CHAPTER 33

(MICRO)POLITICS OF ALGORITHMIC MUSIC

Towards a Tactical Media Archaeology

GEOFF COX AND MORTEN RIIS

33.1 Introduction

Algorithms have effects and play an increasingly determining role in our lives—from the inner workings of financial capitalism to decision-making processes in everyday circumstances. They are controlling the tiny microsounds of Curtis Roads and the minute generative drum structures from Autechre, but algorithms also provide structure to the 1000-year-long composition *Longplayer* by Jem Finer and John Cage's 639-year-long organ piece *As SLow aS Possible*.[1] More than simply instructions to be performed, algorithms modulate across different scales and temporalities; they are techniques that offer tactics to order and control materials between microtemporal processes and larger data sets. Based on mathematical models, algorithms process massive amounts of data, to predict gains and reduce risks, to exert control over increased complexity, but as can be seen from the financial crash of 2008, they are hardly infallible. Our reliance on them is a leap of faith and yet they are abstractions with powerful effects, as Andrew Goffey puts it: 'Algorithms act, but they do so as part of an ill-defined network of actions upon actions, part of a complex of power-knowledge relations, in which unintended consequences, like the side effects of a program's behavior, can become critically important' (2008, 19).

How algorithms act then becomes hugely significant for understanding how they operate within larger power–knowledge systems at different scales and for their creative potential. They do not merely manage and organize sound, as in the case of selection algorithms for Spotify or iTunes, but generate the deep rhythms and structures of what constitutes cultural and political life. This chapter unfolds the discussion in relation to algorithmic music to develop an argument for a shift of emphasis from the imposition

of rules or instructions as a structuring device for new musical forms—as has been the tendency in electronic music—to a deeper techno-materialist understanding of what is happening at various scales and temporalities of operation. In this way our argument is that algorithms become epistemological tools to understand the increased dependency on scripts, scores, and programs as part of informational systems and wider socio-technical assemblages that shape our operational logic and decisions. This is especially important when algorithms like Google's PageRank or Facebook's EdgeRank make sense of big data in distorted ways to 'reify' knowledge and make sure that communication is linked to market forces.

In contrast to a perspective rooted in the political economy, this chapter develops an argument based upon ideas from media archaeology and the critical tradition of tactical media. These perspectives are significant as they shift attention to the ability of nonhuman entities to generate alternative forms of knowledge that are not easily perceptible to humans. The critical tradition of media archaeology is informed by the archaeological work of Michel Foucault and the media theory of Friedrich Kittler and Marshall McLuhan. Other significant writers that have influenced the development of media archaeology include Walter Benjamin, Siegfried Giedion, Ernst Robert Curtius, Dolf Sternberger, and Aby Warburg. In brief (as more detail is provided later in the chapter), the archaeological excavation becomes a mode of reverse-engineering of normative understandings, a transformation of what has already been written, and thereby counterhistory. Media archaeology builds upon these principles to assert that the material-technological dimension is not sufficiently developed in terms of accounting for the way that media produces knowledge and experience. In adding media to Foucault's 'archaeology of knowledge', the limits of the human sensory apparatus are exposed and other nonhuman forms of knowledge are made apparent through the operative use of technologies. By extension we can say that there are emergent kinds of music to discover that we simply would not be able to hear were it not for the use of certain algorithms.

The chapter is structured into four further sections. First, we provide an overview of our proposed shift of emphasis from the macro to micro scale of algorithmic music, in keeping with our understanding of political processes (section 33.2, 'From Macro to Micro Politics of Algorithmic Music'). Second, media archaeology is introduced in order to align it more closely to tactical media as methodological foundation for a critical practice in algorithmic music that is attentive to engineering (section 33.3, 'Tactics of Media Archaeology'). The next section (33.4, 'Microtemporality and Time-Criticality') leads to a more detailed discussion of microtemporality, with particular reference to the media archaeology of Wolfgang Ernst, and in turn to Gilles Deleuze and Félix Guattari's notion of micropolitics, and finally to Shintaro Miyazaki's concept of algo*rhythmics*. The final section (33.5, 'Tactical Algo*rhythmics*') aims to connect these concepts to form the main proposition of the chapter: that 'tactical media archaeology' offers an analytical method for developing alternative compositions of both algorithmic music and politics. Examples are provided throughout, but the argument is quite abstract, with the intention of emphasizing more speculative approaches and broader ecologies of practice (exemplified by the critical engineering of Martin Howse). Our claim is that it is

only through exposing the way that algorithms operate as part of wider socio-technical assemblages that musical and political experimentation can really develop.

