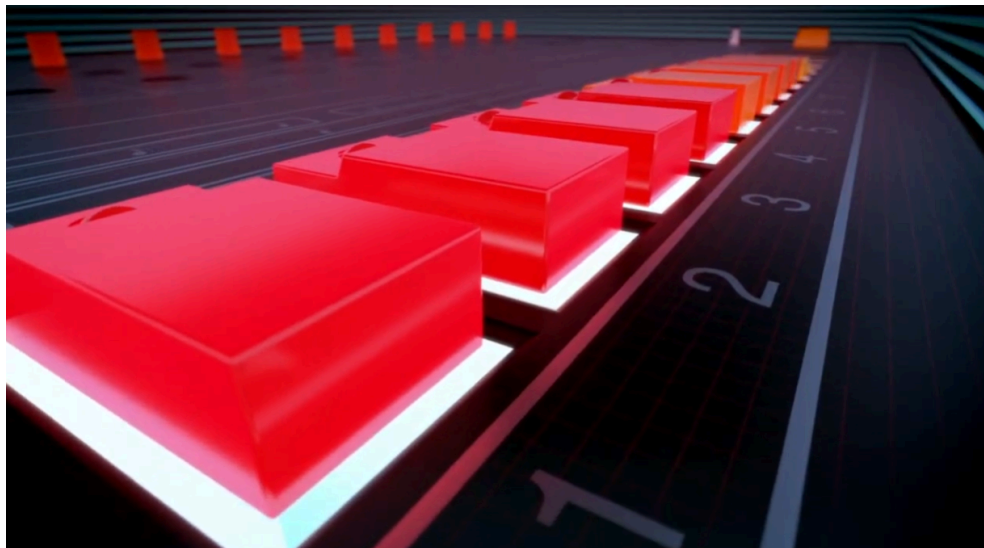
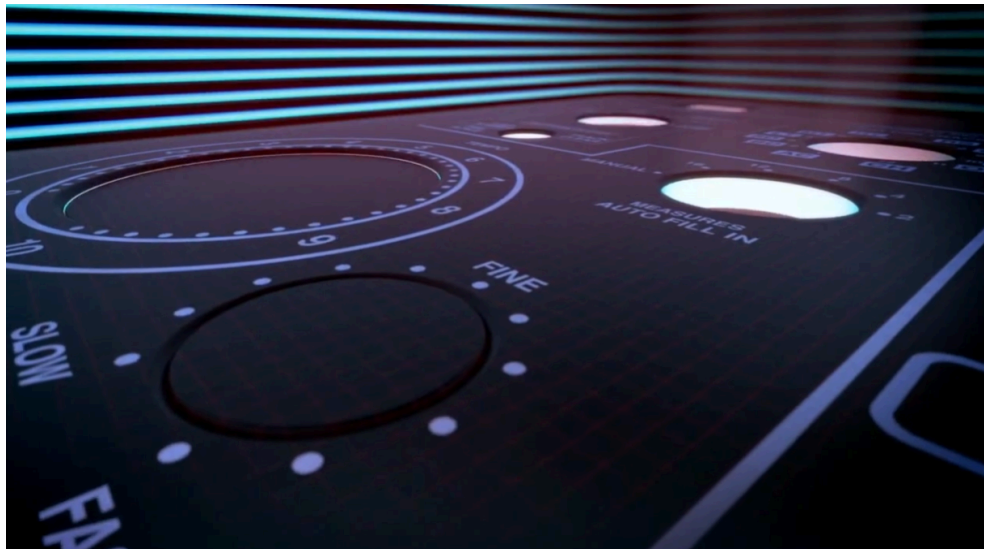


Fig.xv Stills from the 808 title sequence

Chapter Three: Haunting the Roland TR-808

An orthogonal plane floating in space is framed from an oblique angle. According to the labelling, the depressed square button is in the ‘on’ position. Another oblique shot, this time from the other side, a circular level knob is depressed—flush with the panel. The camera pans slowly across the device—relishes it—and labelling of the numbers 1, 2, and 3 cast specular reflections on the glossy surface of the interface. Suddenly the two-dimensional panel springs to life, coloured buttons majestically arise out of the flat plane (Fig.xv). The syncopated rhythms of Jamie XX’s “Gosh” pump, the song’s exuberant rubbery melody sounds unbridled wonder and optimism.

“You Know Films Presents, in Association with Atlantic Films.” This isn’t an *actual* electronic device, it’s a digital rendering. The camera pans across more oblique shots of the panel. Imaginatively, the labelling—levels, pattern variation—is juxtaposed with film credits: “Executive Producer: Alex Noyer. Producers: Alex Noyer, Alexander Dunn. Producer Craig Kallman.” Another dramatic angle: glowing buttons rise out of the panel. Four red, then four orange, then four yellow. A close-up of a dial with settings HT, RS, CP, CB. It’s labelled “Instrument Select.” More labelling appears onscreen interpolated with production credits. A rapid-fire sequence flits through more shots: “Track Clear,” “Hand Clap,” “Level,” and “Tempo” labels all flash onscreen briefly alongside illuminated dials and buttons. The sequence ends with a full-frame view of the interface the edits have been teasing: it’s the Roland TR-808 drum machine. The scene fades to black, a half second of VHS tape noise glitches, and a wireframe graphic of the globe centred on New York appears onscreen. A voice with a thick British accent intones “*In the late 1970s, electronic music as we know it today was beginning to emerge.*”

Didactic labelling begets didactic narration. It's not that narrator Zane Lowe is wrong, it's that he articulates a tired narrative about one of the most significant pieces of music technology to emerge in the late twentieth century. Ultimately, Alexander Dunn's 2015 documentary 808, captures much of what is significant about the Roland TR-808 Rhythm Composer, but what it omits is equally important.



Fig.xvi The Roland TR-808

Dunn's documentary centres what is probably the most famous drum machine ever made: The Roland TR-808 (Fig.xvi). The TR stands for 'transistor rhythm,' music technology sloganeering for an analog circuit-based programmable drum machine. This was a fairly new idea at the time and the machine's innovations needed to be marketed to users. Part of what makes the 808 so historically significant was that it was released at a transitional moment in electronic instrument design. On one hand, it's part of the last wave of early 1980s music technology to use analog circuits, which generated its idiosyncratic bass, snare, hi-hat, and handclap sounds (and 8 other percussion voices). But it was also among the earliest devices to be powered by a central processing unit (CPU), and that microprocessor made the drum machine powerful compared to the clunky 1970s rhythm boxes. Building on innovations in the Roland CR-78 that Roland released two years earlier,

the 808 offered a suite of unique drum sounds and a fundamentally new way to sequence them.

The *sounds* are what Dunn lingers on in his documentary, describing the 808 as “*otherworldly—futuristic.*” Narrator Zane enthuses, “*The low sonic boom of the kick, the tinny snare, cowbell, and the odd-sounding handclap. These elements all combine to make it completely unique.*” And he’s right, the circuitry that created the “sonic boom” kick yielded a heavy resonant sub-bass that didn’t so much sound like a conventional bass drum as a robotic sci-fi reimagination of what a kick drum could be. Famously, this was due to economy rather than aesthetic preferences, as revealed by Dunn’s interview with Roland Founder Ikutaro Kakehashi: the prohibitive cost of digital memory in the late 1970s prompted him to use cheaper analog circuitry to *emulate* the sound of drums rather than reproduce them in high fidelity. In that interview, recorded three years before his 2017 passing, he reflected, “I could only catch the character of a sound, never reach the real drum sound,” speaking of the bass, congas, and toms specifically.

It’s that *gap* between signifier and signified that Dunn relies on so heavily in his film, ostensibly describing the 808 as a ‘magic box’ from which “otherworldly” sounds emanated; one that forward-thinking musicians in New York and Miami seized on to create new genres. This sentiment is shared by many producers interviewed in the film, including Arthur Baker, Rick Rubin, and Pharrell Williams, who all wax poetic on screen about how the 808 ‘changed everything’ with its progressive sound. This characterization is best articulated by the UK drum ‘n’ bass artist Goldie: “[the 808] just filled a massive void in the sound spectrum that wasn’t there.”

That's two gaps now. One between the cost of digital memory and analog circuitry, and another between our receptiveness to low-end frequencies in the early 1980s and what they evolved into three decades later. While Dunn's documentary acknowledges the impact Roland Corporation had on electronic instrument design and the idiosyncratic genres—rap, house, techno, electro—synthesizers and drum machines helped forge, it's essentially fan fiction. Its simplistic narrative re-historicizes the device's impact with an air of inevitability that obfuscates both the messiness of musical genre formation and the (electronic) materiality of its subject. "Without [the 808] music would sound completely different today," intones Narrator Zane with the thick British accent that is regularly superimposed on top of electronic music history by critics like Simon Reynolds and Mark Fisher.

Electronic music is full of venerated figures and machines. Kraftwerk, Wendy Carlos, and Juan Atkins all have places in the genre's lore as do the sonic contributions of synths and drum machines like the Sequential Circuits Prophet 5 and the E-mu SP-12. What I find so irksome about Dunn's documentary is how it collapses history; it takes the verbal hypothesis of its interview subjects and suggests the *sound* of the 808 was somehow missing in pre-1980 music, and then when that void was suddenly filled—voilà, musical innovation! From a contemporary perspective, now the 808 sub-bass is ubiquitous, this makes sense. But, the argument that the 808 engendered modern percussion sidesteps the nuance of 1980s genre formation and largely erases the numerous accomplishments of Roland Corporation. As is so often the case in electronic music, the contributions of Japanese artists and engineers are downplayed while the role of Americans and Europeans are elevated.

This is a Ghost Story

In this chapter I conduct a critical intervention into the received historical framing of the Roland TR-808 that is repeated by synthesizer enthusiasts and the music technology press. Using Dunn's documentary as a point of departure, I identify historical fallacies that it reinforces (and has further propagated through its popularity) and, more importantly, surface and excavate the topics it omits. My goal is not to take potshots at the arc towards 'infotainment' that documentary media has taken over the last decade, but to open up the more messy and troubling narratives that didn't (and couldn't) fit within this narrowly focused film. In particular, I examine what the film and related narratives omit and erase from conversations about technological obsolescence, the conspicuously absent story of Roland Corporation and its founder Ikutaro Kakehashi, and the materiality of the 808's *circuits*. In a moment I will map out my agenda in detail. But first: a ghost story.

In 2019 Roland Corporation published an interview with CEO Jun-ichi Miki, discussing its flagship JUPITER-X synthesizer line. Taking both the nomenclature and legacy of its iconic Jupiter-8 and -6 series that were Roland's premium polysynth offerings from 1981-5, the Japanese manufacturer was tapping into the nostalgia surrounding the big analog sound of that synth that loomed large in that era of music making. It provided the iconic bassline of Michael Jackson's "Thriller" (1982) and the arpeggiated pattern accenting the melody of Duran Duran's "Hungry Like the Wolf" (1982). But Roland would not allow JUPITER-X to ride on the coattails of its progenitor by replicating many aspects of its design. The *new* JUPITER series was digital and offered a range of functionality impossible in the 1980s. The interview was largely self-congratulatory, but one of Miki's answers addressed customer blowback regarding the JUPITER-X. A small but vocal group of Roland users wanted, no,

desired, for the company to release a JUPITER synth that honoured the line's 1980s origins: Big analog sound, a characterful analog filter, and the most revered chorus effect in the history of electronic music. Analog voices, analog filter, analog effects.

Miki had to be tactical in how he addressed these concerns. Pulling a nostalgia card of his own, he invoked a favourite credo that Ikutaro Kakehashi used when contemplating new designs. It was simple: "Never chase a ghost." Speaking of the JUPITER series and the 808, Kakehashi claimed it simply did not make sense to try to re-engineer versions of these analog machines because "We will never catch them." Ghost chasing is quixotic and "does not align with our vision of the future" (Miki 2019). Kakehashi's supernatural metaphor is evocative. His language about forces and presences from the past that still resonate in the present echoes the spectral turn that happened in the humanities in the 1990s and 2000s.

In April 1993, Jacques Derrida delivered a two-part lecture at the University of California, Riverside, entitled, "Whither Marxism?" The lecture, in which the French thinker grappled with the ideological vacuum created by the rapid fall of communism in Eastern Europe, became the basis of *Specters of Marx* (1993). In the resulting text, Derrida lingers on Marx's infamous "a spectre is haunting Europe" analogy that opens the *Communist Manifesto* and uses both the ghost (a figure) and haunting (a state) to ruminate on how Marxism would 'haunt' capitalist liberal democracies into the foreseeable future. "There is something disappeared, departed in the apparition itself as reapparition of the departed," he wrote of Marx's spectre (5) in setting up a discussion about how "mourning ontologizes remains" (9), measuring tensions between the absence of a corpse and the presence of a mysterious force with ties to the past. Derrida was mapping the contours of a world with no alternative to capitalism and his ghost figure was picked up by Avery Gordon four years later when

she described haunting “not as cold knowledge, but as a transformation of recognition” (2008 [1997], 8). Later still, Mark Fisher glommed onto Derrida’s portmanteau hauntology, describing it as “the agency of the virtual” that describes when something “acts without (physically) existing” (2014, 18).

Inspired in equal parts by my adverse reaction to Dunn, and the synergy between Kakehashi and Derrida’s ghosts, my intervention into the historicization of the Roland 808 drum machine will happen on four fronts. First, I will schematize how Dunn frames the arrival of the 808 and its adoption across genres, as a way to present a popular understanding of the device. Second, I will address the most serious of omissions from his documentary—the erasure (or at least downplaying) of the role of Kakehashi and Roland Corporation—as an example of the broader historical erasure of Japanese engineers and musicians from western-centric histories of electronic music. Third, I will delve into the device itself and engage its circuitry as the locus of its sonic innovation, and also a site where the life force and biographies of Kakehashi and co. were inscribed. And, finally, I will return to the discourse of spectres and haunting, and use Derrida’s, Gordon’s, and Fisher’s varying articulations of the spectral turn to think about how a drum machine can haunt popular music by simultaneously being everywhere and nowhere at the same time. Inspired by Kakehashi’s credo and this trio of scholars, this too is a ghost story.

A Close Reading of 808

My first task is to schematize the narrative that I want to refute. To do that, I will conduct a close reading of *808*. I’ve already touched on the *tone* of inevitability practically dripping from narrator Zane Lowe’s voice in the film, but the casual narrative it presents goes beyond the verbal statements that bridge the film’s

sequences. Through the aforementioned narration, the songs that are foregrounded, and the cities and musicians that are visited, the film constructs a *particular* narrative about its subject. And, most curiously, Roland Founder Ikutaro Kakehashi is almost entirely absent.

I've selected *808* to focus on as I believe it captures certain, almost folkloric, narratives about Roland's drum machine that are repeated *ad infinitum* in the music technology press. I'm targeting trade publications like *Keyboard*, *Sound on Sound*, and *Future Music* here, which had considerable historical influence, as well as the discourse about the device that lingers in the vernacular of contemporary YouTube 'synthfluencers.' Kurt Werner delves into one of the major mythologies of the 808 in the *Ethnomusicology Review*, where he asserts "an analytic echo chamber has been formed by the journalistic fixation on some of the more twee anecdotes in the 808's history" (2015, 2). In that article he outlines a widely repeated claim that the 808 was originally panned in *Keyboard* magazine as sounding like "marching anteaters." Werner reveals how that never happened, but was a *misattribution* of a comment in a review of the LM-1, though to this day keyboard reviewers and synthesizers still repeat the "marching anteater" anecdote.

I think the issues around the 808's mythology extend much further than mere anteater nomenclature. The *sound* of the device has been so influential that it's tempting to cite it as a cause or catalyst of musical changes that occurred after its release. And I further think that the script of Dunn's documentary falls into this trap with the timeline it sets up and the technological causality it implies. This is moderately concerning given the film has been well received by audiences and critics alike, with the film being characterized in a *Los Angeles Times* review as successfully drawing on its cast of musician interviewees to clarify how "[the 808]

helped to develop and foster a pivotal mix of new musical genres” (Goldstein 2016). I am troubled by Dunn’s argument being absorbed by a new generation of music fans and the marginalization of Kakehashi in this narrative.

Dunn begins his argument that contemporary music would sound “completely different” without the 808 with Afrika Bambaataa and The Soulsonic Force’s 1982 hit “Planet Rock.” He provides a cursory account into the song’s recording and then surveys subsequent recordings, arguing that the sound of “Planet Rock” had an immediate and profound impact on [rap] production norms. To tell the story behind the single, he interviews Soulsonic Force’s Afrika Bambaataa, Mr. Biggs, and G.L.O.B.E. (respectively Lance Taylor, Ellis Williams, and John Miller) as well as producer Arthur Baker. In the traditional ‘making of’ style of popular music documentary, Dunn interviews the group about the studio sessions in which the single was recorded.

In their interviews, Taylor and his collaborators describe an uncanny and visceral response to the 808’s sub-bass. Williams enthuses how the low end elicited an immediate and wildly enthusiastic feeling that articulates with an enthusiastic “Yo, what the hell?” while grinning from ear-to-ear, while Miller recalls how “Your whole body would just shake.” Baker enthuses the 808 kick offered “a low end that you couldn’t really hear” and that it could “just blow up a speaker.”³⁸ Taylor steps back a bit in his assessment, describing the song’s innovation as adding “The soulful bass volume that was needed,” to the iconic melody borrowed from Kraftwerk’s “Trans-Europe Express” (1977).

Never mind the novelty of rapping over a 128 bpm—dramatically uptempo from other production at the time—beat, the otherworldly vocal processing and

³⁸ That explosive claim was not hyperbole. In a Point Blank Music School session Baker reminisced how in 1982 a “Planet Rock” test pressing did blow up the speakers, much to the chagrin of the record buyer at Rock and Soul Records (2022).

post-P-Funk afrofuturism, and other enduring innovations within the song, which include popularizing the ORCH5 digital sample, an orchestral hit of a pitched “brooding minor triad” from Igor Stravinsky’s ballet *The Firebird* (Fink 2005, 341). In Dunn’s editing of the Planet Rock interview sequences, the 808 sub-bass is positioned as a kind of musical glue that holds the “Planet Rock” mix together, and a template for new sonic aesthetics. This sentiment is perhaps most succinctly described by Pharell Williams when he describes the 808’s sound as “tech-y,” appended with the disclaimer that “[but] we didn’t know what tech-y was [yet].”

Dunn’s framing of “Planet Rock” aligns with orthodox histories of the song. In *How To Wreck a Nice Beach*, Dave Tompkins lingers on its futurity noting its 1982 release coincided with *Time* magazine naming a computer ‘man of the year’ (23), and also crediting the song with “[giving] us Miami bass, due to its speed, sub-frequency ... and an orchestra stab” (211). Dan Charnas deems the track the genesis of “the [drum] machine’s takeover of hip-hop (2011, 52). And Nate Patrin describes the track as reverberating “even more loudly and enduringly” in Los Angeles than New York, bundling it in a constellation of tracks, including Debbie Deb’s “When I hear Music” (1984) and Hashim’s “Al-Naafiysh (The Soul)” (1984), that laid a rhythmic foundation for West Coast rap production (2020, 125). Like Dunn’s, most of these readings centre music technology in their readings of the track.

After chronicling the “Planet Rock” studio sessions there is a montage of brief interview segments with Norman Cook, Pharell Williams, Armand Van Helden, and David Guetta, all offering testimonials about their transformative first experiences in hearing “Planet Rock.” Narrator Lowe returns for another segue, describing how the song kicked off “*A new movement in music ... headed by the 808,*” and that it

marked “*The beginning of electronic music as we know it today.*” The argument structure is more or less in place at this point, sixteen minutes into the film, and the subsequent interviews paint a deterministic picture of a new form of music “led” by an anthropomorphized Japanese drum machine: first the 808 helped forge one of early rap’s most enduring hits, then its low end catalyzed electro and Miami bass.

Def Jam is positioned as the locus of the 808’s prominence in the mid-late ’80s halcyon days of post-“Planet Rock” rap. Featured are singles by Rubin and other artists on the label’s roster. The film chronicles the evolution in Rubin’s early productions, chronicling the T La Rock hit “It’s Yours” (1984) and the Beastie Boys’ “Paul Revere” (1986). In the former, Rubin captures that raw “sound of the clubs” he regularly cites as the driving influence in his early productions,³⁹ with a rudimentary kick-snare-hats pattern overlaid with scratching; in the latter, Ad-Rock, Mike D, and MCA rap over a *backwards* 808 rhythm, with wonky reversed hats and toms infamously sounding a sluggish heavy rhythmic intro. Fittingly, Public Enemy’s “bass, how low can you go” productions are justly credited as pivotal, with Bomb Squad producer Hank Shocklee describing how *Yo! Bum Rush the Show* (1987) songs including “Rightstarter (Message to a Black Man)” and “Miuzi Weighs a Ton” were “not complete” until the 808 bass undergirded the mix.⁴⁰

Dunn positions Miami bass as developing parallel to mid-1980s rap, with narrator Lowe describing how a “*New sound was developing further south, a sound fueled by the 808 kick drum.*” And this characterization of the 808 being integral to the fledgling genre that centred bass and raunchy lyrics in its punchy uptempo

³⁹ In his burgeoning podcasting career, Rick Rubin regularly discusses his production roots with other musicians. On *Broken Record*, he frequently describes the impetus for his early productions as trying to create bass-heavy rap beats that reflected what Bronx clubs *sounded* like circa 1983.

⁴⁰ Hank Shocklee makes a throwaway comment about Marley Marl that warrants mentioning: Marl famously innovated by using 808 sub-bass under other sampled drum kicks, creating a *double* kick that is now ubiquitous across rap. This important point is only touched on briefly here and in another segment about the recording of Dynamix II “Just Give The DJ A Break” (1987).

rhythms is *not* hyperbole. David Font-Navarrete has whimsically characterized Miami bass as “a frequency-based fetish” and namechecked the prominence of the 808’s cowbell, conga, and clave voices in the genre as “stylistic analogs for Miami’s image as artificial and generically Latin” (Font-Navarrete 2015, 490-1). Dunn examines Pretty Tony’s “Fix it in the Mix” (1983) and L’Trimm’s “Cars with the Boom” (1988) are examined, with Tony Butler and L’Trimm’s Lady Tigma explaining the Miami ethos. The former speaks of ignoring the audio engineers that told him, “You can’t put that boom on a record,” when producing his breakout hit. The latter (egregiously the only woman featured in this oral history) describes how her subwoofer ode echoes the Miami credo that “You were fly if your speaker system rattled windows.” Lady Tigma astutely links 808 sub-bass with projections of masculinity—the desire to be “respected, admired, or feared” (Wilkins 2017, 210)—in Southern slab culture.

Historicizing the New York-Miami arc comprises two-thirds of *808*’s running time. I think the reason the film dwells so much on the early and mid-1980s—two genres—are nostalgia and narrative clarity. The narrative Dunn constructs is best served by discussing distinct, recognizable, and beloved genres, and this is easiest to frame through a rearview mirror. Despite his assertions that the sound of the 808 is ‘still going strong,’ he freezes Roland’s drum machine in time within his film. The remainder of *808* is a tableau of scenes and genres and provides a slapdash historicization of the 808’s importance in electronic music. After surveying ’80s rap, electropop, Miami bass, and R&B with a moderate degree of rigour, electronic music is unsatisfyingly distilled down to formative techno, house, and drum ’n’ bass tracks (Cybotron’s “Clear,” 1982; Sleazy D’s “I’ve Lost Control,” 1986; Omni Trio’s “Renegade Snares,” 1993); Italo disco (Klein & MBO “Dirty Talk,” 1982); Charanjit Singh’s singular explorations of Indian raga melodies with the 808 and other Roland

instruments (*Synthesizing: Ten Ragas To A Disco Beat*, 1982); and then a conspicuously janky temporal jump to 2000s electroclash and Chicago House (Tiga & Zyntherius' cover of "Sunglasses at Night," 2001; Felix Da Housecat "Kickdrum," 2009).

I'm not faulting Dunn here. Historicizing electronic music in ninety minutes is impossible, and one could easily film a fifteen-hour documentary on the topic that still elicits grumbling from purists about omissions. But while Dunn establishes the foundation of the "new musical movement" he espouses, his delineation of what that movement entails is ill-formed due to the gap-ridden history he postulates. The viewer is left to triangulate comments from a hodgepodge of contemporary DJs and producers including the aforementioned Guetta, Richie Hawtin, and Diplo. Dunn's narrative is basically: the TR-808 dropped out of the heavens offering previously unheard low-end frequencies and unavailable rhythm programming possibilities, new genres emerged, and they persist to this day. No context is provided as to where Roland's machine sits in the current music technology landscape, or what electronic or digital instruments push the envelope in a similar fashion today.

As *808* winds down, 1980s and '90s production team and Janet Jackson hitmakers Jimmy Jam and Terry Lewis assesses the 808's legacy. They consider it uniquely positioned as a machine that kicked off not just one but "A few musical movements." Lewis opines, "It would be really interesting to read or hear what they [Roland] think about the 808 and the music that's been created from it." Jam replies, "I have a feeling they have no idea." End scene. And then, eighty-five minutes into the ninety-two-minute film, Kakehashi appears and talks about the origins of his drum machine.

Before I discuss Kakehashi's appearance late in *808*, I want to underscore my disdain for Jam and Lewis' comments—the jokey assumption that Roland engineers didn't understand what their own machines were capable of or their impact on modern music. It was a quip, and the duo clearly hold Roland in high regard,⁴¹ but the way Dunn uses the comment to transition to the next segment in the film delineates a lazy and unnuanced distinction between East and West. A distinction between who makes the machines and who plays them.

To be generous, it felt like Dunn only had access to Kakehashi for a brief window. The octogenarian Roland founder appears with breathing tubes in his nose and the interview was filmed a few years before his 2017 passing. Questions of access notwithstanding, making Kakehashi, Roland Corporation, and Japan into an epilogue—an afterthought—is a dubious decision. And what Kakehashi offers is a monologue about the device's conception, design, and integrally, it turns out, component sourcing. As mentioned earlier, he shares that the price of microprocessors in the late 1970s was prohibitively high, so rather than go down the digital road (like the “real drums at your fingertips” Linn Electronics' LM-1 offered, as discussed at length in my first chapter) Kakehashi emulated drum sounds with cheaper analog electronics. The big reveal in the interview is that Roland intentionally purchased defective transistors to use in the 808's noise circuit, creating “the sizzling sound” the device became renowned for. “Semiconductor technology got better and better and there was no way to come back,” he says of how Roland was ultimately ‘boxed in’ by this design decision and rapidly improving (and more affordable) microprocessor technology. The film ends with a caption explaining the

⁴¹ Jam and Lewis wrote the foreword to *Inspire the Music: 50 Years of Roland History*, a hefty tome mapping out the entire history of the Japanese instrument maker. There, the duo affectionately write “[Roland] not only gave us our first hits as producers, but they also introduced the 'boom' into R&B music.” (Metlay and Reid 2022, 5)

808 was discontinued after its 1980-3 production run of 12,000 units when Roland could no longer source the transistors. Despite the obsolescence, a final cloying caption states “the 808’s heart continues to beat today.”

The Life of Ikutaro Kakehashi

A musical instrument is not a pure distillation of the biography of its creator, but by limiting Kakehashi’s visibility in his TR-808 documentary, Dunn situates the machine’s significance within a narrow frame. Beyond documentarian negligence, he missed out on considerable storytelling potential given the improbable and Hollywood biopic-worthy life of Roland’s founder. Instead, he relies on a cast of recognizable musicians that produced recognizable songs featuring the device, and argues the 808 was foundational bedrock for recognizable genres. My intervention is to dig beneath this ‘ground’ implied by Dunn’s narrative and think about how we might use Kakehashi’s life (and death) to consider the 808 and its circuits. Songs like “Planet Rock” and “Clear” are certainly integral to the 808’s mythology, and rap and techno genre histories, but I posit by re-centring the device’s creator—and the company he built—it yields new insights in what was gained and lost from the birth, obsolescence, and seemingly enduring relevance of Roland’s most famous drum machine.

In the following section, I sketch out Kakehashi’s biography including the launch of his first fledgling company, Ace Tone, and his second, Roland Corporation, and then expand on the significance of his erasure in *808*. In many ways, Kakehashi’s personal and corporate biography mirrors how Japan bootstrapped its cratered postwar economy into a consumer electronics giant in just three decades. Kakehashi literally embodies a key twentieth century historical trajectory of his

homeland. To illustrate this, I draw heavily on Takehashi's *two* music industry memoirs: *I Believe in Music* (2002) and *An Age Without Samples: Originality and Creativity in the Digital World* (2017). The latter subtitle is important because, on reading, the tone of his second book suggests Takehashi had some things to say about his lifelong dedication to instrument making and the nitty-gritty details of running an international business that did not fit into the structure of his first, more standard autobiography. Interestingly, the latter contains many sequences from the first book, some reproduced verbatim, but others refined, revised, and fleshed out; it's clear that Takehashi was interested in 'getting his story right' late in life, so my intervention is an attempt to honour that amazing life and bring some of his wisdom to Dunn's characterization. And the TR-808 (and Roland) is not *just* a story about Takehashi either. Tadao Kikumoto was the lead on the 808 design and along with other engineers he made the device within the house that Takehashi built.

Instructively, in *An Age Without Samples* Takehashi speaks to the erasure of instrument makers. In a several-page segment, titled "Quiet are the Makers," he observes that orthodox narratives about musical instruments emanate from books produced by "performers, composers, critics, and historians of music." The critic in particular, he laments, has the power to subject a humble instrument maker to a Kafkaesque "trial without a defence." He notes that because of the novelty of electronic instruments, "It is impossible to expect people to be satisfied with and understand everything that we do" (209-10). It is precisely this concern that drives my (re)encapsulation of his biography here.



Figure.xvii Ikutaro Kakehashi

Ikutaro Kakehashi was born in Osaka in 1930 (Fig.xvii). Raised by his grandparents after his parents died of tuberculosis, he came of age during the Second World War. Kakehashi developed an affinity for electronics in his teens and drew energy from the “tunes and harmonic structures” of the era's patriotic music and scanning the airwaves with a homemade crystal radio set (2002 1-2). Among the first traumatic reflections in his autobiography are tales of the firebombing of his childhood home and his conscription, when, as a shipyard student worker, among other manufacturing duties, he discovered with horror that kamikaze submarines were being produced at the facility where he worked. In the aftermath of the war, he applied for a chemical engineering program at an Osaka university but failed an entrance health exam due to protracted malnourishment. Kakehashi left Osaka to join his relatives in rural Kyushu and found work as a surveyor; he became fascinated with clocks and was taken on as an apprentice in a local repair shop. A quick study, he rapidly learned clocks' inner mechanisms and became adept at their disassembly. His master admonished him for having the audacity to ask for instruction about (more elaborate) wristwatch repair just a few months into his

apprenticeship; the apprenticeship process took seven years, and a long regime of deliveries, polishing, and bookkeeping was scheduled before wristwatch training. He quit, studied a mail-order watch repair manual, opened his own repair shop, and began learning about the world of contrast between shoddy Japanese wristwatches and the intricacy of Swiss craftsmanship. As his business grew, he expanded his tinkering to radios. Noting that while watch repair brought a sense of pride, “It was nothing like the sense of accomplishment I felt when I created an all-new radio receiver.” (9) Kakehashi began salvaging defunct receivers, creating functional radios from the parts of derelict devices. After four years of timepiece repair and radio tinkering, he sold his shop and headed to Osaka to study electrical engineering at Nishinoda Technical High School.

Kakehashi's plans for a fresh start were short-lived—in 1950, he was hospitalized with tuberculosis. Sent to National Sengokuso Hospital, the treatment regime of the era was 'idleness and fresh air,' so he had endless time on his hands. Kakehashi built a radio receiver so he could sequester himself to headphones, insulated from the hospital's administrative squalor and the lingering presence of death, without disturbing other patients; he borrowed money from a family member and purchased a prohibitively expensive vacuum tube and constructed an ad-hoc television—and tuned in to the very first Japanese broadcasts, gathering throngs of patients who marvelled at static and test patterns. His condition deteriorated, and in his fourth year at Sengokuso—diminished to eighty pounds—Kakehashi was selected to participate in an experimental streptomycin injection treatment. It saved his life. Ill for the same amount of time it would have taken to earn a degree, he resiliently declared himself a graduate of “Sengokuso University,” married his fiancée

Masaka, who had steadfastly supported him during his illness, started a family, and opened an electrical appliance repair shop in Osaka.

In 1958, Kakehashi Musen expanded its offerings from radio and television repair into home appliance retail. He changed the business name to Ace Electronic, and after intriguing encounters with a Theremin and Ondes Martenot, decided he wanted to design and manufacture electronic instruments. It was hearing the majesty of an electronic organ at a church, one that produced “authentically wonderful sounds produced by readily available technology” (33) that cemented these goals. By 1960, he had developed his first prototype, obtained financing for production, and sold the design to Technics, who released it as the SX601 electronic organ. Kakehashi describes this period as working in a vacuum, as electronic instrument design in Japan “was individual amateurs operating in relative isolation” via “trial and error” (35). Ace Electronic shuttered its appliance retail arm to focus entirely on electronic instrument design.

Kakehashi ventured to Chicago for the National Association of Music Merchants (NAMM) show in 1964, taking two designs: the Canary S-2 and the R-1 Rhythm Ace. The former was a curious vacuum tube clavoline that never went into production, the latter was a clumsy first step toward the modern drum machine. Unlike the 1958 Wurlitzer Sideman, which was tube-based and electromechanical, Kakehashi used analog circuitry to model the R-1’s six drum voices; the Sideman played fixed genre loops (e.g. waltz), the R1 had six buttons⁴² that were tapped to trigger one-hit drum sounds. At that first of many NAMMs he would attend, Kakehashi discovered he was no salesman, but his marketers couldn’t do much better, as Roland self-defeatingly pitched the first “fully transistorized” rhythm

⁴² The R1 curiously did not emulate a full trap set: it had a pair of toms, wood block, clav, maraca, and cymbal voices.

machine as “quite useless for an organist” (Metlay and Reid 2022, 12) when that was the intended customer base. While he did not find a product-market fit at NAMM, Kakehashi derived satisfaction from the fact that ten established firms purchased the R-1 to tear it down in their R&D labs.

Ace Electronic's early product line was primarily organs, capitalizing on Japan's fervent interest in keyboard-based instruments. But Kakehashi stuck with and iterated on the design and functionality of his first rhythm box, despite the fact it was a commercial failure. Because organists lacked the required third arm to tap out rhythms while playing keys, his next design needed to automate rhythm production. Under the freshly rebranded Ace Tone moniker, the Rhythm Ace FR-1 was released in 1967 and featured an innovative diode matrix circuit that subdivided musical time and sequenced drum voices across sixteen generic loops (rock, waltz, swing, rumba, etc.). Contemplating musical timing for several years by this point, Kakehashi knew that a bar needed to be subdivided into *at least* twenty-four pulses to capture foundational rhythms via quantization, the FR-1 doubled that. “Although a 48-part division was not truly sufficient to produce technically accurate sounds, it was not economically feasible to go further” (Kakehashi 2002, 57). The diode matrix was also unforgiving in how it sequenced and routed the genre loops, and they were effectively fixed (hardwired) into the circuitry. The design offered the ability for exploration of the loops though, with bass and balance dials to sculpt the mix; mute buttons for the bass drum, cowbell, clave, and cymbal voices; and the idiosyncratic ability to layer loops by pressing multiple genre buttons at once (mambo-rumba!).

While Kakehashi was frustrated by its crude subdivision of musical time, the FR-1 marked “a turning point” for Ace Electronic. Its positive reception in Europe laid the foundation for future distribution networks, and American organ virtuoso (and

later Roland consultant) Don Lewis was so struck by the device he incorporated it into his high-profile performances (Kakehashi 2017, 90).⁴³ 1967 also marked the beginning of a partnership with Hammond, who incorporated Ace rhythm units into their product lines and subcontracted Japanese organ manufacturing to Ace Electronic; Kakehashi personally oversaw the retooling of a piano production facility in Hamamatsu, foreshadowing the role he'd play in modernizing Japanese instrument manufacturing in the coming decades. All this momentum was for naught, as a new investor brought on to finance the Hammond partnership was taken over by a Chemical company, which became a majority owner of Ace Electronic. These new owners had no interest in music and the situation quickly became untenable. In 1972, Kakehashi resigned from the company he founded.

For his second act, Kakehashi used his hard-earned business savvy to create a sturdier foundation for progressive electronic instrument design. In his autobiography, he describes his deep curiosity about “the science of time” as emerging from recognizing that “traditional timepieces embodied the quintessence of machinery.” With Roland, the wristwatch-tinker-turned-rhythm-box-designer set out to “discover and define new market sectors” and give musicians new modes of expression (2002, 65-6). Roland Corporation was founded to trailblaze and experiment—not closely adhering to tradition—and we can see the origins of his “we don't chase ghosts” credo in his second company's first principles.