33.2 From Macro to Micro Politics of Algorithmic Music

It might be claimed that algorithmic music entails a specific aesthetic ideal or even genre—especially when taking into account the development of computer-based composition from the 1960s onwards. These compositional styles or strategies could, for instance, result in the implementation of bio-algorithms for musical organization (like the viral artificial life algorithms found in the works of Joseph Nechvatal [2011, 18, 40]), the creation of formalistic structures based on complex mathematics (Xenakis), or the more recent experiments of sound artist Florian Hecker in his *Untitled (F.A.N.N.)* (2013). With explicit references to David Tudor's work with neural networks (Riis 2013b), Hecker creates an ever-changing generative three-channel audio piece in which the artist starts an algorithmic process, and then steps back to let the computer execute a never-repeated autopoietic expression that stages technology as the creating force. It could be claimed that these examples have a specific 'sound' to them, but they also demonstrate a strategic quality—which comes out of the algorithmic approach to composition—to foreground computation and technology as a self-organizing creative force, while human agency fades into the background.

The politics of this is complex. The formal structure of algorithms offers an insight into the ways in which creative operations are organized and regulated, and a new kind of political rationality is generated that is based on control structures and accelerated automation. Algorithmic music is hardly new in this respect; automation and formalism within composition have traditions established long before the advent of computers at a macro level. Athanasius Kircher's *Arca Musarithma*, as described in his *Musurgia Universalis* from 1650 (Nierhaus 2009, 24–26), is an early example of an algorithmic compositional system that enabled untrained musicians to compose music, a system that recently became implemented within software (Bumgardner 2009). In the early twentieth century, Russian Formalism similarly sought to uncover the structural formations of language that might be applicable to wider social phenomena, founded on the idea that language consists of a set of rules that are executed according to command structures, rendering the creative subject—author, artist, musician, composer, programmer—a function of a discursive system or part of wider compositional assemblage. Taking the formalism of music into account is the notion of the music-in-itself, an autonomous entity that does not mean anything other than the sound it consists of, as exemplified by the iconic quote by Hanslick: 'Music has no subject beyond the combinations of notes we hear, for music speaks not only by means of sounds, it speaks nothing but sound' (Benestad 1977, 299). The autonomy of music is additionally expanded by incorporating

algorithmic and serial techniques as seen in the works of Boulez, Stockhausen, and others. Collective works such as Arseny Avraamov's *The Symphony of the Factory Sirens* of 1922, in which trained musicians are replaced with workers combined with the machinery of industrial production, offers an example of how creative autonomy, authorship, and authority are undermined by wider human–nonhuman assemblages. In this massively orchestrated piece of public sound art, the ships' horns of the entire fleet, two batteries of artilleries, several full infantry regiments, trucks, seaplanes, twenty-five steam locomotives, an array of pitched whistles, and several massive choirs resonated together across the entire city of Baku.

Aside from the celebration of work, what about the politics of the composition? There are numerous examples of how the tactics of social hacking and sound cultures interact, including how sound can be utilized a tactical weapon (Goodman 2010). GlobalNoise is a more contemporary example that revives the traditional practice of making a loud noise by beating a pan or other kitchen equipment to gain attention to demonstrate unrest on a global scale. The algorithmic dimension is that the organizers, the international Occupy and Spanish Indignados movements, invite people to make noise on a certain day and at an agreed time (GlobalNoise 2012). Following our description of wider compositional assemblages, we would expand the notion of the political subject to not only include the demonstrators but also to the objects themselves as if they themselves exhibit political agency.[2] Political subjects and objects become 'entangled' and are activated by scripts and scores that operate under particular conditions that require technical, legal, and discursive detail to fully account for their transformative potential.

33.2.1 Composition as Political Reworking

More than simply an expression of formal logic, algorithms do things through their command structure to accomplish a decisive action with political effects. The way algorithms impose structure on material–discursive elements might be likened to compositional processes more broadly, and the socially engaged algorithmic practices of Cornelius Cardew provide an obvious example for the discussion of the political dimensions of algorithmic music. In the essay 'All Problems of Notation Will Be Solved by the Masses', Simon Yuill (2008) discusses the work of Cardew and the Scratch Orchestra in relation to other techno-social movements such as free-software development and hacker labs, as well as the practice of live coding as an instantiation of making source code available and modifiable in real time. Also relevant here is ap's 'Life Coding' (involving Martin Howse), which plays with both software and hardware systems in real time (Yuill 2008). Clearly, algorithms play an important part in this as they define how the music is generated but in the case of live coding, unlike much electronic music, the processes themselves are made somewhat apparent as changes to the code are made public at the time of the performance.