Due to the cutthroat nature of the domestic Japanese market, as well as the positive reception the FR-1 received in Europe, Roland launched with global ambitions. Kakehashi spends more ink describing cash management and credit arbitrage than instrument design, and the earliest Roland accomplishments he

⁴³ Not only a virtuoso, Don Lewis was a gifted engineer. A friendship blossomed between him and Kakehashi, and he contributed to the CR-68, CR-78 and TR-808 designs.

mentions were European and North American distribution deals. Roland released its first products in 1972, many expanding on his Ace Electronic rhythm machine designs. This included the TR-33 -55 and -77 series which iterated on FR-1-type functionality at different scales. In 1973 Roland released the TR-66 Rhythm Arranger, a cuboid little cabinet-enclosed box with a handsome panel featuring tempo and rhythm variation dials, voice toggles up top, and a row of genre selection buttons underneath. The sound in Kakehashi's 1970s designs was improving incrementally design-by-design, but this post-Ace Electronic burst of iteration is where he began to move towards the form factor that would be so celebrated with the 808 and 1980s designs. Mid-1970s Roland design features include instrument parts, per-voice faders, combinations, variations, and usability-enhancing panel section colour coding (Metlay and Reid 2022, 15), all of which came to a head with the release of the Roland CompuRhythm CR-78 in 1978.

The CR-78 was a clever little box that took the generic loop concept from the earlier designs in new directions: several individual voices could be muted, loops had variations that could be toggled between, and, notably, the device was the first drum machine to incorporate a microprocessor, which provided a pittance of Random Access Memory (RAM) to store a whopping *four* user-entered rhythms. Players could tap out their own beats with a peripheral device. While the sonic fidelity was still lacking compared to a drum kit, it marked a step forward—the CR-78's hi-hats had a metallic voice setting that delivered a signature tinny sound that endeared itself to British New Wave producers. The clave and block voices were idiosyncratic and playful. Beyond its novel programmability, the CR-78 had *character*.

One British New Wave musician who fully embraced the CR-78 was John Foxx, who celebrated its diminutive tinny sound in his 1980 single "Metal Beat." Foxx

is a pertinent figure because, on the one hand, he used Roland gear to forge a singular aesthetic, and on the other, his attitudes reflect an emotional distance from Kakehashi and the Roland Corporation. Even decades after his prolific early 1980s use of the CR-78—its rhythmic loops—in a 2014 interview, he ungenerously refers to its stock patterns as a “non-dancing Japanese programmer’s idea of strange Western generic rhythm patterns” (‘Drum Patterns and Memories: 12 Artists Reflect on Iconic Drum Machines’). While he acknowledges the CR-78’s sound “endeared it to me immediately,” these comments underscore the stark cultural divide between Eastern instrument manufacturers and Western musicians.

The broader history of instrument manufacturing is full of fruitful relations between instrument makers and musicians using their kits. In drumming, Gene Krupa famously endorsed, consulted for, and performed on signature kits by the Slingerland drum company (Brennan 2020, 146). Due to the distance between Japan and the West and Japanese and English, and his rapid procession of models, Kakehashi did not seek out specific musicians to endorse specific drum machines. He found both lifelong friendship and impassioned advocates in organist and fellow instrument-maker Don Lewis and jazz pianist Oscar Peterson, but Roland’s 1970s and 1980s drum machines never benefitted from endorsements and star power. The machines—their sound, their capacity—spoke for themselves.

Kakehashi’s Machines

In Dunn’s documentary, Roland’s pre-history from Kakehashi’s birth through the corporation’s formation through its release of the CR-78 is collapsed into a 30-second montage. This suggests Dunn considered the key figure behind the 808 somewhat incidental in his story about the instrument. Yes, Dunn provides

Kakehashi ‘the final word’ about his fabled drum machine, but the detail Roland’s founder provides is largely unsatisfying aside from the tantalizing revelation about the defective transistors—and that avenue is left unexplored. That Dunn chose to centre musicians is perhaps understandable, as lay music fans develop emotional connections to songwriters and producers—not the inventors of the kit used to make the songs they love. But engineers like Robert Moog, Roger Linn, and Don Buchla have received retroactive recognition for their innovative designs. Roland is a household name in electronic instruments, why does Kakehashi—as an individual—not have the same name recognition as his peers? The fact he is Japanese is undoubtedly a factor, but the degree to which Roland Corporation dwarfed scrappy American operations like Moog Music is probably more to blame. Paul Théberge has written about the dichotomy between invention and innovation in electronic instrument design (1997, 42), and it’s easier to attribute breakthroughs (inventions) to a genius designer than recognize the nuance of sequential product-by-product improvements (innovation). Working at scale and often vertically integrated, corporations excel at the latter.

None of this broader electronic instrument political economy is broached in *808* and Dunn instead fetishizes the Japanese-ness of Roland when he finally introduced Kakehashi. Before Kakehashi speaks, Japan is introduced in a brief montage. In it, a traditional Gagaku string arrangement and sparse 808 tom, snare, and hi hat pattern (fusing old and new) plays over Tokyo street scene B-roll. The segment is rife with clichés, including footage of Shibuya Crossing, the Shinkansen bullet train whizzing by the base of Mount Fuji with a field of blooming pink shibazakura in the foreground, and, least subtle of all, a time-lapsed sunrise. Curiously, a clip documenting the 1970s Japanese electronics manufacturing boom,

which introduced Americans to globalized production and consumption (McKevitt 2017), did not make the cut for this establishing sequence. Other than the noise circuit discussion, you wouldn't know about this history from Dunn's interview with Kakehashi. What goes unsaid—what is lost—is how Kakehashi's biography mirrors Japan's comeback trajectory, and how it embodied the deleterious effects of wartime austerity, reinventing himself through watch and radio repair, and his navigation and mastery over the electronic instrument manufacturing landscape, both nationally and internationally. Neither Japan's nor Kakehashi's incredible 'comeback' makes it into Dunn's historicization of the 808. The comeback narrative is also seldom featured in electronic instrument trade publications or electronic music histories, which generally take Roland's legacy and run of iconic 1980s instruments for granted. One-off explorations of the 808's legacy tend to be oriented on the far ends of a spectrum that ranges from technical analysis (Werner 2015) to explorations of the affective and aesthetic qualities of the drum machine (McKittrick and Weheliye 2017).

What Dunn's narrative suggests is that hip-hop culture was more influential than the machines used to make music. This framing is slightly surprising since Arthur Baker has a production credit on the film. One would expect the studio to play a more prominent role in the film beyond being the environs in which the various featured songs 'happened.' In an establishing montage, Kakehashi's R-1 design flashes on screen; it's attached to an organ, and the shot bolsters an observation from Questlove that the earliest drum machines were only useful for accompaniment. In Kakehashi's extremely condensed biography, the CR-78 is reduced to "a rhythm machine with basic programmable features" before Dunn jumps into the 808 'came out of nowhere' narrative.

Make no mistake: the 808 *did* come out of nowhere, as far as rap is concerned. But Roland's previous rhythm machines like the DR-55 and the CR-78, and the broader landscape of American competitors like the Linn Electronics LM-1, Sequential DrumTraks, and the Oberheim DMX all carved out hallowed little corners in 1980-2 music production. Each machine endeared itself to particular producers, and each engendered sounds and styles while rap production norms were still in flux. And this was just the *early* 1980s, E-mu Systems released the Emulator II (1984) and SP-12 (1986) in the following years, and increasingly affordable sampling gained steam to capture the imagination of rap producers. This shift from drum machines to sampling is never really addressed by Dunn, but *808* does provide passing mention of how producers like Marley Marl, Hank Shocklee, and Dynamix II used sampling to layer the 808's signature sub-bass kick under other kick drums—crafting a kick that 'hits' at two frequencies—but that producer's trade secret is never flushed out in the film.

The only reason Dunn provides for the termination of the 808's production run is 'defective transistors.' That was undoubtedly a factor, but unmentioned are two major technological innovations that were introduced in 1983: the MIDI interoperability standard and the arrival of the Yamaha DX7, the first consumer-grade digital synthesizer. The former, which Kakehashi incidentally was integral in developing, facilitated a free flow of synced musical data across devices from competing manufacturers, allowing producers more flexibility in building a studio populated with kit from various vendors.⁴⁴ The latter was a commercial bonanza for Yamaha that sold hundreds of thousands of units and shifted the focus

⁴⁴ My earlier claim that Kakehashi does not garner the same 'name recognition' of Robert Moog, Roger Linn, and other engineers does have one notable exception: in 2013 he and Dave Smith received a Technical Grammy Award for developing MIDI. While MIDI was truly a game changer for networking instruments, the impact of the interoperability standard he co-designed arguably overshadows his instrument design.

away from the waning analog-era squelchy electronic instruments toward a new pristine digital sound almost overnight. Long associated with futurity, the sonic aesthetic of analog electronics were suddenly moribund. While the defective transistors may have made production beyond the 1980-2 run of 12,000 units untenable, there were much bigger shifts happening in the electronic instrument market that drove Roland's decision to discontinue the 808 than the unavailability of a key component.

Haunted Circuits

In Rick Rubin's final appearance in the film, the producer wrestles with the tension between the fact the 808 "was obsolete after 18 months" and the irony that, here he is, still talking about it 35 years later. "Because it was used on these great records it has such a signature sound, it lives on forever." And while that paradox acknowledges technological obsolescence, Kakehashi and Roland are both absent from that equation. And I think about not only that conspicuous absence, some of the implications of which I have teased out, but the fact that Kakehashi, who died in 2017, is now gone as well. Dunn's documentary does a serviceable job of capturing how the 808's sonic boom haunts the ears of listeners to this day, but I feel obliged to consider how Kakehashi haunts his machine. I want to chase *his* ghost, and the place that makes the most sense to do that is not the low frequencies recorded from the machine, but the circuits from which those sounds *emanate*. A site where certain logics of signal processing were *inscribed* and where certain aesthetics emerged from the material conditions of circuitry. Kakehashi's biography or Roland's corporate history are not literally inscribed there, but in the following section I will speculatively argue that they *could be*. I'm guided by Avery Gordon, in particular, who offers

advice for ghost chasers when she channels William James to describe the condition of being haunted as affective and as drawing us into a structure of a feeling that imparts “not cold knowledge, but a transformation of recognition” (2008 [1997], 8). According to Gordon following ghosts is not simply about being corrective, looking for a ‘fix’ to patch-up an erasure or under-crediting, but a striving to understand how a memory was created and possibly yield a “countermemory, for the future” (22).

I will consider the notion that Kakehashi haunts the 808 on two fronts: the material and the affective. The former is a site of considerable mystification and obfuscation in electronic music as the analog circuits that generate and sculpt signals are weirdly *under*-discussed in popular music scholarship—most electronic music analysis fetishizes synthesizers and drum machines and treats them as monolithic objects rather than assemblages of discrete components. Here, I will draw on Thor Magnusson’s notion of the electronic instrument as a distinct instrument class, as well as scholarship by Paul Théberge, Nicholas Collins, and Ezra J. Teboul, to set up a conversation about some of the idiosyncrasies of the 808’s circuits. This analysis will be followed by discussions of two instances where the 808 haunts contemporary electronic instruments: the burgeoning market for clones of Roland’s fabled machine and the curious ‘afterlife’ of the TR-808’s analog circuits in subsequent digital machines made by Roland. My goal with this analysis is to recentre the framing of classic Roland designs at the circuit rather than interface level. However, it’s not an accident that these kinds of readings of circuits are insular affairs because while a listener can connect with tones, the technical configuration of the device that produced them is not necessarily important to that connection. So, after delineating how Kakehashi haunts the 808’s circuits, I will briefly consider bass (and particularly sub-bass) as the place where listeners encounter his presence.

For all the ink spilled valorizing electronic music the simple question, ‘What is a circuit?’ is conspicuously unasked by many of the popular music writers that have mythologized the genre. The soaring narratives of Kodwo Eshun and Simon Reynolds, the herstories documented by Tara Rodgers,⁴⁵ and even in Trevor Pinch and Frank Trocco's monograph on the Moog synthesizer the circuits themselves do not get much airtime. And this is presumably for good reason as you don't need an electrical engineering degree to appreciate the rich timbres that an analog circuit produces. Hearing a rich tone (or kick drum) is visceral—you not only hear it, you *feel* it. However, blackboxing the electronic instrument skews perception of its material qualities and what that particular instrument is even doing when in use. As noted by Ezra J. Teboul, a circuit is a site where knowledge, resources, and intention are “crystalized” and there is an inherent “lossiness” between the circuit itself (as an opaque artifact) and the song or performance that is coaxed out of it (2017, 126).

At the most basic level, a circuit is a closed network where “streams of electrons are controlled and manipulated” (Mims 2000 [1983], 22); it's an assembly of a power source and a combination of resistors, inductors, capacitors, switches, and transistors that collectively generate alternating pulses of electricity. These pulses take the shape of rigid on/off signals and more sinuous, sawtoothed, or triangle waves, which can make tones or manipulate other signals. At a fundamental level, circuit assemblies can function as logic gates and execute a vocabulary of boolean functions like AND (join signals), OR (switch between them), NOR (invert a signal), etc. to contort signals in dramatic and sometimes unpredictable ways, generating the rich timbres electronic music is revered for.

⁴⁵ A noteworthy exception in *Pink Noises* (2010) is Rodgers exciting conversation with ex-Buchla engineer Jessica Rylan, a musician whose compositions are intrinsically centred on custom circuit designs. Rylan's practice is also discussed in Ezra J. Teboul's dissertation *A Method For The Analysis Of Handmade Electronic Music As The Basis Of New Works* (2020).

Famously, Robert Moog began a dialogue with Herbert Deutsche in 1963, and Moog—still selling theremin kits at the time—began designing circuits for composers and artists working with sound. Deutsche explained the concept of an envelope (a temporal window in which a sound happens) to Moog, who quickly whipped up a schematic—their envelope generator proof-of-concept was controlled by a doorbell (Bjørn 2020, 13).⁴⁶ Moog worked out a series of modular stock circuits, including oscillators (sound sources derived from basic waveforms and offset signals), filters (for modifying waveform harmonics), low-frequency oscillators (LFOs, signals that modulate other signals), and amplifiers that, in aggregate, prototyped what is now commonly referred to as ‘subtractive’ synthesis. Moog also originated the volt-per-octave standard for moving up and down the chromatic scale by modulating voltage—as well as the ‘synthesizer’ nomenclature itself. The first implementation of Moog’s ‘musically useful’ circuits was a hulking modular system that filled a room and engendered a logic of nonlinear signal routing and rerouting (via patch cables) in which players physically enacted the logic of forging connections across the underlying components. Moog competed with San Francisco-based Don Buchla to furnish the labs and studios of artists and academics interested in the nascent field of electronic music with dueling modular systems. In 1971, Moog distilled the learnings from these daunting and modular systems into a compact form factor with a much more prescriptive signal routing workflow: the Minimoog. With a 3.5-octave keyboard as an interface, an affordable price point, and portability for gigging musicians, the synthesizer moved “from the studios to the streets” (Pinch and Trocco 2002, 257) and was democratized, setting the mass-market commercial synthesizer industry in motion. Until this point, composers exploring electronic sound were either

⁴⁶ A plucked violin string will sound and dissipate, but an electronic tone is continuous. An envelope generator controls the amplification of a tone so it sounds, sustains, and falls off.

crafting “shambolic arrays” of homemade noisemaking circuits (Collins 2015) or purchasing fabulously expensive modular systems by Moog or Buchla.

Takehashi was working in parallel to Moog, but a world away from the Western music industry that welcomed inaugural synthesizer breakout albums and singles like Wendy Carlos’ *Switched-On Bach* (1968) and Emerson, Lake & Palmer’s “Lucky Man” (1970) that sparked interest in fresh, strange, and otherworldly tones. Takehashi, Moog, Buchla, Oberheim—all of these engineers and entrepreneurs spent the 1970s hunched over workstations, thinking through different circuit schematics, soldering prototypes, and—crucially—trying to integrate their circuit design prototypes within form factors and interfaces that were intuitive to musicians. It was a clumsy affair, and it was over almost as soon as it started.

In 1975, Dave Rossum and Scott Wedge of E-mu Systems developed a microprocessor-controlled keyboard scheme for synthesizers. As noted by Paul Théberge, the microprocessor was a “technological discontinuity” that destabilized still-not-established design norms in the nascent industry (1997, 57), and it was also the harbinger of the digital revolution. The breakthrough programmability of Takehashi’s 1978 CR-78 design was enabled by a microprocessor; Dave Smith also used microprocessors in the iconic Prophet-5 in 1979. There was barely even consensus on what form factor synthesizers should take by the late 1970s, and digital technology was already coming for analog electronics. First the microprocessor, then the MIDI standard and digital synthesis, then affordable digital sampling. This wave of innovation rolled out approximately 1975 to 1985 and the electronic instrument industry rapidly retooled around these new technologies.

Thor Magnusson’s distinction between electrical and digital instruments is useful here. He denotes the former as generating sound from “the material

properties of electricity,” characterized by “chaotic and entropic principles,” and distinguishing themselves from their acoustic predecessors by mobilizing “an increased logic of calculation, science, and engineering.” Conversely, in digital instruments, “the ‘workshop’ is the meta-machine of the computer” (not the soldering bench) and rather than electricity, it’s “a set of instructions turned into binary information” that’s manipulated (2009, 172). The Yamaha DX7 and the mass-market digital samplers that followed marked a fundamental shift away from analog circuits and toward the virtualized digital audio workstation (DAW) and computer-based studios of the 1990s, 2000s, and present era. As noted by Jonathan Sterne, we subsequently use the term ‘analog’ as a stand-in for “everything that’s not digital” (2016, 32).

With all of this noted, it’s important to understand the circuits of the 808 are not an isolated set of circuits reflecting bespoke design decisions and material qualities but a snapshot of approaches to using electricity to model drum sounds at a *particular moment in time* with a *particular set of techniques*. If the device was designed just a year or two later, it could have easily relied on incorporated digital samples (the subsequent TR-909 did for some of its voices), but due to the components and techniques available at the time it was designed to be an affordable electronic percussion instrument. Reflecting on the design process decades later, 808 engineering lead Tadao Kikumoto insists his team set out to make a drum *synthesizer*, not a drum machine (Metlay and Reid 2022, 19). The distinction may seem superficial, but the idea was to provide a palette from which musicians could sculpt a wide range of drum voices. Antithetical to the Linn Electronics LM-1, the goal was not *verisimilitude* but possibility; while Roger Linn famously collected

one-hits and laboured over their bit-reduced waveforms, the 808 team set to work on building on the accomplishment of previous circuits in the CR-78 and -68.

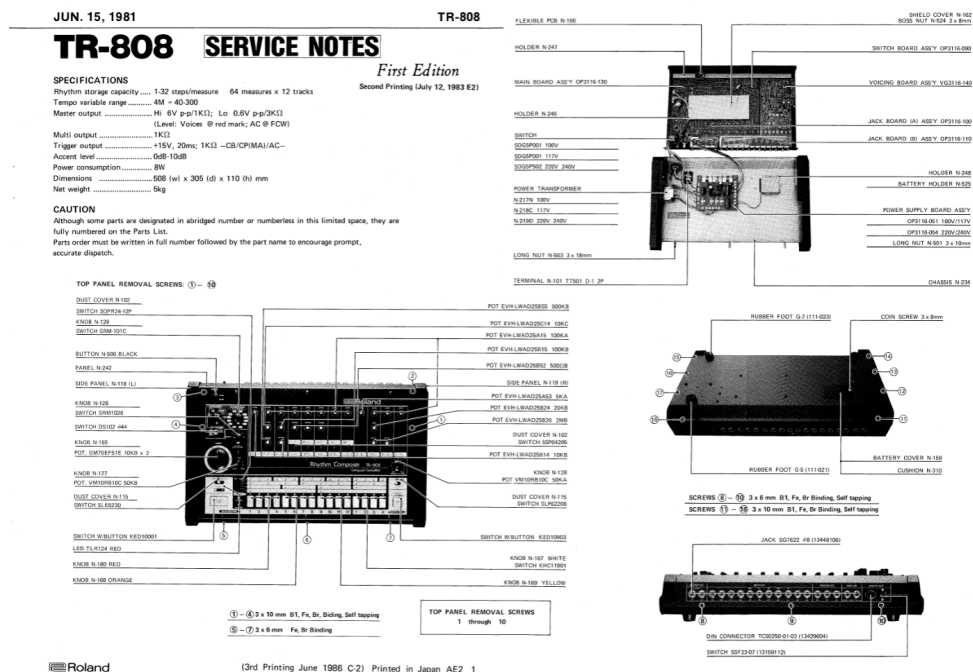


Fig.xviii TR-808 Service Notes (1981)

A Close Reading of the TR-808 Circuits

Getting to the circuits of a drum machine is not difficult, it only requires a screwdriver and a bit of bravery (Fig.xviii). About 10 screws, an oversized tempo dial, and a few other pots hold the 808's interface panel snug against its chassis. Once these are removed the panel, ostensibly a dust shield with the dual function of labelling each knob or dial, can be detached to reveal the machine's components. Inside the chassis there are two assemblies, a power supply that is fixed to the bottom of the case, and a large board that is roughly the entire length and width of the machine sits between the power supply and the interface panel. That main board is green substrate with tiny conductive pathways linking dozens of transistors, diodes, integrated circuits, and semiconductors. Two dozen potentiometers that control different aspects of each drum voice (e.g. the snare drum has dials for level, tone, and snappy) are soldered to the board, as are switches for alternating between

voice options (e.g. low conga vs. low tom), and the 808's signature sixteen-step sequencer buttons (banks of four red, orange, yellow, and white buttons) protrude up from the assembly. The main board is subdivided in half, with basic functionality (input/output, instrument and pattern selection, clock circuits) on the left, and sections on the right of the board are parcelled out for each drum voice (bass drum, snare drum, hand clap etc.). To the uninitiated the mass of components and underlying substrate may as well be hieroglyphics. But while making circuits is a skill that requires some training, a basic understanding of synthesis can render a diagram for an individual circuit (semi) legible.

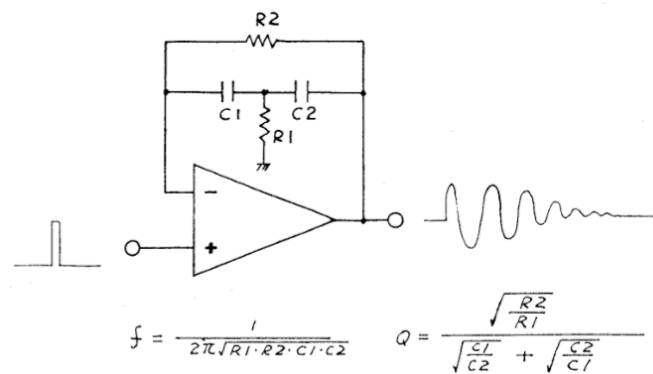


Fig.xix Bridge T-Network Schematic ('TR-808 Service Notes' 1981, 5)

A bridged T-network filter is the circuit at the heart of the 808 (Fig.xix). It is responsible for dampening the release and decay of a percussion hit, which is one of the trickier tasks in modelling acoustic drum-like sound through analog electronics. The *TR-808 Service Notes* dryly describe how “decay time becomes longer as Q increases” (5), when in fact a large amount of the device's character results from this simple design decision. Filters resonate at the user-selected cutoff frequency, creating 'sweet spots' of squelchy texture and feedback. Q signifies the intensity of the resonance. Across many of the 808's voices, resonance controls falloff—the higher the Q, the longer the decay. Variations of this correlation take many of the

instrument's voices outside the familiar confines of acoustic percussion and in strange, otherworldly directions.

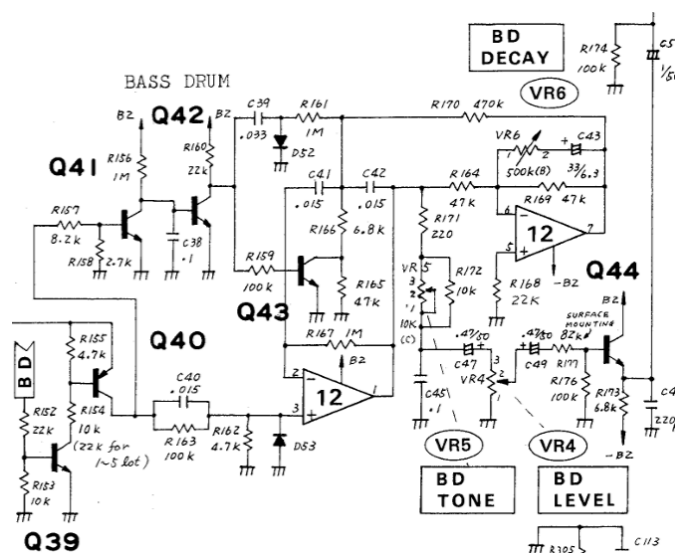


Fig.xx TR-808 bass drum circuit ('TR-808 Service Notes' 1981, 9)

The potentially (it's not default but user-specified) weird lingering decay of the 808 kick is one of the signature aspects of its bass drum and the bridged T-network is central to that affecting quality. As analyzed by a team led by Kurt Werner, the T-network is the primary “block” of the 808's bass drum voice (Fig.xx), and it is central within a subcircuit network that includes a retriggering pulse; pulse shaper; feedback buffer; and a tone, level and output buffer that collectively create qualities that include a pitch sigh and a frequency jump during the attack (Werner, Abel, and Smith III 2014, 2). A kick signal triggers the oscillator with a fundamental frequency of 60 Hz, which passes through the T-network (acting as a low-pass filter) and the signal passes to the voltage control amplifier. It's not a unidirectional signal flow: the T-network filters the pulse shape (envelope), the feedback buffer (tonal colour), and the retriggering pulse (decay or falloff) (4).

A kick accompanied by an accent will *half* the signal's falloff and *double* the frequency it resonates at for a half-cycle period creating “a punchier crisp bass”

(‘TR-808 Service Notes’ 1981); kick programming requires musicians to demarcate where emphasis—a downbeat—is desired, so this simple design decision allows players to alternate between lighter and heavier kicks. This functionality to modulate kicks (and other voices) with accents was standard in drum machines by 1981. In the 808 this simple formula proved to be devastatingly effective.

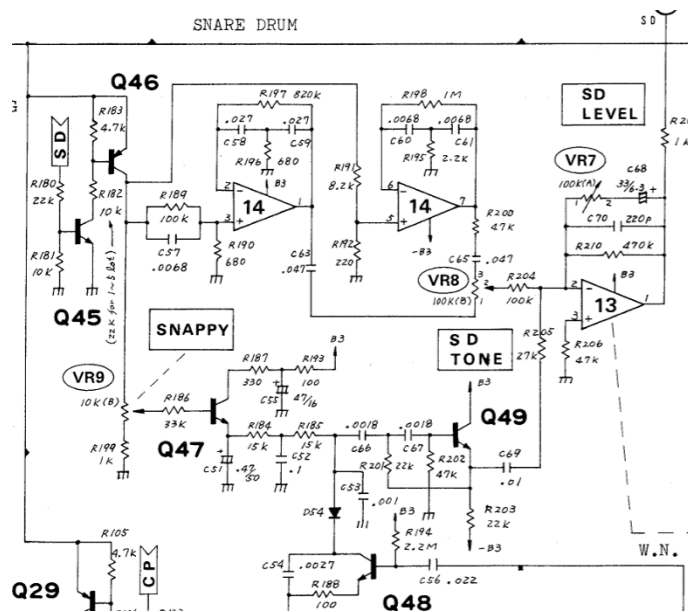


Fig.xxi TR-808 snare circuit (‘TR-808 Service Notes’ 1981, 9)

The snare circuit (Fig.xxi) uses a pair of bridged T-networks to generate a waveform and accompanying (tonal colour) harmonics, allowing nuanced relationships between snappiness and timbre. Here, the T-networks serve as a similar resonant filter, but process *two* pitched sounds—an emulation of a beater hitting a membrane and the resulting falloff—which are mixed together by the T-network, in tandem allowing user control over the envelope and harmonics. Snappiness is user-controlled via a potentiometer.

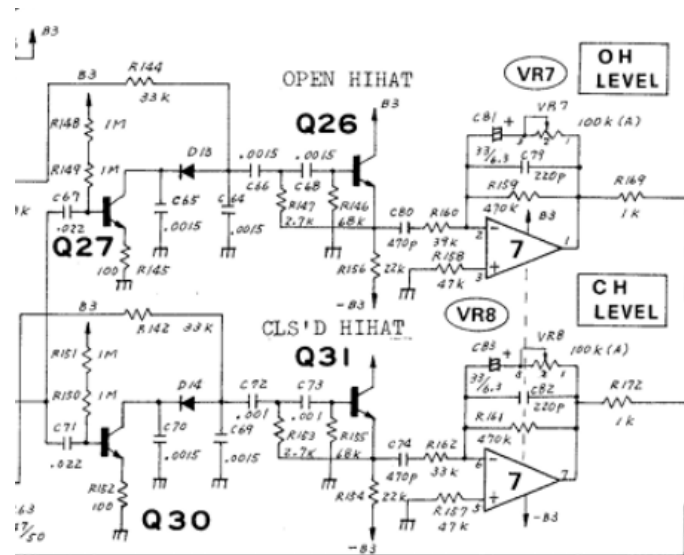


Fig.xxii TR-808 hi-hat circuits ('TR-808 Service Notes' 1981, 13)

Alongside the resonant kick and noise snare, the robotic-sounding handclap is one of the most venerated sounds produced by the 808. When modelling the sound, Kikumoto and team studied handclap sounds on an oscilloscope, observing “a random signal sound ... [passing through] a series of amplitude modulations comprised of several sawtooth-shaped envelopes.” They recreated the sound by passing white noise through a bandpass filter tuned to 1,000 Hz and modulating the resulting sound through a *pair* of envelopes (Metlay and Reid 2022, 20) similar to the snare. One of the envelopes is fleeting, and the other has a longer decay time, emulating the reverberation of handclaps in space, and the two are mixed to create the desired effect. Similarly, the open and closed hi-hats draw (Fig.xxii) on the noise circuit, passing the noise through a high pass filter, and then shaping a sloping decay envelope for the open hat and a more abrupt one for the closed hat.

Kick, snare, hats. Of the 808's voices, these three, in particular, would propagate across genres in the coming decades. First, they became *the sound* of mid-1980s rap, ubiquitous in nascent techno and house (and then enshrined for perpetuity), and then pushed further into commercial R&B, pop writ large, and later

genres including trap and dubstep in the early twenty-first century. Though the sonic character was not solely derived through a low-end kick coupled with resonance and decay wizardry. It was the 'defective transistors' after all, according to Kakehashi—an idiosyncratic feat of procurement—that provided a little more than the prescribed chaos expected by a noise generator circuit to the snares, claps, and toms. Due to varying material (substrate and die) across transistors used from unit to unit, no two 808s sounded quite alike.

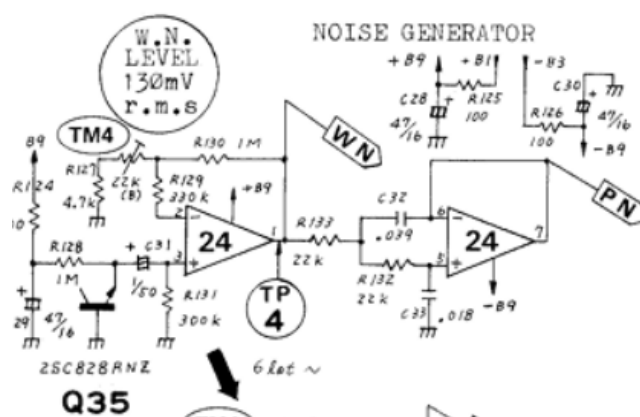


Fig.xxiii TR-808 noise circuit ('TR-808 Service Notes' 1981, 8)

While not specified by Kakehashi in Dunn's documentary, the transistor in question was the 2SC828-RNZ (Fig.xxiii), nondescriptly labelled "selective noise" in the 808's service manual (15). The general principle of a transistor-driven noise circuit (Fig.xxiv) is to connect a diode in reverse, limit the current passing through it, and increase the voltage passing through it to create a small amount of noise—which is then mixed with an oscillator signal and filtered to create the basis of a drum sound. In the 808, transistor Q35 has only two of its three terminals connected and small noise that emanates from that connection is amplified and distributed, producing the "all-important" white noise for the snare and hand clap sounds, which is filtered into pink noise for use on the other voices on the machine.

Functional 2SC828-RNZ transistors did not produce this crucial noise profile (Sue and Jones 2018).

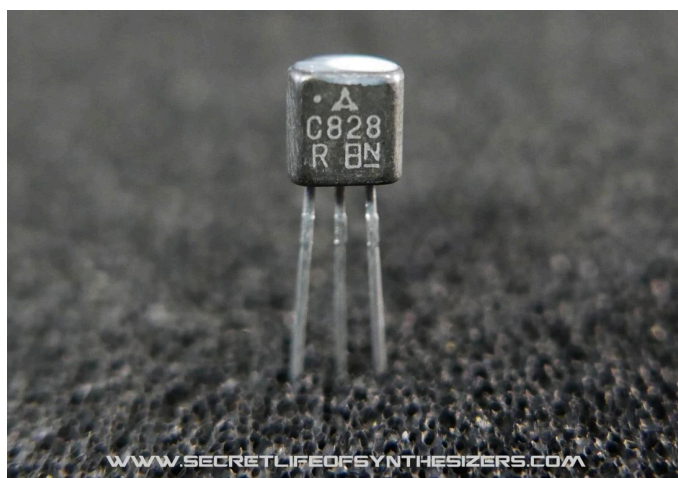


Fig.xxiv 2SC828-RNZ transistor, photo: secretlifeofsynthesizers.com

Due to advancing semiconductor manufacturing standards in the 1980s, a large run of transistors would have a significant reject rate. The 2-3% of transistors that did not make the cut would be graded 'out of specification.' Kakehashi has never revealed what drew Roland to use the semiconductors to create the 808's "sizzle" that he described to Dunn, but the 2SC828-RNZ transistors were demarcated with a special dab of paint by Roland, marking them fit for use in the 808's noise circuit (ibid). As Kakehashi reveals to Dunn, when these transistors were no longer possible to obtain he had no choice but to discontinue the 808. The subsequent TR-909 was a very different drum machine than the 808, incorporating both nascent MIDI and digital samples and moving further away from embracing the idiosyncrasies of analog electronics in which the 808's design seemed to revel.

The 808's Circuits Live On (Kind Of)

The above schematization of the 808's circuits captures the spirit of many of the technical decisions made during the design process. They also provide some

further context on some of the signature voices that were, with time, accepted into the canon of modern percussion sounds. Beyond the original circuits, these decisions and their sonic aesthetics have been permuted and propagated in countless subsequent designs. Most prominently, Roland continues to iterate on the legacy of the TR-808 and its other beloved drum machines—ironically through software modelling. And most literally, other companies cloned the original circuits as the basis for new designs. I will now provide a brief synopsis of each of these ‘extensions’ of the 808’s legacy to set up a conversation about how the drum machine continues to haunt us 40 years after being discontinued.

Despite the assertions of former CEO Jun-ichi Miki that chasing the ghost of the TR-808 did not align with Roland’s “vision of the future,” the Japanese company capitalized on the fact the TR-808 has become a revered collectors’ item.⁴⁷ While they never revisited the original analog materiality of the 808, a software emulation was the basis of the AIRA TR-8. The 2014 device debuted proprietary Analog Circuit Behaviour (ACB) digital modelling, which tasked Kikumoto and other surviving engineers with digitally recreating the 808’s voices “right down to the way the individual circuitry and components behaves and reacts with each other” (*Roland Corporation* 2020). Not limiting themselves to *one* classic, the TR-8 also included software recreations of the voices of the circuits of other Roland machines including the CR-78, TR-909, -707, and -606. Kikumoto and company’s handiwork was lauded in industry publications including music technology mainstay *Sound on Sound*, where a reviewer noted “the fact it [the TR-8] never strays out of character boosts the sense of authenticity considerably” (Nagle 2014). The same ACB recreations of the 808’s voices were reimplemented in 2017 in the TR-8S, a new flagship drum

⁴⁷ As I write this footnote in early June 2024, there are 10 used TR-808s available for sale on the online retailer Reverb.com. Based on service history and if they have been modified (if MIDI in and thru ports have been added), they range in price from \$5,000-\$9,000 USD.

machine focused on improvisation and performance; and the TR-08 (Fig.xxv), released in 2019, which took the sound of the 808 and offered it in the Boutique Series form factor, a compact mini-synth line expanding on classic Roland machines at beginner- and hobbyist-friendly price points.



Fig.xxv The Roland TR-08

While Roland took the idea of the 808 into the digital realm in the 2010s, a new generation of smaller manufacturers stayed closer to home with their veneration. In 2013, E-licktronic released the Yocto, a DIY kit with which a musician handy with a soldering iron could hand-build a 808-a-like that sounded close to the original. The Acidlab Miami was a similar device (that did not require self-assembly) released the following year, and it was received as an “authentic-sounding TR-808 for those who desire but can’t locate or afford the real thing” (Nagle 2014). Both of these devices paid homage to the 808’s circuits, form factor, and interface.⁴⁸

In a 2016 forum post on the online synth forum Gearspace, Swiss engineer Uli Behringer eagerly shared his plans to lead an engineering team to “resurrect” the TR-808 and -909. The plan was to emulate Roland’s fabled circuits with contemporary affordances and adapt original circuit designs as the basis of new

⁴⁸ It’s a tangent, but there is an entire history to be written about the impact of the 808 on modular synthesizers. In the post-2010 explosion of interest around modular synths 808 circuits have been venerated, reimagined, or expanded on by manufacturers including ADDAC System, Erica Synths, MFB, Nonlinearcircuits, System80, Tiptop, and many others. One of the exciting things about recontextualizing a drum machine in a modular context is you could assemble new kits out of different circuits (e.g. a kick drum inspired by the 808 paired with a snare emulating the 909 and hi-hats inspired by the CR-78).

analog drum machines, “not to clone these products but to evaluate analog sound generation and add a great user interface and a sequencer” (2016). Behringer’s eponymous music technology company was part of the portfolio of Music Tribe, a China-based holding company of 10 music technology companies (other properties include Klark Teknik, Midas, and TC Electronic) with deep pockets, global distribution, and the ability to manufacture at scale. Behringer’s tactic of copying and undercutting successful products had landed them in hot water in the past. The company faced a lawsuit by Mackie in the late 1990s for copying the Onyx 1220i compact mixer line—both its circuitry and design—which noted Behringer’s corresponding Xenyx X1204 was “manufactured and assembled by companies located in China, and ... sold at substantially lower prices than authentic Mackie products.” (‘Signals: Mackie Files Lawsuit’ 1997). Mackie lost the case, with the presiding judge ruling that although Behringer’s circuit boards were plagiarized, circuit designs were not covered by US copyright law. In 2005 Roland Corporation sued Behringer for copying the functionality and aesthetics of their popular BOSS guitar pedal line; Behringer settled out of court.