Although there is nothing particularly unusual about experimental and improvisation techniques such as this, it is the recognition of the political potential that has

relevance for our argument. Emerging out of various creative energies of the late 1960s (such as the Anti-University of London), the Scratch Orchestra managed to develop a collective compositional form for the sharing of resources, self-organization, and peer critique.[3] The orchestra was open to all, regardless of musical training or ability, under the principles of free improvisation and experimentation. Notes, or 'scratches' as they were called, were performed and developed into larger collage forms, like the sharing of source code, distributed for further modification, and performed under 'copyleft' principles (reverse-engineering normative property relations). Works played with organizational forms and hierarchies, as in the instruction piece cited by Yuill, were likened to the procedures of generative automata: 'Each person entering the performance space receives a number in order. Anyone can give an order (imperatively obeyed) to a higher number, and must obey orders given him by a lower number' (Yuill 2008).[4]

The attention to algorithms highlights the implicit command and control structures of computation and the parallels that can be drawn between technical and social systems. Making explicit political allegiance to Marxism (Cardew was a founding member of the Revolutionary Communist Party in the United Kingdom), Cardew attacked the conservatism of musical notation and announced that 'all problems of notation will be solved by the masses' (Yuill 2008), in keeping with the perceived revolutionary potential of the worker to rewrite history. The utopianism of the Scratch Orchestra is explained by Yuill, as is its collapse as an ideological project through its overreliance on notation as a determining factor and the inherent contradiction that in legislating for nonconformity it operated its own tyranny (as, arguably, all algorithms do). Accordingly, we argue for something less totalizing for algorithmic music and more nuanced in recognition that the relations between subjects and objects are far more complex and that there are inherent conceptual problems with totalizations like 'history' or 'the masses' as the privileged agent of social change.

33.2.2 Microtemporal Rhythms

The conceptual distinction we wish to make with respect to algorithmic music is to shift attention from formalist instruction-based composition to an engagement with the temporal-sonic register of the algorithm itself. Algorithms do not simply define an ensuing event but also a movement and rhythm of signals that oscillate between various materialities and systems. This is what artist-researcher Shintaro Miyazaki has discussed through his concept of 'algo*rhythmics*' (Miyazaki 2012, 2013a): on the one hand, it is a finite sequence of step-by-step instructions (algorithm), a procedure for solving a problem, and on the other a temporal ordering of infinite movement (rhythm). We use this concept centrally in this chapter to try to better understand the operation of algorithms and their inherent rhythmical structures and the musical potential of nonhuman objects. Rather than examine music as such, Miyazaki develops a method for recording the electromagnetic waves that fill the airwaves of our information society. When these recordings are played back and the speaker membrane begins to vibrate, a set of events

unfold from a 'microtemporal' perspective (something discussed in more depth in the following section). In one recording, first there are rapid bursts of white noise, slowly transformed into more rhythmical structures accompanied by high-pitched melodic fluctuations hovering high over the low rumblings of metronomically accurate steps, forcing the speaker membrane to its utmost extreme positions. This close description of musical events taking place within the demodulated electromagnetic waves becomes an alternative way of analysing and conceptualizing the way in which algorithms function and somewhat control our experience and behaviour.

33.2.3 Micropolitical Tactics

The chapter develops this 'microtemporal' perspective in order to expose both the micropolitical lines within formalized and rule-based music and how algorithms increasingly mediate contemporary life and politics at multiple scales and temporalities. All politics is both *macro*political and *micro*political simultaneously, according to Deleuze and Guattari (2005), and we therefore ignore the small details at our peril. By connecting micropolitics and microtemporality more closely in this chapter, a more nuanced and subtle form of power can be seen to operate across scales and territories of social order and to address the increased importance of 'media'. This is also where 'tactical media' arguably becomes a useful critical tool for assessing the ability of oppositional movements to create meaningful change—building on Michel de Certeau's *The Practice of Everyday Life* (1984) and Hakim Bey's anarchist notion of 'Temporary Autonomous Zone' (1991). By 'reverse-engineering' aspects of the social order from within the very system itself, at a level of operation that is not directly apparent, tactical media offers contemporary forms of political action that lie somewhere between creative experimentation and a reflexive engagement with communicative forms and social change, using tactics that recognize shifting identifications, temporary alliances, and affinities according to relations, contingency, and context.