Behringer’s reputation as an unscrupulous manufacturer long preceded their project to “resurrect” the 808 and 909’s circuits. Considered in that context, Behringer’s forum posts announcing the initiative were obviously careful in framing his company’s goals and motivations. Regardless, a debate ensued in music technology circles whether this was a nostalgia-steeped vampire attack on legacy of classic designs or a democratizing force that would put facsimiles of legendary designs into the hands of average producers at prices that were unimaginable in the 1980s. These tensions were astutely framed by music technology writer Peter Kirn, who asked “will the availability of cheap remakes make it tough to bring out new

designs—or, alternatively, will it effectively mandate coming out with something new to compete?” (2017).



Fig.xxvi The Behringer RD-08

In 2020, Behringer’s ‘resurrected’ 808, the RD-8 (Fig.xxvi), was released, in a line that soon expanded to include the RD-9 and RD-6 (clones of the TR-909 and -606). Reviewer Gaz Williams described the RD-8’s sonic quality as “close enough to be really useful,” but also noted players who were concerned with fidelity were probably better served by Roland’s TR-08; the RD-08 “goes into a new [sonic] territory,” slightly beyond what the original 808 accomplished. Another reviewer assessed the RD-8 kick, snare, hats, and other voices as “close recreations of the originals, and some have extra controls” (Sherbourne 2020).

Kakehashi’s Ghost

Resurrected, reanimated, zombified—there are many words to describe the stubborn persistence of the 808’s circuits. Despite the fact they were conceived forty-odd years ago, they live on in myriad boutique ‘hommages’ and mass-market drum machine ‘clones,’ dozens of modular synthesizer components which break up the 808 as a monolithic entity into smaller elements closer to the discrete original circuits, and software emulations. The question that this stubborn ubiquity raises is:

why won't we let them die? In conducting his 'resurrections,' Uli Behringer cannot be tidily dismissed as a fiendish graveyard skulker—clearly there is an audience for his resurrections. And there is an undeniable savviness to reengineering the 808's circuits around contemporary manufacturing and supply chain affordances for a new generation of producers. What I posit this represents is that the 808 is more than a singular instrument, as an assemblage and unified form factor it's a desirable instrument *class*—like a Stratocaster guitar or Rhodes piano—not simply a one-off revered drum machine model. Behringer has made a tidy profit capitalizing on this truth and Roland, with their more tactful software-based reformulations of the 808, could also be accused of straying from their “don't chase ghosts” credo by consistently releasing instruments that draw on nostalgia for the TR series.

The synthesizer showroom in an instrument store should not be a mausoleum full of dusty relics. However, in thinking about how nostalgia permeates the shiny new products on offer, Mark Fisher and Avery Gordon are both helpful here. In *Ghosts of My Life* Fisher uses Derrida's 'whither Marxism?' *Specters of Marx* ruminations to mount a broader conversation about “the slow cancellation of the future” (2014) and how the erosion of social democracy echoes and reverberates in popular film, television, and music. He waxes poetic about how he came of age post-Thatcher and pre-rave scene, was swept up in the 1990s explosion of electronic music, and then watched with horror as independent cultural production ground to a halt at the turn of the millennium. In his excoriation, a slow rot of pop culture commenced in the 2000s, and it was haunted by outlying “persistences, repetitions, prefigurations” (28)—‘traces’ in the Derridean vernacular. Fisher commandeers Derrida's notion of hauntology and uses it to describe how the unrealized potential from the past lives on as an eerie presence. On the topic of burying recent history,

he notes “there is a danger of (over)killing something to such an extent that it becomes a spectre, a pure virtuality” (22).

I think Fisher’s notion of overkill perfectly describes the nostalgia-caked fate that has befallen the 808. While lionizing Roland’s fabled drum machine in *808*, Dunn severs the device from a coherent timeline and flattens its impact and relevance to ‘immensely influential and eternally relevant.’ The film’s unironic description of the genres the 808 helped forge as “still going strong” suggests that time moves in a straight and uninterrupted line—that advances are steady, incremental, and sequential. Dunn provides a relatively thorough survey of the 808’s adoption in rap and Miami bass circles, but beyond those narrow generic and geographic confines the legibility of his map drops off dramatically. History is much messier than what is depicted in *808* and any serious consideration of either musical genre formation or the evolution of music technology reveals irrational zigzags, dramatic leaps and bounds, and contested framings. Dunn and other music technology historians often place the 808 at the pantheon of 1980s music technology with other revered machines like the Linn Electronics LM-1 and Yamaha’s DX7. Make no mistake, it deserves to be cited alongside that elite company, but the separation of the device from the *mess* of its successors and predecessors enacts a certain violence on the flows of influence of features, functionality, and engineering—from one instrument to another—across electronic instrument models and manufacturers.

I can’t help but wonder if these lapses are a result of a lack of material understanding of his subject matter. I’m an oaf with a soldering iron who can barely kludge together the simplest of circuits—but even this most basic levels of electronics literacy is absent from most histories of electronic instruments. Dunn’s

decision to defer to musicians to demonstrate 'what the machine can do' is pragmatic and in many ways these virtuoso producers, players, and programmers are the interpreters of circuits of an electronic instrument. They coax new symphonies from silicon and sound new imaginaries. But they also obscure, overwrite, and, with enough repetition, *overkill* the stories about how these machines came into the world. They enshroud in aura and mystique, and we are beguiled by the illusion. This is what Dunn's history falls victim to—it chronicles the mythology of a machine and (largely) erases its creator. It perpetuates a surface understanding and tired takes rather than use the documentary film format to excavate new truths.

This missed opportunity brings me back to Avery Gordon's suggestion that following ghosts is not only about "repairing representational mistakes" but "putting life back in where only a vague memory or a bare trace was visible to those bothered to look" (2008 [1997], 22). And I feel compelled to 'put life back' in the facile popular reading of the 808—Dunn's take on it and beyond. Within *808* an easy correction would have been to recognize Tokyo—to look beyond the Bronx and Miami—as a site of innovation. Kakehashi was not working in a vacuum by the time Roland was executing its TR series and had close ties to Japanese electronic musicians. Giving airtime to Yellow Magic Orchestra⁴⁹ in *808* would have been a no-brainer, given their arrangement of band member Ryuichi Sakamoto's "Thousand Knives" (on their 1981 studio album *BGM*) was one of the earliest recordings to feature an 808; in the song, the machine's toms and claps syncopate with the majesty of Sakamoto's affective melody. This *second* erasure by Dunn perhaps underscores a broader truth about

⁴⁹ Yellow Magic Orchestra (YMO) was the formidable trio of Haruomi Hosono, Yukihiro Takahashi, and Ryuichi Sakamoto, who all had illustrious solo careers beyond the audacious and playful electropop sound they pioneered between 1978 and 1983. For all the (past and present) ink spilled extolling the influence of Kraftwerk, YMO remains criminally underexamined.

the illegibility of Japanese music and culture to the North American and European audiences his documentary was so clearly aimed at.

Another place to give space for Kakehashi's legacy, and one not incongruous with Dunn's narrative, is that he haunts the sub-bass for which the 808 is so revered. One could argue that the 808's TR-REC drum sequencing circuitry, and how those sequential four banks of four red, orange, yellow, and white buttons "let non-musicians, DJs, and producers program the rhythm patterns which went on in their head" (Metlay and Reid 2022, 20) were the machine's biggest innovation because it established a venerated form factor for countless drum machines (hardware and software) that followed; but that's inside baseball for producers and synth nerds. What is universally graspable about the 808 is the chest-rattling low sub-bass it produces. Unlike any drum machine before it for sculpting low end frequencies, those kicks moved bodies worldwide for decades. In his bass treatise, Paul Jasen describes how "the bass drenched dancefloor is a laboratory for investigating the asymmetrical effects of low-frequency undulation as it alters the body's image of itself" (2016, 22). Here we have a phenomenological reading of bass divorced from discographies of producers like Pharrell or Rick Rubin—it's just bodies moving and feeling in the night. If the political economy of Japanese versus American electronic instrument manufacturers is a little too opaque for the lay music fan (or documentary maker) to understand, then perhaps this is where we might best commune with Kakehashi's ghost.

An Age Without Samples was released in 2017, the same year Kakehashi died. In it, the engineer pragmatically marvelled that the entire history of electronic music was synonymous with cost reductions (121). Standardization, procurement, and supply chain management begat both efficiency and innovation. It's boring and

the exact opposite of the eureka-type narratives we want to hear about product design and innovation. But, boring or not, it's how Takehashi iterated his way through a series of clumsy rhythm machines to more intuitive functionality to crude programmability to the 808. It's how he landed on T-Networks and the 2SC828-RNZ selective noise circuit. That fleeting decision based on economic realities and available materials bequeathed the world a drum machine with a sound so big and undeniable that it has largely eclipsed its creator.

Conclusion: Crate Digging with Missy Elliott

“Music makes you lose control.” The sample repeats twice. Its male voice is resonant and metallic. An electro beat and looped keyboard line kick in, and the latter’s shimmering tones ascend upward. The central synth hook and drum machine beat are from the 1983 electro song “Clear” by Cybotron (Juan Atkins and Rik Davis). After hype man Fatman Scoop sets the stage, Missy Elliott rhymes atop the loop. *“Planet rocker, show stopper / flow proper, head knocker / beat scholar, tail dropper / do my thang, motherfuckers.”*



Fig.xxvii Missy Elliott emerges from the underground in the “Lose Control” video

“Lose Control” was the lead single from Missy Elliott’s 2005 album, *The Cookbook*. While other producers credited on the album include The Neptunes, Scott Storch, and Rich Harrison, it’s one of only two tracks for which Elliott has the sole producer credit. Elliott intentionally distanced herself from her longtime production partner, Timbaland, when forging the album’s sound, quipping that if the friends went “any further left, we gonna be on Mars somewhere” (Reid 2005). While she passed on the fifty-five-million-kilometre trip to the red planet, Elliott travelled twenty-two years back in time with her “Lose Control” sample. Her referencing 1983 was not a purely nostalgic retrieval, though—it was surgical and reconstructive.

The sequences Elliott samples in “Clear” mostly cut around sequences with the song’s bass line, and she instead substituted in a much more pronounced and

contemporary bass growl. She also swapped one robot voice for another, ignoring Rik Davis' machine vocalizations and instead selecting a slightly pitch-shifted sample of a voice rigidly proclaiming, "*Music makes you lose control*," plucked from the intro to Hot Streak's 1983 song "Body Work." Prominently featured in *Breakin'* (1984)—the film that entrenched breakdancing in the public consciousness—the sample had impeccable hip-hop bona fides that were a better match for Elliott's brand of gritty hedonism than Cybotron's aloof robot prognostication. The way she used the beat and synth line from "Clear" fits into Elliott's pattern of sonic identity construction that subverts rap norms, "chewing on the 'golden age' of hip hop and spitting out an image that includes her, and others" (Lane 2011, 790).

I remember being gobsmacked when I first heard "Lose Control." I thought, 'Wow, Cybotron sampled by one of the greatest living rappers. This is a real moment for techno.' Two decades later, I find it interesting that I hoped the genre would receive some kind of validation from increased attention. If nothing else, techno gaining more widespread acceptance would make for a more interesting sonic palette in rap. While this didn't happen, Elliott's plucking a synth line and electro rhythm from relative obscurity and putting them in dialogue with her verses and rhythms—introducing Cybotron to a new generation of listeners—still feels noteworthy, even if techno remains fairly esoteric. She *reclaimed* sounds from a hallowed corner of her memory banks and incorporated them into her repertoire—she made them her own.

In her opening verses to "Lose Control," Elliott self-identifies as a "beat scholar." I read this as both braggadocio and a nod of respect to Cybotron for the electro pattern she deemed worthy of resurfacing in her song. I love the self-seriousness of the phrase—it recasts the history of percussion and the grammar

of familiar drum patterns as warranting close scrutiny—and I think *beat scholarship* is an apt description of my work in this dissertation. I, too, have reached back and reclaimed fragments, recontextualized them, and put them in conversation with contemporary moods, motifs, and aesthetics to make sense of the popular music histories I've inherited.

Beat scholarship interrogates and interpolates the three major strands that run through my research: virtuosity, automation, and political economy. These framings of music technology open up broader conversations about drums and drumming, whereby, riffing on Matt Brennan's conclusion in the *Kick It: A Social History of the Drum Kit*, the drum machine is more than just an object or practice—it's a *symbol* (2020, 317). A cipher for interpreting and resequencing popular music and technological histories and creating new entry points and discourses.

Virtuosity, Automation, Political Economy Revisited

In my introduction, I sketched my thoughts about how virtuosity, automation, and political economy run through my dissertation. Since these themes permeate my chapters and analyses, I feel obliged to return to them and offer some final thoughts on how my understanding of them has evolved through this research.

Virtuosity: Sarah Angliss notes that drum machines represent the “loosening of the coupling between musical sounds and the instrumentalists who made them” (2013, 95). Any attempts to pin down what virtuosity entails relative to the drum machines is going to be different than how one would frame the talent of a top-tier violinist or saxophonist. Virtuosity is generally associated with knowledge, mastery, and knowing an instrument inside-out. But while hearing John Coltrane navigate the treacherous chord changes in “Giant Steps” makes your jaw drop, the way Suzanne

Ciani coaxes rich and burbling timbres out of the interface of the Buchla Music Easel is a little harder to qualify. Prince was a productive monkey wrench to throw into this equilibrium because his talent and legacy are complicated and nuanced. Celebrated as a guitarist and pianist, capable of playing dozens of instruments, and a brilliant arranger—to this day these talents and, *particularly*, his battle with Warner Brothers all overshadow his mastery of the LM-1. But I’m left lingering on his auspicious start in the music industry—when he ran himself into the ground playing all the parts on his debut album *For You* (1978). For Prince, the LM-1 became a songwriting accelerant that allowed him to sketch rough tracks and get them into the studio to iterate and jam with collaborators—ironically helping him move away from his controlling tendencies and toward increased collaboration with his bandmates.

While electronic percussion remains relatively under-discussed in assessments of Prince’s legacy, I’m encouraged by how (more) contemporary musicians like Jeff Mills and J Dilla have received recognition for their mastery of specific drum machines. Mills is known for TR-909 solos during his performances—programming patterns in real-time, sculpting the timbre of individual voices, starting and stopping the sequencer—echoing the showy “exhibitionism” of rock drumming (Brennan 2020, 236); and J Dilla so totally mastered the microtiming capabilities of the Boss SP-303⁵⁰ and the Akai MPC3000 sampling drum machines, his ability to program “multiple expressions of straight and swing time simultaneously” created a signature “rhythmic friction” (Charnas 2022, 146) in his productions. As drum machines approach their fifth decade of widespread use, I’m

⁵⁰ The Boss SP-303 Dr. Sample was an affordable sampling drum machine released in 2001. With rudimentary sampling capability, onboard effects, and eight drum pads for tapping out rhythms, a dedicated producer could build entire tracks on the compact device. J Dilla was an enthusiastic fan and used it and a 45 record player to produce *Donuts* (2006). The Boss SP-303 was succeeded by the Roland SP-404 in 2005 and Roland has continued iterating on the popular sampler form factor (releasing the SP-404MKII in 2021).

confident that a broader segment of attentive critics and more passive listeners will develop a robust vocabulary for recognizing and appreciating the deep and nuanced ways musicians devote themselves to individual drum machines.

Automation: Part of the reason why the way musicians *play* drum machines is inscrutable is that many of their key features take programming and sequencing outside of real-time performance. Jeff Mills' 909 solos notwithstanding, step sequencers take the 'drumming' out of drums and re-cast rhythm creation as plotting or placing beats in a grid—this is a fundamentally different form of musical gesturing than working up a sweat at a drum kit. And the addition of onboard memory for storing drum patterns or building songs further divorced drumming from being an embodied act that happens in the moment. These were some of the fundamental changes offered by Roland's CR-78 and TR-808 and Linn Electronics' LM-1, and the early adopter musicians that incorporated these and related devices into their workflows during my 1978-1985 study period were working through the implications of a shift from real-time to asynchronous modes of drum programming. As Warren Cann predicted when reviewing the LM-1 on its release, the programmable drum machine was destined to "breed new players and new techniques" (1981, 29). New players like Juan Atkins who not only helped establish an entire genre focused on the technics and aesthetics of 'programmability,' but did so in a city where robotization was displacing labour on the factory floor.

As noted by Theo Cateforis, new wavers "opted for simple repetitious melodic and rhythmic patterns" on their electronic instruments, rejecting "the transcendent work of the virtuosic musician" (2011, 153). Atkins and the 'first wave' of techno musicians doubled down on this rejection by leaning into electronic instruments' automation capabilities. Their 1980 setups—a sequencer, a few synths and drum

machines, and effects processors networked via MIDI—anticipated the virtualized digital audio workstation (DAW) of the 2000s, and their production workflow and stripped-down machine aesthetic responded to the waves of deskilling that so profoundly transformed Detroit’s economy. Labour economists classify new workplace technologies as either replacing or enabling technologies; the former deskill and displace while the latter make workers “more productive in existing tasks or create entirely new jobs for them” (Frey 2019, 13). Techno is the *epitome* of an enabling technology. The musicians that made it articulated agency in the face of redundancy-by-machine and enshrined a romantic vision of bodies working together to make meaning. The 1980s drum machine, alongside the synthesizer and sequencer, was a cipher for making sense of automation and a site of resistance for mobilizing against it.