Derived from independent media activism and radical pragmatism, tactical media is also inspired by the ballistics of Dada and the Situationist notion of *détournement*, as well as other contemporary sources that draw together art, activism, and hacking, such as 'hacktivism' and 'artivism'. Much has been written on the topic of tactical media—a term that derives from 1996 and in particular the *Next 5 Minutes* festival, held in Amsterdam—especially by Geert Lovink and David Garcia, but also by Rita Raley in her book *Tactical Media* (Raley 2009) that describes some of the hacktivist practices of cultural producers such as Critical Art Ensemble, Electronic Disturbance Theater, and The Yes Men, amongst others. After the proliferation of social media and events such as the Occupy movement, the legacies of tactical media and its connections to the present have become the subject of ongoing examination in keeping with its aim of adapting according to conditions.[5]

AQ: 'recently': since the shelf life of this book will one hopes be long, could you be specific about

Part of the difficulty of the use of tactical use is that it is prone to recuperation, effectively nullifying its critical effects. The noise and glitch music cultures make good

examples in providing some useful critical tools for analysing informational flows and at the same time an aesthetic for commercial exploitation. The noise outbursts and screaming digital glitches of Merzbow and Oval in the early 1990s may have had a critical voice at that time, but today these explorations within the 'aesthetics of failure' (Cascone 2000) are subsumed within mainstream culture. Commercial sample packs containing 'the most original and inspiring glitch content possible' (Loopmasters 2012a), 'creating all manner of weird and unlikely sounds' (Loopmasters 2012b), and adding 'some serious twisted nastiness' (Loopmasters 2012c), are today a well-established part of the electronic music producer's sounding palette. Commercialization has transformed auditory glitches from a possible political critique into a well-established music genre, which Kim Cascone later recontextualizes as the 'failure of aesthetics' (Cascone 2010).

But whether tactical media works in the long term is the wrong question to ask. Instead, what should be asked is to what extent are its activities effective at any given moment in time. This describes the tactical as a temporary critical intervention that is highly contingent on the circumstances within which it finds itself, even to the point where its own contradiction can be embraced as a critical move. It is possible to speculate on how certain kinds of critical practice using algorithmic logic can also be pushed to their extremes—as an over-identification with financial capitalism. One challenging example, in the context of a critique of financial capitalism, is the Robin Hood Minor Asset Management project (Vesikukka 2015). Robin Hood uses financial technology upon itself, with a dynamic data-mining algorithm called Parasite. The algorithm analyses the big data of financial transactions to raise money and redistribute wealth. So rather than examine the broader political efficacy of these tactical interventions, this chapter aims to concentrate on those tactics that expose the relatively hidden layers of technological complexity through the inner workings of algorithmic machines. In this sense the chapter can be read as a tactical intervention in itself, to draw attention to algorithmic details in order to break down informational and networked flows of power—echoing Michel Foucault. This is why the micropolitical dimension of socio-technical assemblages needs greater elaboration and closer forensic analysis—as seen in the work of Kirschenbaum (2012)—in order to unfold practices that are sensitive to the mode of production and techno-materialist conditions.

33.3 Tactics of Media Archaeology

This section will briefly introduce and situate media archaeology, forming a methodological framing for our further investigation of the micropolitical aspects of algorithmic music. The term 'media archaeology' originates from Jacques Perriault's book *Mémoires de l'ombre et du son: Une archéologie de l'audio-visuel* [Memories of shadow and sound: An archaeology of audiovisuality] from 1981 (Huhtamo and Parikka 2011, 3), but the research field became more established during the 1990s, through scholars such as Erkki Huhtamo, Siegfried Zielinski, and Wolfgang Ernst, building on the media theory

of Kittler and the counterhistory of Foucault. Foucault's notion of history opposes the traditional one, which is built upon drawing the great lines, building large-scale chronological tables that order series of continuous events and reflections (Foucault 1972, 3–4). Instead of lines of continuity, he insists on writing a history that focusses on discontinuity and rupture. The term 'archaeology' becomes central for Foucault in unfolding his counterhistory to investigate how various discourses within historical documents are often conflicting and contradictory. The archaeological excavation thus becomes a rewriting, a transformation of what has already been written, focusing greatly on the gaps or the forgotten details—meaning that the archaeological study always functions on many levels at the same time—comparing and opposing them (Foucault 1972, 157). The multiple and diverse discourses are not be regarded as obstacles or something to be overcome, but rather to be seen as what they exactly consist of in order to differentiate them and bring them into new formations of knowledge.

But despite the similarities of approach and connection to Foucauldian methodology, the media archaeological approach is far more complex and diverse. The media archaeological approach emphasizes cyclical rather than chronological development, which is in contrast to the customary way of thinking about technological culture in terms of a constant progress from one technological breakthrough to another, making earlier machines obsolete along the way. The aim of the media archaeological approach then is not to negate the 'reality' of technological development, but rather to balance it by placing it within a wider and more multifaceted social and cultural frame of reference (Huhtamo 1997, 223). This approach introduces a shift from the chronological and positivistic ordering of media technologies towards treating history as a multilayered dynamic system. In that perspective, media archaeology can be seen as a critique of media history in the narrative mode, where continuities are favoured instead of incorporating discontinuities.

The media archaeological focus on a materialistic temporality and processuality can be grounded in the work of Kittler, who redefined and modified Foucault's original concept of archaeology and gave it a more materialist approach. As Kittler claims (1999, 229), the factual conditions of any material object are no simple matter, and need to be examined and understood from a technological perspective, in order to be able to understand the development of technical media and its consequences for modern society. Furthermore, Kittler underlines the importance of the practitioners of cultural studies being able to thoroughly learn and understand mathematics in order for *Medienwissenschaft* to develop past its current media historical status. The fundamental technological logic, such as the procedures of data processing, must be studied from the engineer's point of view rather than merely evaluated 'from the point of view of their social usage' (xiv).

33.3.1 Antidisciplinary Tactics

Even though Foucauldian methodology echoes a distinct political agenda within the field of media archaeology, the approach that focuses on more fundamental materialistic layers of recording and archiving is often critiqued by the apparently nonpolitical

nature of this special media ontology (Parikka 2011a, 257; 2011b, 54). In order to stress the inbound political aspects within the media archaeological research tradition, we connect the critique of linear history within Foucault and media archaeology to Certeau's conceptualization of tactics and strategics, which becomes useful in unfolding deeper perspectives of the political issues within technological apparatuses. In *The Practice of Everyday Life*, Certeau unfolds how the strategical can be understood as a force-relationship that occurs when a subject 'of will and power' can be isolated from an environment—executing what could be denoted as a long-time plan, which is a condition for, for example, political and economic models (Certeau 1988, xix). The tactic, or tactical, on the other hand, is described as not belonging to a spatial or institutional context. Tactics can be understood as dynamic processes that are dependent on flowing temporalities which constantly open up to new opportunities that must be seized on the wing. Thus tactics have no base at their disposal in which they can 'capitalise on its advantages, prepare its expansions, and secure independence with respect to circumstances' (xix).

In examining how autonomy might be reclaimed from the forces of commerce and politics, Certeau asserts that users operate opposing established rules in the most ordinary of circumstances. The concern is with the modes of operation, not human subjects as such but their actions, that together form a culture wherein models of action are characterized by users in ways that resist the idea of passive usage or consumption. According to Certeau, consumers negotiate discipline and power exerted on them by tactical forms and makeshift creativity; through what he calls 'antidiscipline'—making a direct reference to Foucault (Certeau 1988, xv). His examples are social practices like walking or cooking, but we might add playing or listening to music in the most ordinary of circumstances—everyday practices that constitute what has become known as popular culture in which social relations are reconstituted and thereby necessarily political. Everyday practices are potentially 'tactical in character', offering new ways of operating and doing politics (Certeau 1988, xix). For instance, the practice of hacking might be usefully described in these terms, as a tactical reuse of existing materials and structures, the modification of instructions and rule sets that we work and live by. Through these conceptualizations proposed by Certeau the media archaeological approach develops perspectives on the dynamic and fluid processes of technological apparatuses, thus unfolding what could be described as antidisciplinary tactics and antihistorical epistemologies.

33.3.2 The Media Archaeological Ear

Through media archaeology it is possible to discern new kinds of historical knowledge that exceed the visible and readable to include ways of listening to historical material: according to Ernst, it becomes possible to hear history. Following in the tradition of Kittler, Ernst takes media to be a blind spot in humanities research, and in the case of the phonograph, for instance, this opens up other sonic registers beyond music. His example is the way that the telephone or gramophone changes the way we understand the relations between writing and speech. According to Ernst, the human voice

is frozen by technical media, by reducing it to symbolic code, but can be unfrozen by its replay with all its richness and variations of frequencies. In the case of a recording of a voice, the noise also becomes an important carrier of information—the frozen technical knowledge that is also made available. Ernst describes how technical repeatability generates 'an almost ahistorical functional reenactment' (2013, 175) and thus an experience of media time in contrast to the historicist notion of time. The tactic of 'reenactment' can operate as a time machine in this sense, not operating in the same time as such, but in the way knowledge is generated: 'the original experience is repeatable; the actual experiment allows for (com)munition across the temporal gap' (177).