Political Economy: Due to the timing of my study period, there was no avoiding the outsized influence Japan had on consumer electronics and manufacturing in America. Based on my findings, I am most struck by how Paul Théberge’s schematization of musical inventors versus innovators explains the 1980s misfortune of American drum machine 'inventors' like Roger Linn and Tom Oberheim; All of whom went bust and shuttered due to a combination of product flops or a lack of business acumen. As Théberge wrote, “the failure and/or gradual absorption of these enterprises into larger industrial concerns and the displacement of the individual inventors by engineering teams must be regarded as a key sign of the maturation of the synthesizer industry” (1997, 55). I am struck by how this process played out in such a short timeframe, whereby Linn and Oberheim, designers of the LM-1 and the Oberheim DMX—two of the most important early

programmable drum machines—shuttered within a few years of producing their (now) fabled devices.

So, the epilogue of the 1980s drum machine is also a story about how 'inventive' American entrepreneurs were outpaced by the innovation of Roland, Korg, Yamaha, Akai, and other Japanese conglomerates. This is perhaps most perfectly encapsulated by the fact that Linn's breakout success was not with the company that bore his name but as a designer for Akai. He took what he learned designing the LM-1 and LinnDrum and used that as the basis for the MPC60, a 12-bit sampling drum machine released in 1988. Its iconic 4x4 drum pad cemented the form factor of sampling drum machines, particularly for rap producers. The core design elements are still evident in Akai's still-going-strong MPC line and other sampling drum machines, including Elektron's Analog Rytm series (2014-).

Whether Linn or Kakehashi, I am struck by how engineers chart a path into seas animated by the gusty trade winds that animate markets with each design. Individual designs can be inventive but still 'ahead of their time' or 'out of sync' with the direction the market is headed. If companies can't scale, remain solvent, anticipate the needs of their customers, or make one major miscalculation with a product launch, they can implode. The TR-808 was an iconic design with sonic character and an innovative interface. Still, due to circumstances beyond Kakehashi's control, it was out of step with where the market was headed when it was released in the early 1980s. Four decades later, what remains compelling about the 808 is that its sonic palette is ubiquitous despite the stamp of obsolescence that was so ungenerously, and seemingly *inaccurately*, applied to the instrument.

Key Findings

Building on my concluding reflections on virtuosity, autonomy, and political economy, I identify four key findings in my research. First, the drum machine—as an identifiable object—was rendered largely illegible by the profound technological disruption during my study period. Second, the tensions between realism and abstraction—electronic percussion voices that ‘sound real’ versus those that playfully explore what drums *could* sound like—was an existential question for 1980s instrument designers. Third, the drum machine had a transformative impact on musicians and genres. Finally, the beat scholarship methodology I developed while doing this work provides a novel way to historicize and study electronic percussion.

Illegibility: The technological disruption during my study period prevented engineers from establishing a recognizable form factor and feature set for the programmable drum machine. The 1983 release of the Yamaha DX7 FM synthesizer—a fundamentally new sonic aesthetic compared to analog subtractive synthesis—sent shockwaves through the instrument industry. This coincided with the adoption of the MIDI standard by an industry coalition led by Ikutaro Kakehashi and Dave Smith, which meant that every instrument before 1983 lacked key functionality expected in a modern studio. MIDI was a “digital *lingua franca*” developed by competing firms to grow an emerging industry (Diduk 2018, 20-2). In tandem, mass-market digital synthesis and MIDI made first-wave programmable drum machines, including the Boss DR-55, Linn LM-1, Roland TR-808, and Oberheim DMX, obsolete overnight.

At the same time, affordable digital sampling technology became a reality. The E-Mu Systems Drumulator was released in 1983 and offered twelve 8-bit percussion

voices at a fraction of the price of the LM-1.⁵¹ More advanced samplers like E-Mu's SP-12 (1985) and Akai S900 (1986) followed a few years later, which allowed producers to sample sounds directly onto onboard memory versus working with the constraints of pre-loaded sound libraries on clunky electrically erasable programmable read-only memory (EPROM) modules.⁵² The shift from machines focused on generating sounds natively to those that recorded and processed samples brought entirely different technical modalities and aesthetics. This was a full circle moment in rap, as the genre began with DJs resequencing the breakdowns of funk, soul, and disco records in real-time—digital samplers brought that aesthetic from the block party or club into the studio. With decades of dusty grooves to reclaim, by the mid-1980s rap producers had largely moved on from programmable drum machines to samplers.⁵³

In aggregate, these three technological shifts made the early 1980s drum machine an 'object in flux' that was (somewhat) illegible to musicians and audiences alike. The clunky form factor of the CR-78 and its eccentric library of generic loops, the divergent modes of sound generation in the 808 and the LM-1, and the rollout of consumer-grade *sampling* drum machines all illustrate how the drum machine instrument class was a work in progress during my study period. This fluidity and lack of fixed form have persisted. Four decades later, a 'drum machine' could mean anything from a hardware drum machine with analog electronics to a DAW plug-in.

⁵¹ The Drumulator's drum samples are of Bill Gibson of Huey Lewis and the News. When the session commenced, he was reportedly flummoxed when asked to play single drum hits (Milner 2010, 328).

⁵² LM-1, the Linndrum (1982), and the Drumulator used EPROM chips to store samples. If a producer wanted another library of drum voices this would require the cumbersome task of swapping out the voice chip. The SP-12 and S900 made it much easier to read and write samples, dramatically changing producers' workflows.

⁵³ Famously, Mantronix kept working with drum machines while other rap producers embraced funk and soul drum samples. Their first albums *The Album* (1985) *Music Madness* (1986) are decidedly more raw and electronic sounding than other rap production from the same time period.

Being a player entails navigating an ever-changing landscape of possible form factors, interfaces, and modes of sound generation.

Verisimilitude vs. abstraction: My second key finding relates to this idea of the drum machine as an object in flux. It can be encapsulated in a single question: *What should a drum machine sound like?* My first chapter dwelled on the “Real drums at your fingertips” tagline under which the LM-1 was marketed. In 1980 it made sense to market the authenticity of the first ‘real’ sounding drum machine whose one-hit drum voices were sampled from real-session drummers on a real drum kit. But contrast that verisimilitude with the wider (and weirder) range of sound sculpting possible on the Roland TR-808, which lead engineer Tadao Kikumoto crucially described as “not a drum machine, but a drum synthesizer” (Metlay and Reid 2022, 19). As discussed at length in my third chapter, the 808 takes electronic percussion voices in abstract directions that are more informed by circuit design than how a steel snare shell or rawhide drumhead is ‘supposed’ to sound. This tension about whether electronic and digital percussion instruments should emulate those volumetric and material properties is a central question in drum machines and software today. Letting go of these traditional notions of what drum, snare, or hi-hat voices ‘should’ sound like creates opportunities to embrace new sonic aesthetics that emerge from the affordances of electronics and software. There is essentially a spectrum with artificial and abstract sounds on one side and more traditional ones on the other, and where a particular percussion voice falls on that spectrum is at the musician’s discretion. Only limited by the producer’s or player’s imagination, contemporary popular music is full of percussion sounds spanning the full width of this spectrum of sonic possibility.

Transformation: Musicians who used drum machines fundamentally transformed their music-making practices. Drum machines were not just a tool used in songwriting; engaging their interfaces and affordances changed how musicians *thought* about percussion. I've examined how Prince and Juan Atkins used electronic percussion to forge new genres or complicate existing ones, and I presented these case studies as a 'core sample' of early adopters (or reflexive users or user-to-be as I discussed in my first chapter). A similar analysis could be conducted on other musicians' recordings from my study period. Blondie, Warren Cann, Marvin Gaye, and Phil Collins are just a few figures who have come up repeatedly in my research whose methods of making music were fundamentally changed once they incorporated drum machines into their practices—you can hear it in their subsequent recordings. For late 1970s and early 1980s musicians, the drum machine was not just an alternative to the drum kit, but a means to think beyond the conventional backbeat and the four-piece band. It was one of the electronic instruments that demarcated the "fork in the road" in late 1970s recording practices that Samantha Bennett characterized as a choice between capturing live performances on one side and embracing increasingly automated processes on the other (2019, 19).

Beat scholarship: Perhaps my most important finding in this work is the beat scholarship methodology I developed while doing this research. I was initially motivated by calls within platform studies to go beyond content analysis and engage deeper materialities of media technologies (Bogost and Montfort 2009, 146-50). That prompted me to put drum machine interfaces and circuitry under the microscope, but I've cast my net much wider. In line with media archaeological approaches, beat scholarship dwells on the material affordances and design logic implicit in the interfaces of specific drum machines. It also considers the industrial context into

which these instruments are introduced. Combining material and economic readings of musical instruments, in addition to the close readings of songs, discourse analysis, and careful consideration of the sites and scenes expected in popular music studies, yields a robust method that is more than the sum of its parts.

Next Steps: Itinerary for a Beat Scholar

This dissertation is not the end of my research. Capturing a sweeping history of a class of musical instruments will require (at least) several more years of research, and there are many avenues for me to pursue. First, I must broaden my core sample of musicians and get more breadth and diversity of subjects. I already have a moderate amount of research and writing on Blondie and Phil Collins, so they would be obvious starting points. Genre-wise, I need to address new wave or industrial, while house and disco have thus far been neglected in my research. Yellow Magic Orchestra, whom I discuss briefly in my third chapter, is a promising potential subject, and analyzing their body of work would allow me to expand my research on the importance of Japan as a site of musical innovation. Likewise, the story of the Sleng Teng riddim's origin and propagation in Jamaica⁵⁴ would be a rich opportunity to widen my analysis across race, genre, and geography.

The next steps in this research are more about musicians and genres. In addition to my chapters oriented around the circuit, interface, and the studio, I envision additional key sites related to the drum machine that warrant attention. Given the outsized role of political economy in my research, a specific trade show

⁵⁴ The Sleng Teng riddim took Reggae by storm in 1985 when Noel Davey, Wayne Smith, and King Jammy released "Under Mi Sleng Teng." Derived from the rock preset that was composed by musicologist Hiroko Okuda for the Casiotone MT-40 keyboard (1981), it is characterized by an exuberant square wave rolling bassline. A perfect foundation for toasting and dub effects, the Sleng Teng riddim has been versioned over 500 times (Vlado and Camphouse, n.d.) and it also kicked off a 1980s 'digital' sound in dancehall that starkly contrasted earlier (more) analog productions.

edition would be a logical event to foreground. The National Association of Music Merchants (NAMM) conference is the leading global music technology manufacturer expo, it is a forum where new products are introduced and new consumer narratives are road-tested. Both Kakehashi and Linn frequented it and it would be a natural environs to examine. And the dance floor is quite crucially missing in this research, as a ‘first principle’ of why drum machines exist. Bodies moving in unified revelry, sweat, and desire. Paradise Garage (NYC), the Warehouse (Chicago), and the Music Institute (Detroit); there are so many specific 1970s and 1980s dance floors that fostered the musicians and genres I engage. Addressing the oral histories of one of these sites in detail, or surveying several of them, would also be a way to honour the roots of dance music in queer and racialized spaces.

The drum machine is not a linear procession of devices made by competing manufacturers with particular sounds and features but a connective tissue across space and time. From the Osaka and Los Angeles workbenches where Ikutaro Kakehashi designed Roland’s foundational circuits and Roger Linn assembled the first LM-1 prototype to Prince and Juan Atkins’ studios in Minneapolis and Detroit—these are just a few of the sites where the programmable drum machine was conceived, refined, and *tested*. The impact of this early experimentation was substantial, as electronic percussion is *everywhere* today. It’s ubiquitous across all genres of popular music, provides the soundtrack for revelry and consumption, and any car that zooms by with a rumbling subwoofer will likely be blaring kicks programmed on a drum machine—not a trap drum kit. Whether that ‘drum machine’ is a desktop module with analog circuits, an Ableton Live software plug-in, or a \$200 groovebox with a pirated 808 sample pack loaded onto it is irrelevant. The drum machine democratized rhythm and utterly transformed music-making practices.

Bibliography

- Abbate, Carolyn. 1999. 'Outside Ravel's Tomb'. *Journal of the American Musicological Society* 52 (3): 465–530.
- Abdurraqib, Hanif, ed. 2019. *Prince: The Last Interview and Other Conversations*. Melville House Publishing: Brooklyn, NY.
- Abel, Mark. 2014. 'Meter, Groove and the Times of Capitalism'. In *Groove: An Aesthetic of Measured Time*, 187–222. Leiden, NL: Brill.
- Acland, Charles R. 2007. 'Mechanics of Obsolescence'. In *Residual Media*, edited by Charles R. Acland, 3–65. Minneapolis, MN: University of Minnesota Press.
- Alpern, Ron. 1979. *Union Town: A Labor History Guide to Detroit*. Detroit, MI: Workers Education Lcal.
- Anable, Aubrey. 2018. 'Platform Studies'. *Feminist Media Histories* 4 (2): 135–40.
- Angliss, Sarah. 2013. 'Mimics, Menaces or New Musical Horizons?' In *Material Culture and Electronic Sound*, edited by Frode Weium and Tim Boon, 95–130. Washington, DC: Smithsonian Institution Scholarly Press.
- Apel, Dora. 2021. 'Against the Ruins: Music and Black Space in Detroit'. In *Electronic Landscapes: Music, Space, and Resistance in Detroit*, edited by Isaac Diggs and Edward Hillel, 100–103. Queens, NY: Kris Graves Projects.
- Arsenault, Dominic. 2017. *Super Power, Spooky Bards, and Silverware: The Super Nintendo Entertainment System*. Platform Studies. Cambridge, MA: MIT Press.

Arthur Baker Shows How He Produced Afrika Bambaataa's Iconic 'Planet Rock'

@ *IMS Ibiza 2022*. 2022. Point Blank Music School.

<https://www.youtube.com/watch?v=8Y93jBY7Wgo>.

Auslander, Philip. 2006. *Performing Glam Rock: Gender & Theatricality in Popular Music*. Ann Arbor, MI: University of Michigan Press.

Baade, Christina. 2018. 'Lean Back: Songza, Ubiquitous Listening and Internet Music Radio for the Masses'. *Radio Journal: International Studies in Broadcast & Audio Media* 16 (1): 9–27.

Babson, Steve. 1984. *Working Detroit*. New York: Adama Books.

Bangs, Lester. 1975. 'Kraftwerkfeature'. *CREEM*, September 1975.

Bardini, Thierry, and August T. Horvath. 1995. 'The Social Construction of the Personal Computer User'. *Journal of Communication* 45 (3): 40–65.

Behringer, Uli. 2016. 'Behringer Analog Drum Machine'. *Gear Space*.

<https://gearspace.com/board/showpost.php?p=12338504&postcount=576&s=1f8fff6c0515f4d04534ba7f345d6a15>.

Benanav, Aaron. 2019a. 'Automation and the Future of Work—1'. *The New Left Review*, no. 119, 5–38.

———. 2019b. 'Automation and the Future of Work—2'. *The New Left Review*, no. 120, 117–46.

Bennett, Samantha. 2019. *Modern Records, Maverick Methods: Technology and Process in Popular Music Record Production*. New York: Bloomsbury Academic.

Birnbaum, D., R. Fiebrink, J. Malloch, and M.M. Wanderley. 2005. 'Towards a Dimension Space for Musical Devices'. In *Proceedings of the 2005*

- International Conference on New Interfaces for Musical Expression (NIME05)*, 192–95. Vancouver, CA.
- Bjørn, Kim. 2017. *Push Turn Move: Interface Design in Electronic Music*. Copenhagen: Bjooks Media.
- . 2020. *Patch & Tweak with Moog*. Copenhagen: Bjooks Media.
- Blanco, María del Pilar, and Esther Peeren, eds. 2013. *The Spectralities Reader: Ghosts and Haunting in Contemporary Cultural Theory*. New York: Bloomsbury.
- Boggs, James. (1963) 2009. *The American Revolution: Pages from a Negro Workers Notebook*. New York: Monthly Review Press.
- Bogost, Ian, and Nick Montfort. 2009. 'Afterword on Platform Studies'. In *Racing the Beam: The Atari Video Computer System*, 145–50. Cambridge, MA: MIT Press.
- Boyd, Herb. 2017. *Black Detroit: A People's History of Self-Determination*. New York: HarperCollins.
- Boym, Svetlana. 2001. 'Hypochondria of the Heart: Nostalgia, History, and Memory'. In *The Future of Nostalgia*, 3–71. New York: Basic Books.
- Breihan, Tom. 2007. 'Good Girl Gone Bad'. *Pitchfork*, 15 June 2007.
<https://pitchfork.com/reviews/albums/10320-good-girl-gone-bad/>.
- Brennan, Matt. 2020. *Kick It: A Social History of the Drum Kit*. Oxford, UK: Oxford University Press.
- Brett, Thomas. 2016. 'Virtual Drumming: A History of Electronic Percussion'. In *The Cambridge Companion to Percussion*, edited by Russell Hartenberger, 82–94. Cambridge: Cambridge University Press.

- . 2020. 'Prince's Rhythm Programming: 1980s Music Production and the Esthetics of the LM-1 Drum Machine'. *Popular Music and Society* 43 (3): 244–61.
<https://doi-org.libaccess.lib.mcmaster.ca/10.1080/03007766.2020.1757813>.
- Brewster, Bill, and Frank Broughton. 2011. 'Juan Atkins: Techno Rebel'. In *The Record Players*, 298–305. London: Virgin Books.
- Brooks, Daphne A. 2010. "Once More with Feeling": Popular Music Studies in the New Millennium'. *Journal of Popular Music Studies* 22 (1): 98–106.
- Brown, Jake. 2010. *Prince In the Studio (1975-1995)*. Phoenix, AZ: Colossus Books.
- Brown Jr., DeForrest. 2019. 'Techno Is Technocracy'. *Fact*, 17 December 2019.
<https://www.factmag.com/2019/12/17/techno-is-technocracy/>.
- . 2022. *Assembling a Black Counter Culture*. Brooklyn, NY: Primary Information.
- . FW21-22. 'Rhythm Runs Deep'. *Kaleidoscope*, FW21-22.
- Bruford, Bill. 2018. *Uncharted: Creativity and the Expert Drummer*. Ann Arbor, MI: University of Michigan Press.
- Bush, Vannevar. 1945. 'As We May Think'. *The Atlantic*, July 1945.
<https://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/>.
- Cage, John. (1937) 2004. 'The Future of Music: Credo'. In *Audio Culture: Readings in Modern Music*, edited by Christoph Cox and Daniel Warner, 25–28. New York: Continuum.
- Cann, Warren. 1981. 'The Linn LM-1 Drum Computer'. *Electronics & Music Maker*, September 1981.

- Carr, Roy. 1980. 'Dirty Mind'. *NME*, 29 November 1980.
- Cateforis, Theodore. 2011a. *Are We Not New Wave?: Modern Pop at the Turn of the 1980s*. Ann Arbor, MI: University of Michigan Press.
- . 2011b. 'From Neurasthenia to Nervousness: The Whiteness of the New Wave'. In *Are We Not New Wave?: Modern Pop at the Turn of the 1980s*, 71–94. Ann Arbor, MI: University of Michigan Press.
- . 2011c. "Roll Over Guitar Heroes, Synthesizers Are Here . . ." In *Are We Not New Wave?: Modern Pop at the Turn of the 1980s*, 151–81. Ann Arbor, MI: University of Michigan Press.
- Chadabe, Joel. 1997. *Electric Sound: The Past and Promise of Electronic Music*. Upper Saddle River, NJ: Prentice Hall.
- Charnas, Dan. 2022. *Dilla Time: The Life and Afterlife of J Dilla, the Hip-Hop Producer Who Reinvented Rhythm*. New York: MCD.
- Christopher, Roy. 2018. *Dead Precedents: How Hip-Hop Defines the Future*. London, UK: Repeater Books.
- Chun, Wendy Hui Kyong. 2013a. 'Daemonical Interfaces, Empowering Obfuscations'. In *Programmed Visions: Software and Memory*, 59–96. Cambridge, MA: MIT Press.
- . 2013b. *Programmed Visions: Software and Memory*. Cambridge, MA: MIT Press.
- Clark, Daniel J. 2018. *Disruption in Detroit: Autoworkers and the Elusive Postwar Boom*. Champaign, IL: University of Illinois Press.
- Clough, Patricia T. 2010. 'The Affective Turn: Political Economy, Biomedicine, and Bodies'. In *The Affect Theory Reader*, 206–27. Durham, NC: Duke University Press.

- Collins, Nicolas. 2015. 'Semiconducting: Making Music after the Transistor'. In *Musical Listening in the Age of Technological Reproduction*, edited by Gianmario Borio. London: Routledge.
- Cosgrove, Stuart. 1988. 'Techno! The New Dance Sound of Detroit'.
- Costa, J.C. 1981. 'Turn up the Drummer'. *Musician, Player, and Listener*, 1981.
- Cox, Christoph, and Daniel Warner, eds. 2004. 'Electronic Music and Electronica'. In *Audio Culture: Readings in Modern Music*, 365–98. New York: Continuum.
- Crane, Larry. 2017. 'Susan Rogers: From Prince to Ph.D.' *Tape Op*, February 2017. <https://tapeop.com/interviews/117/susan-rogers/>.
- Deleuze, Gilles. 1992. 'Postscript on the Societies of Control'. *October* 59:3–7. <https://doi.org/www.jstor.org/stable/778828>.
- Demers, Joanna. 2010. *Listening Through the Noise: The Aesthetics of Experimental Electronic Music*. Oxford, UK: Oxford University Press.
- . 2014. 'Materialism, Ontology, and Experimental Music Aesthetics'. In *Tomorrow Is the Question: New Directions in Experimental Music Studies*, edited by Benjamin Piekut, 254–76. Ann Arbor, MI: University of Michigan Press.
- Denby, Charles. 1971. 'Worker's Battle Automation'.
- Derrida, Jacques. 1994. *Spectres of Marx*. Translated by Peggy Kamuf. New York: Routledge.
- Diduck, Ryan. 2018. *Mad Skills: MIDI And Music Technology In The 20th Century*. London, UK: Repeater Books.
- Doering, Chris. 1982. 'Electronic Drums: The Shape of Traps to Come'. *Musician*, 1 October 1982.

- Doerschuk, Robert. 2011. 'New Synthesizer Rock'. In *Keyboard Presents: The Evolution of Electronic Dance Music*, edited by Peter Kirn, 15–33. Milwaukee, WI: Backbeat Books.
- Doran, Robert, ed. 2020. 'Virtuosity and Liszt'. In *Liszt and Virtuosity*, 1–38. Suffolk, UK: Boydell & Brewer.
- Dourish, Paul. (2001) 2004. *Where the Action Is: The Foundations of Embodied Interaction*. Cambridge, MA: MIT Press.
- 'Drum Patterns and Memories: 12 Artists Reflect on Iconic Drum Machines'. 2014. *Vinyl Factory: Magazine* (blog). 18 October 2014. <https://thevinylfactory.com/features/drum-patterns-and-memories-12-artists-reflect-on-iconic-drum-machines/>.
- Dunn, Alexander, dir. 2015. *808*. Atlantic Films.
- Dyer, Richard. 1979. 'In Defence of Disco'. *Gay Left*, Summer 1979.
- Echols, Alice. 2010a. *Hot Stuff: Disco and the Remaking of American Culture*. New York: WW Norton.
- . 2010b. 'Ladies' Night: Women and Disco'. In *Hot Stuff: Disco and the Remaking of American Culture*, 72–121. New York: WW Norton.
- Eriksson, Maria, Rasmus Fleischer, Anna Johansson, Pelle Snickars, and Patrick Vonderau. 2019. *Spotify Teardown: Inside the Black Box of Streaming Music*. Cambridge, MA: MIT Press.
- Eshun, Kodwo. 1995. 'Sound Check'. *The Wire*, July 1995.
- . 1998. *More Brilliant than the Sun: Adventures in Sonic Fiction*. London: Quartet Books.
- Fantinatto, Robert, dir. 2014. *I Dream of Wires*. First Run Features.

- Fast, Susan. 2001. 'Stairway to Heaven: Myth, Epic, Ritual'. In *In the Houses of the Holy: Led Zeppelin and the Power of Rock Music*, 49–84. Oxford: Oxford University Press.
- Ferguson, Ben. 2010. 'Label of Love: Metroplex'. *The Guardian*, 15 June 2010. <https://www.theguardian.com/music/2010/jun/15/label-love-metroplex>.
- Fink, Robert. 2005a. 'Do It ('til You're Satisfied): Repetitive Musics and Recombinant Desires'. In *Repeating Ourselves American Minimal Music as Cultural Practice*, 25–60. Berkeley, CA: University of California Press.
- . 2005b. 'The Story of ORCH5, or, the Classical Ghost in the Hip-Hop Machine'. *Popular Music* 24 (3): 339–56.
- Fintoni, Laurent. 2020. *Bedroom Beats & B-Sides*. London: Velocity Press.
- Fisher, Mark. 2014. *Ghosts Of My Life*. London, UK: Zero Books.
- Flory, Andrew. 2017. *I Hear A Symphony: Motown and Crossover R&B*. Ann Arbor, MI: University of Michigan Press.
- Font-Navarette, David. 2015. 'Bass 101: Miami, Rio, and the Global Music South'. *Journal of Popular Music Studies* 27 (4): 488–517.
- Forman, Murray, and Mark Anthony Neal, eds. (2004) 2012. 'Looking for the Perfect Beat: Hip-Hop Aesthetics and Technologies of Production'. In *That's the Joint!: The Hip-Hop Studies Reader*, 2nd ed., 389–492. New York: Routledge.
- Fraser, Nancy. 2013. 'Struggle over Needs: Outline of a Socialist-Feminist Critical Theory of Late-Capitalist Political Culture'. In *Fortunes of Feminism: From State-Managed Capitalism to Neoliberal Crisis*, 53–82. Brooklyn, NY: Verso.
- Frey, Carl Benedikt. 2019. *The Technology Trap: Capital, Labor, and Power in the Age of Automation*. Princeton, NJ: Princeton University Press.

- Frykman, Jonas, and Maja Povrzanovic Frykman, eds. 2016. 'Affect and Material Culture'. In *Sensitive Objects: Affect and Material Culture*, 9–30. Lund: Nordic Academic Press.
- Fuller, Matthew, ed. 2008. *Software Studies: A Lexicon*. Cambridge, MA: MIT Press.
- funkyhead. 2009. 'What Was the LM-1' and 'what Was Drummer Bobby P'. *Prince.Org*. <https://prince.org/msg/7/315643>.
- Galloway, Alexander. 2012a. *The Interface Effect*. Cambridge, UK: Polity.
- . 2012b. 'The Unworkable Interface'. In *The Interface Effect*, 25–53. Cambridge, UK: Polity Press.
- Geffen, Sasha. 2020. *Glitter Up The Dark*. Austin, TX: University of Texas Press.
- Gilroy, Paul. 2010. *Darker than Blue: On the Moral Economies of Black Atlantic Culture*. Cambridge, MA: Belknap Press.
- Ginsborg, Jane. 2018. "'The Brilliance of Perfection" or "Pointless Finish"? What Virtuosity Means to Musicians'. *Musicae Scientiae* 22 (4): 449–566.
- Goldmann, Stefan. (2015) 2018. *Presets—Digital Shortcuts to Sound*. 4th edition. London, UK: The Bookworm.
- Goldstein, Gary. 2016. 'Music Stars Pharrell Williams, the Beastie Boys and More Discuss Influential Roland Drum Machine in Documentary "808"'. *The Los Angeles Times*, 8 December 2016. <https://www.latimes.com/entertainment/movies/la-et-mn-capsule-808-review-20161206-story.html>.
- Gordon, Avery F. (1997) 2008. *Ghostly Matters*. Minneapolis, MN: University of Minnesota Press.
- Gray, Louise. 1992. 'The Great Bleep Forward'. *The Wire*, February 1992.

- Gurevich, Michael, and Jeffrey Treviño. 2007. 'Expression and Its Discontents: Toward an Ecology of Musical Creation'. In *Proceedings of the 2007 Conference on New Interfaces for Musical Expression (NIME07)*, 106–11. New York.
- Haraway, Donna. (1985) 2016. 'A Cyborg Manifesto: Science, Technology, and Socialist- Feminism in the Late Twentieth Century'. In *Manifestly Haraway*, 3–90. Minneapolis, MN: University of Minnesota Press.
- Hardt, Michael, and Antonio Negri. (2000) 2001. *Empire*. Cambridge, MA: Harvard University Press.
- Hawkins, Stan. 2016. *Queerness in Pop Music : Aesthetics, Gender Norms, and Temporality*. London, UK: Routledge.
- Hawkins, Stan, and Sarah Niblock. (2011) 2016. *Prince: The Making of a Pop Music Phenomenon*. London, UK: Routledge.
- Henry, Thomas. 1987. *Build a Better Music Synthesizer*. Blue Ridge Summit, PA: Tab.
- Herron, Jerry. 1993. *AfterCulture*. Detroit, MI: Wayne State University Press.
- Holt, Fabian. 2007. 'Introduction'. In *Genre in Popular Music*. Chicago, IL: University of Chicago Press.
- Horn, Delton T. 1982. *The Beginner's Book of Electronic Music*. Blue Ridge Summit, PA: Tab Books.
- Hornbæk, Kasper, and Antti Oulasvirta. 2017. 'What Is Interaction?' In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 5040–52. Denver, CO.

- Ingrassia, Paul, and Joseph B. White. (1994) 1995. *Comeback: The Fall and Rise of the American Automobile Industry*. First Touchstone. New York: Simon and Schuster.
- Iwabuchi, Koichi. 2002. *Recentering Globalization: Popular Culture and Japanese Transnationalism*. Durham, NC: Duke University Press.
- James, Robin. 2008. “Robo-Diva R&B”: Aesthetics, Politics, and Black Female Robots in Contemporary Popular Music’. *Journal of Popular Music Studies* 20 (4): 402–23.
- Jasen, Paul C. 2016. *Low End Theory: Bass, Bodies and the Materiality of Sonic Experience*. Bloomsbury Academic.
- Jay, Mark, and Philip Conklin. 2020. *A People’s History of Detroit*. Durham, NC: Duke University Press.
- Jiménez, Gabriela. 2011. “Something 2 Dance 2”: Electro Hop in 1980s Los Angeles and Its Afrofuturist Link’. *Black Music Research Journal* 31 (1): 131–44.
- Johnson, Cecilia. 2017. ‘Roger Linn, Inventor of the LM-1 Drum Machine, Talks Prince and “When Doves Cry”’. *The Current*, 1 March 2017.
<https://www.thecurrent.org/feature/2017/03/01/roger-linn-inventor-of-the-lm1-drum-machine-talks-prince-and-when-doves-cry>.
- Kajikawa, Loren. 2015. ‘Part I. Stylistic Change and Racial Formation in Rap’s First Decade’. In *Sounding Race in Rap Songs*, 19–84. Berkeley, CA: University of California Press.
- Takehashi, Ikutaro. 2017. *An Age Without Samples: Originality and Creativity in the Digital World*. Milwaukee, WI: Hal Leonard Books.

Katz, Barry. 2015. *Make It New: The History of Silicon Valley Design*.

Cambridge, MA: MIT Press.

Katz, Mark. 2010. 'The Turntable as Weapon: Understanding the Hip-Hop DJ Battle'. In *Capturing Sound: How Technology Has Changed Music*, 1st, revised ed., 124–45. Berkeley, CA: University of California Press.

———. 2012. 'The Amateur in the Age of Mechanical Music'. In *The Oxford Handbook of Sound Studies*, edited by Trevor Pinch and Karin Bijsterveld, 459–79. Oxford, UK: Oxford University Press.

Kay, Roy. 2022. 'Minneapolis, Prince, and the Minneapolis Sound'. *Boundary 2* 49 (2): 213—241.

Kelley, Robin D.G. (2004) 2012. 'Looking for the "Real" Nigga'. In *That's the Joint!: The Hip-Hop Studies Reader*, edited by Mark Anthony Neal and Murray Forman, 2nd ed., 134–52. New York: Routledge.

Kinos-Goodin, Jesse. 2017. 'A Brief History of Prince Throwing Guitars'. *CBC Radio*, 6 June 2017.

<https://www.cbc.ca/radio/q/blog/a-brief-history-of-prince-throwing-guitars-1.4147959>.

Kirn, Peter, ed. 2011. *Keyboard Presents the Evolution of Electronic Dance Music*. Milwaukee, WI: Backbeat Book.

———. 2017. 'Behringer Go Nuts, Plan to Clone Every Historic Synth, Drum Machine'. *Create Digital Music*, 13 December 2017.

<https://cdm.link/2017/12/behringer-go-nuts-plan-clone-every-historic-synth-drum-machine/>.

Kline, Stephen, Nick Dyer-Witheford, and Greig de Peuter. 2003. 'Media Analysis in the High-Intensity Marketplace: The Three Circuits of

- Interactivity'. In *Digital Play: The Interaction of Technology, Culture, and Marketing*, 30–59. Montreal: McGill-Queen's University Press.
- Kopf, Biba. 1996. 'Underground Resisters'. *The Wire*, August 1996.
- Kun, Josh. 2005. 'Basquiat's Ear, Rahsaan's Eye'. In *Audiotopia: Music, Race and America*, 113–42. Berkeley, CA: University of California Press.
- Lacey, Kate. 2013. 'Listening in and Listening Out'. In *Listening Publics: The Politics and Experience of Listening in the Media Age*. Cambridge, UK: Polity Press.
- Lane, Nikki. 2011. 'Black Women Queering the Mic: Missy Elliot Disturbing the Boundaries of Racialized Sexuality and Gender'. *Journal of Homosexuality* 58 (6–7): 775–92.
- Laurel, Brenda, ed. 1990. 'Sermons'. In *The Art of Human-Computer Interface Design*, 345–438. Reading, MA: Addison-Wesley.
- Lawrence, Tim. 2004. *Love Saves the Day: A History Of American Dance Music Culture, 1970–1979*. Durham, NC: Duke University Press.
- . 2016. *Life and Death on the New York Dance Floor, 1980–1983*. Durham, NC: Duke University Press.
- Lena, Jennifer C., and Richard A. Peterson. 2008. 'Classification as Culture: Types and Trajectories of Music Genres'. *American Sociological Review* 73 (5): 697–718.
- Lewis, George. 1996. 'Improvised Music after 1950: Afrological and Eurological Perspectives'. *Black Music Research Journal* 16 (1): 91–122.
- Licklider, J.C.R. (1960) 2003. 'Man-Computer Symbiosis'. In *The New Media Reader*, edited by Noah Wadrip-Fruin and Nick Montfort, 73–82. Cambridge, MA: MIT Press.

- Liu, Alan. 2008. 'Transcendental Data'. In *Local Transcendance*. Chicago, IL: University of Chicago Press.
- Lordi, Emily J. 2020. *The Meaning of Soul: Black Music and Resilience Since the 1960s*. Durham, NC: Duke University Press.
- Magnusson, Thor. 2009. 'Of Epistemic Tools: Musical Instruments as Cognitive Extensions'. *Organised Sound* 14 (2): 168–76.
<https://doi.org/10.1017/S1355771809000272>.
- . 2019a. 'Material Inscriptions'. In *Sonic Writing*, 17–68. London: Bloomsbury Academic.
- . 2019b. 'Signal Inscriptions'. In *Sonic Writing*, 71–120. London: Bloomsbury Academic.
- Marsh, Allison. 2019. *The Factory: A Social History of Work and Technology*. Santa Barbara, CA: Greenwood.
- Matos, Michelangelo. 2004. *Sign 'O' the Times*. 33 $\frac{1}{3}$. New York: Bloomsbury.
- McKevitt, Andrew C. 2017. *Consuming Japan: Popular Culture and the Globalizing of 1980s America*. Chapel Hill, NC: University of North Carolina Press.
- McKittrick, Katherine. 2013. 'Plantation Futures'. *Small Axe: A Caribbean Journal of Criticism* 17 (3 (42)): 1–15.
<https://doi.org/10.1215/07990537-2378892>.
- McKittrick, Katherine, and Alexander G. Weheliye. 2017. '808s & Heartbreak'. *Propter Nos* 2 (1): 13–42.
- McLeod, Kembrew, and Peter DiCola. 2011. *Creative License: The Law and Culture of Digital Sampling*. Durham, NC: Duke University Press.

- McLuhan, Marshall. (1964) 1994. 'Part I'. In *Understanding Media: The Extensions of Man*, 3–73. Reprint, Cambridge, MA: MIT Press.
- McRobbie, Angela. 2016. 'Unpacking the Politics of Creative Labour'. In *Making a Living in the New Culture Industries*, 33–60. Malden, MA: Polity Press.
- Medina, Ismael. 2017. 'And The Beat Goes On: The Story of the Drum Machine'. Seaside, CA: California State University, Monterey Bay.
https://digitalcommons.csUMB.edu/caps_thes_all/98/.
- Metlay, Mike, and Gordon Reid, eds. 2022. *Inspire the Music*. Copenhagen: Bjooks Media.
- Metro Times music staff. 2007. 'The 100 Greatest Detroit Songs Ever!' *Detroit Metro Times*, 21 November 2007.
<https://www.metrotimes.com/detroit/the-100-greatest-detroit-songs-ever/Content?oid=2190229>.
- Michaels, Rob. 1999. 'Juan Atkins: Mastermix Volume One'. *Spin*, 1 January 1999.
- Miki, Jun-ichi. 2019. 'The JUPITER-X & Xm Story'. *Roland.Com*, 2019.
https://www.roland.com/us/promos/jupiter-x_story/.
- Miller, Debby. 1983. 'Prince's Hot Rock'. *Rolling Stone*, 28 April 1983.
- Miller, Karl Hagstrom. 2010. 'Race Records and Old-Time Music: The Creation of Two Marketing Categories in the 1920s'. In *Segregating Sound: Inventing Folk and Pop Music in the Age of Jim Crow*, 187–214. Durham, NC: Duke University Press.
- Milner, Greg. 2010. *Perfecting Sound Forever: An Aural History of Recorded Music*. New York: Farrar, Straus and Giroux.

- Minniti, Sergio, and Paolo Magaudda. 2019. 'Retromedia-in-Practice: A Practice Theory Approach for Rethinking Old and New Media Technologies'. *Convergence: The International Journal of Research into New Media Technologies* 25 (4): 673–93. <https://doi.org/10.1177/1354856519842805>.
- Moggridge, Bill. 2007. *Designing Interactions*. Cambridge, MA: MIT Press.
- Morris, Jeremy Wade. 2015. 'Introduction: The Digital Music Economy'. In *Selling Digital Music, Formatting Culture*, 1–29. Berkeley, CA: University of California Press.
- Morrison, Toni. 1995. 'The Site of Memory'. In *Inventing the Truth: The Art and Craft of Memoire*, edited by William Zinsser, 2nd ed., 83–102. Houghton Mifflin.
- Morris-Suzuki, Tessa. 1984. 'Robots and Capitalism'. *New Left Review* 1 (147): 109–21.
- Moten, Fred. 2003. *In the Break: The Aesthetics of the Black Musical Tradition*. Minneapolis, MN: University of Minnesota Press.
- Nagle, Peter. 2014. 'Roland TR8 Rhythm Performer'. *Sound on Sound*, April 2014. <https://www.soundonsound.com/reviews/roland-tr8-rhythm-performer>.
- Nelson, Andrew J. 2015. 'Duet for Stanford and Yamaha'. In *The Sound of Innovation: Stanford and the Computer Music Revolution*, 73–96. Cambridge, MA: MIT Press.
- Neumann, Tracy. 2016. *Remaking the Rust Belt: The Postindustrial Transformation in North America*. Philadelphia, PA: University of Pennsylvania Press.

- Niebur, Louis. 2010. 'The Coming of the Synthesizers'. In *Special Sound: The Creation and Legacy of the BBC Radiophonic Workshop*, 120–57. Oxford: Oxford University Press.
- Nooney, Laine, Kevin Driscoll, and Kera Allen. 2020. 'From Programming to Products: Softalk Magazine and the Rise of the Personal Computer User'. *Information & Culture* 55 (2): 105–29.
- Norman, Don. (1988) 2013. *The Design of Everyday Things*. Revised and Expanded. Philadelphia, PA: Basic Books.
- Normant, Lynn. 1986. 'Interview with Prince'. *Ebony*, July 1986.
- Ogborn, David. 2016. 'Live Coding Together: Three Potentials of Collective Live Coding'. *Journal of Music, Technology & Education* 9 (1): 17–31.
- Palmer, David L. 1998. 'Virtuosity as Rhetoric: Agency and Transformation in Paganini's Mastery of the Violin'. *Quarterly Journal of Speech* 84 (3): 341–56.
- Parikka, Jussi. 2012. 'Introduction: Cartographies of the Old and the New'. In *What Is Media Archaeology?*, 1–18. Cambridge, UK: Polity Press.
- Patrin, Nate. 2020. *Bring That Beat Back: How Sampling Built Hip Hop*. Minneapolis, MN: University of Minnesota Press.
- Patteson, Thomas. 2016. "'The Joy of Precision": Mechanical Instruments and the Aesthetics of Automation'. In *Instruments for New Music: Sound, Technology, and Modernism*, 18–51. Oakland, CA: University of California Press.
- Pinch, Trevor. 2002. 'Emulating Sound. What Synthesizers Can and Can't Do: Explorations in the Social Construction of Sound'. In *Wissen Und Soziale Konstruktion*, edited by C. Zittel. Berlin: Akademie Verlag.

- Pinch, Trevor, and David Reinecke. 2009. 'Technostalgia: How Old Gear Lives on in New Music'. In *Sound Souvenirs: Audio Technologies, Memory and Cultural Practices*, edited by Karen Bijsterveld and José Van Dijck, 152–66. Amsterdam: Amsterdam University Press.
- Pinch, Trevor, and Frank Trocco. 2002. *Analog Days: The Invention and Impact of the Moog Synthesizer*. Cambridge, MA: Harvard University Press.
- Pollard III, Alton B. 1989. 'Religion, Rock, and Eroticism: Prince'. *Black Sacred Music* 3 (2): 133–41.
- Prince. 2019. *The Beautiful Ones*. Edited by Dan Piepenbring. New York: Spiegel & Grau.
- 'Prince Rogers Nelson Interview'. 1999. *Larry King Live*. CNN.
- 'Prince Talks'. 1985. MTV.
- Ramos, Nic John. 2014. 'Towards an Epistemology of Prince'. *Journal of Popular Music Studies* 26 (4): 431–44.
- Ramsey, Guthrie P. 2004. "'We Called Ourselves Modern": Race Music and the Politics of Afro-Modernism at Midcentury'. In *Race Music: Black Cultures from Bebop to Hip-Hop*, 96–130. Berkeley, CA: University of California Press.
- Reid, Gordon. 2002. 'Practical Bass Drum Synthesis'. *Sound on Sound*, February 2002.
<https://www.soundonsound.com/techniques/practical-bass-drum-synthesis>.
- Reid, Shaheem. 2005. 'Missy Elliott's Greatest Challenge on the Cookbook: Getting Ciara to Rap'. *MTV News*, 14 July 2005.
<https://www.mtv.com/news/1505732/missy-elliotts-greatest-challenge-on-the-cookbook-getting-ciara-to-rap/>.

- Reinecke, David M. 2009. “‘When I Count to Four ...’”: James Brown, Kraftwerk, and the Practice of Musical Time Keeping before Techno’. *Popular Music* 32 (5): 607–16.
- Reynolds, Simon. (1998) 2013. *Energy Flash: A Journey Through Rave Music and Culture*. London: Faber and Faber.
- Richman, Robin. 1969. ‘An Infinity of Jimis’. *Life*, 3 October 1969.
- Roads, Curtis. 1996. ‘Musical Input Devices & Performance Software’. In *The Computer Music Tutorial*, 617–702. Cambridge, UK: MIT Press.
- . 2015. *Composing Electronic Music: A New Aesthetic*. Oxford, UK: Oxford University Press.
- Rodgers, Tara. 2010. *Pink Noises*. Durham, NC: Duke University Press.
- Rodman, Gilbert B. (2004) 2012. ‘Race ... and Other Four Letter Words: Eminem and Hte Cultural Politics of Authenticity’. In *That’s the Joint!: The Hip-Hop Studies Reader*, edited by Mark Anthony Neal and Murray Forman, 2nd ed., 228–48. New York: Routledge.
- Roland Corporation. 2020. ‘What Is Analog Circuit Behaviour? (ACB)’, 2020.
<https://rolandcorp.com.au/blog/what-is-analog-circuit-behaviour-acb>.
- Rose, Tricia. 1994. *Black Noise: Rap Music and Black Culture in Contemporary America*. Hanover, NH: University Press of New England.
- Royce, Anya. 2004. *Anthropology of the Performing Arts: Artistry, Virtuosity, and Interpretation in a Cross-Cultural Perspective*. Walnut Creek, CA: Altamira Press.
- Rubin, Mike. 2016. ‘Rik Davis: Alleys Of His Mind’. *Red Bull Music Academy*, 24 May 2016.
<https://daily.redbullmusicacademy.com/2016/05/rik-davis-alleys-of-his-mind>.

Rubin, Rick. n.d. 'Broken Record: Missy Elliot'. Accessed 4 April 2022.

<https://www.pushkin.fm/episode/missy-elliott/>.

Ruseell, James. 2019. 'Music Tech Legend Roger Linn: "I Rarely Listen to Anything with Drum Machines in It"'. *Music Radar*, 3 July 2019.

<https://www.musicradar.com/news/music-tech-legend-roger-linn-i-rarely-listen-to-anything-with-drum-machines-in-it>.

Russolo, Luigi. 2004. 'The Art of Noises: Futurist Manifesto'. In *Audio Culture: Readings in Modern Music*, edited by Christoph Cox and Daniel Warner, 10–14. New York: Continuum.

Sanadzadeh, Iran. 2023. 'Developing Gestural Virtuosity for Electronic Music'. In *Contemporary Musical Virtuositie*, edited by Louise Devenish. London, UK: Taylor & Francis Unlimited.

Schafer, R. Murray. 2004. 'The Music of the Environment'. In *Audio Culture: Readings in Modern Music*, edited by Christoph Cox and Daniel Warner, 29–39. New York: Continuum.

Schütte, Uwe. 2020. *Kraftwerk: Future Music from Germany*. London, UK: Penguin Books.

Shallcross, Mike. 1997. 'From Detroit to Deep Space'. *The Wire*, July 1997.

Shepherd, John, and Kyle Devine, eds. 2015. 'Consumption'. In *The Routledge Reader on The Sociology of Music*, 141–67. New York: Routledge.

Sherbourne, Simon. 2020. 'Behringer RD-8 Rhythm Designer'. *Sound on Sound*, January 2020.

<https://www.soundonsound.com/reviews/behringer-rd-8-rhythm-designer>.

Sicko, Dan. (1999) 2010. *Techno Rebels: The Renegades of Electronic Funk*. 2nd Revised. Detroit: Painted Turtle.

- 'Signals: Mackie Files Lawsuit'. 1997. *Professional Sound* 8 (4): 11.
- Smith, Gareth Dylan. 2016. *I Drum, Therefore I Am: Being and Becoming a Drummer*. SEMPRE Studies in The Psychology of Music. London, UK: Routledge.
- Stahl, Matt. 2012. 'Freedom, Unfreedom, and the Rhetoric of the Recording Contract'. In *Unfree Masters: Popular Music and the Politics of Work*, 143–81. Durham, NC: Duke University Press.
- Steedman, Ian. 1985. 'Robots and Capitalism: A Clarification'. *New Left Review* 1 (151): 125–28.
- Sterne, Jonathan. 2003. 'The Social Genesis of Sound Fidelity'. In *The Audible Past: Cultural Origins of Sound Reproduction*, 215–86. Durham, NC: Duke University Press.
- . 2016. 'Analog'. In *Digital Keywords: A Vocabulary of Information Society and Culture*, 31–44. Princeton, NJ: Princeton University Press.
- Sterne, Jonathan, Mary Caton Lingold, Darren Mueller, and Whitney Trettien. 2018. 'Demands of Duration: The Futures of Digital Sound Scholarship'. In *Digital Sound Studies*, 267–84. Durham, NC: Duke University Press.
- Stetson, Damon. 1970. 'Walter Reuther: Union Pioneer With Broad Influence Far Beyond the Field of Labor'. *New York Times*, 11 May 1970.
- Stoeber, Jennifer Lynn. 2016. 'Introduction: The Sonic Color Line and the Listening Ear'. In *The Sonic Color Line: Race and the Cultural Politics of Listening*, 1–28. New York: NYU Press.
- Sue, Craig, and Steve Jones. 2018. 'The Mysterious Heart of the Roland TR-808 Drum Machine'. *The Secret Life of Synthesizers*, 19 May 2018.
<https://secretlifeofsynthesizers.com/the-strange-heart-of-the-roland-tr-808/>.

- Taylor, Timothy D. 2015. 'Introduction: Capitalism, Music, and Social Theory'. In *Music and Capitalism: A History of the Present*, 19. Chicago, IL: University of Chicago Press.
- Teboul, Ezra J. 2017. 'Electronic Music Hardware and Open Design Methodologies for Post-Optimal Objects'. In *Making Things and Drawing Boundaries: Experiments in the Digital Humanities*, edited by Jentery Sayers, 177–84. Minneapolis, MN: University of Minnesota Press.
- . 2020. 'A Method For The Analysis Of Handmade Electronic Music As The Basis Of New Works'. Troy, New York: Rensselaer Polytechnic Institute. <https://archive.org/details/teboul-2020-a-method-for-the-analysis-of-handmade-electronic-music-as-the-basis-of-new-works>.
- 'The Intersection: What Detroit Has Gained and Lost, 50 Years after the Uprisings of 1967'. 2017. Traverse City, MI: Bridge Magazine & The Detroit Journalism Collective.
- Théberge, Paul. 1997. *Any Sound You Can Imagine: Making Music/Consuming Technology*. Hanover, NH: University Press of New England.
- Thompson, Marie, and Ian Biddle, eds. 2013. 'Part Two: Hearing, Playing, Feeling: Music and the Organization of Affect'. In *Sound, Music, Affect*, 73–116. New York: Bloomsbury Academic.
- Till, Rupert. 2010. 'Pop Stars and Idolatry: An Investigation of the Worship of Popular Music Icons, and the Music and Cult of Prince'. *Journal of Beliefs and Values* 31 (1): 69–80.
- Toffler, Alvin. (1971) 1970. *Future Shock*. New York: Bantam Books.
- . (1980) 1981. *The Third Wave*. New York: Bantam Books.

- Tompkins, Dave. 2011. *How to Wreck a Nice Beach: The Vocoder from World War II to Hip-Hop, The Machine Speaks*. Reprint Edition. New York: Stop Smiling Books.
- Toynbee, Jason. 2001. 'Dance Music: Business as Usual or Heaven on Earth?' In *Making Popular Music: Musicians, Creativity and Institutions*, 130–62. London: Bloomsbury Academic.
- 'TR-808 Service Notes'. 1981.
- Trask, Simon. 1988. 'Future Shock'. *Music Technology*, December 1988.
- Tudahl, Duane. 2018. *Prince and the Purple Rain Era Studio Sessions 1983 and 1984*. London: Rowman & Littlefield.
- Vecchiola, Carla, and John Collins. 2021. 'From the Dance Floor: A Snapshot of Detroit Techno'. In *Electronic Landscapes: Music, Space, and Resistance in Detroit*, edited by Isaac Diggs and Edward Hillel, 104–7. Queens, NY: Kris Graves Projects.
- Veen, Tobias C. van. 2013. 'Vessels of Transfer: Allegories of Afrofuturism in Jeff Mills and Janelle Monáe'. *Dancecult: Journal of Electronic Dance Music Culture* 5 (2): 7–41. <http://dx.doi.org/10.12801/1947-5403.2013.05.02.02>.
- Verplank, Bill. 2009. 'Interaction Design Sketchbook'.
<http://billverplank.com/lxDSketchBook.pdf>.
- Vincent, Rickey. 2004. 'Hip-Hop and Black Noise: Raising Hell'. In *That's the Joint!: The Hip-Hop Studies Reader*, edited by Murray Forman and Mark Anthony Neal, 2nd ed., 481–92. New York: Routledge.
- Vlado, Pupa, and Robert Camhouse. n.d. 'Sleng Teng Riddim'. *Riddim-ID*.
<https://riddim-id.com/riddims/18/sleng-teng>.

- Von Hippel, Eric. 1986. 'Lead Users: A Source of Novel Product Concepts'. *Management Science* 32 (7): 791–805.
- Waksman, Steve. 2001. 'Black Sound, Black Body: Jimi Hendrix, the Electric Guitar and the Meanings of Blackness'. In *Instruments of Desire: The Electric Guitar and the Shaping of Musical Experience*. Cambridge, MA: Harvard University Press.
- Wang, Oliver. 2014. 'Hear the Drum Machine Get Wicked'. *Journal of Popular Music Studies* 26 (2–3): 220–25. <https://doi.org/10.1111/jpms.12074>.
- Wark, McKenzie. 1991. 'From Fordism to Sonyism'. *New Formations*, no. 15, 43–54.
- Weheliye, Alexander G. 2002. 'Posthuman Voices in Contemporary Black Popular Music'. Edited by Alondra Nelson. *Social Text* 20 (71): 23–47.
- . 2005. *Phonographies: Grooves in Afro-Modernity*. Durham, NC: Duke University Press.
- Werner, Kurt James. 2015. 'The Roland TR-808 and the Tale of the Marching Anteaters'. *Ethnomusicology Review* 20 (1).
<https://ethnomusicologyreview.ucla.edu/content/roland-tr-808-and-tale-marching-anteaters>.
- Werner, Kurt James, Jonathan S. Abel, and Julius O. Smith III. 2014a. 'A Physically-Informed, Circuit-Bendable, Digital Model of the Roland TR-808 Bass Drum Circuit'. In *Proceedings of the International Conference on Digital Audio Effects (DAFx-14)*. Erlangen, Germany.
- . 2014b. 'More Cowbell: A Physically-Informed, Circuit-Bendable, Digital Model of the TR-808 Cowbell'. In *Proceedings of the 137th International Audio Engineering Society Convention*. Los Angeles, CA.

- . 2014c. 'The TR-808 Cymbal: A Physically-Informed, Circuit-Bendable, Digital Model'. In *Proceedings of the 40th International Computer Music Conference (ICMC) / 11th Sound and Music Computing (SMC) Conference*. Athens, Greece.
- Wessel, David, and Matthew Wright. 2001. 'Problems and Prospects for Intimate Musical Control of Computers'. In *Proceedings of the CHI'01 Workshop on New Interfaces for Musical Expression (NIME-01)*, 11–14. Seattle, USA.
- Wiener, Norbert. (1948) 2013. *Cybernetics or Control and Communication in the Animal and the Machine*. 2nd ed. Mansfield Centre, CT: Martino Publishing.
- Wilkie, Katie, Simon Holland, and Paul Mulholland. 2010. 'What Can the Language of Musicians Tell Us About Interaction Design?' *Computer Music Journal* 34 (4): 34–48.
- Wilkins, Langston Collin. 2017. 'Officially Ridin' Swangas: Slab as Tangible and Intangible Cultural Heritage in Houston, Texas'. In *The Routledge Companion to Intangible Cultural Heritage*, edited by Michelle Stefano and Peter Davis, 229–39. London, UK.
- Williams, Ben. 2001. 'Black Secret Technology: Detroit Techno and the Information Age'. In *Technicolor: Race, Technology, and Everyday Life*, edited by Alondra Nelson and Tu Thuy Linh N., 154–76. New York: NYU Press.
- Williams, Sean. 2013. 'Stockhausen Meets King Tubby's: The Transformation of the Stepped Filter into a Musical Instrument'. In *Material Culture and Electronic Sound*, edited by Frode Weium and Tim Boon, 159–83. Washington, DC: Smithsonian Institution Scholarly Press.

Woirol, Gregory R. 2006. 'New Data, New Issues: The Origins of the Technological Unemployment Debates'. *History of Political Economy* 38 (3).
<https://doi.org/10.1215/00182702-2006-003>.

Zielinski, Siegfried. 2006. 'Conclusions: Including a Proposal for the Cartography of Media Archaeology'. In *Deep Time of the Media: Toward an Archaeology of Hearing and Seeing by Technical Means*, translated by Gloria Custance, 255–80. Cambridge, MA: MIT Press.