The claim is that the human sensory apparatus is inadequate for certain tasks and that acoustic archaeology requires the media itself to uncover other hidden aspects of knowledge. This is what Ernst calls the 'media archaeological ear that listens to the sound of material tradition, in fact the technically mediated *sonic* processuality of what is otherwise called history' (2013, 181). Thus media archaeology comes into operation at the point where media (and not just humans) become active archaeologists of knowledge (Ernst 2011, 239), producing a conceptualization in which the media-archaeological ear is more like a microphone and the objects in question become less historical and more processual. Ernst's example is 'Fourier analysis', in which the machine performs a better cultural analysis than the human is capable of. For instance, in signal processing (of audio, radio waves, light waves, seismic waves, and images), Fourier analysis can isolate individual components of a compound waveform, concentrating them for easier detection or removal, in order to generate an expanded cultural understanding of how technology affects and intervenes in culture.[6] In this way, it becomes clear how media archaeology operates as an extension of a Foucauldian 'archaeology of knowledge', extending beyond the limitations of the human sensory apparatus to the nondiscursive realm of technical infrastructures and algorithmic processes.

Today there is an increasing tendency to historicize musical technology, and somehow try to connect a present-day technological reality to historical inventions. But in order for the media archaeological ear to be effective it is very important to distance oneself from the 'retro-maniac' (Reynolds 2011) tendencies within contemporary music technology consumption, and instead dig deeper into operational mechanisms. There are numerous examples of this problem. In 2014 Future Retro released the Zillion Algorithmic Sequencer (Futureretro 2014) a hardware MIDI sequencer that is heavily inspired by the Triadex Muse algorithmic event generator built by Edward Fredkin and Marvin Minsky at MIT in 1972 (Kendall, Haworth, and Cadiz 2014, 9; Sloane 2000, 192). The Triadex Muse was used extensively by composer Maryanne Amacher to create her famous 'eartone' music—a musical construction whose goal is to separate the musical stream from the subjective auditory ear—an aesthetic ideal that later was picked up by sound artist Florian Hecker on his 2012 tribute to Amacher on the album *Triadex Muse Treks* (Hecker 2012). What this contemporary example of reenacting 'vintage' algorithms is missing is that the algorithm cannot be reduced to its discursive symbolic meaning only and does not generate meaning or significance exclusively based on a historical dimension but needs a conceptualization that incorporates the knowledge

FIGURE 33.1 Section of the mechanical musical instrument and performance practice *Steam Machine Music* (2010) by Morten Riis. Courtesy of the artist.

gained from the nondiscursive realm of the technical apparatus itself (Ernst 2009b). So in order to achieve a more nuanced perspective of what constitutes an algorithm, we must shift our analysis towards the micro details of execution and temporality. The way algorithms are embedded within our lives is not just an operation on a symbolic level but an action with effects. Thus in order to understand how algorithms are acting (and controlling) we must go beyond the symbolic register of code and investigate the microtemporal events taking place through a techno-materialist understanding of what is happening at various scales, and across layers of operation, in complex assemblages of hardware and software.

Both *Steam Machine Music* (2010)[7] and *Opaque Sounding* (2014)[8] are examples of this critical media archaeological listening approach that through tactical reenactment operate as time machines and generate knowledge to highlight the materiality of the machine that runs its instructions. Both pieces use perforated paper strips (punch card systems) to store events which are then executed by either a steam engine or a mechanical construction in Meccano driven by a small 12V DC engine. With these programmable machines we are drawn to acknowledge that discursive structures are underwritten by the nondiscursive realm of technical infrastructures and algorithmic processes and that these both run and break down in particular ways. For this reason the combined conceptual and practical approach of media archaeology is successful in challenging the way that informational processes are understood and enacted. Against the grain of technical progress, such examples offer a challenge to media-historical narratives through 'epistemological reverse engineering' as Ernst puts it (2011, 239). From this

perspective, the cultural lifespan of a technical object is not the same as its operational lifespan (e.g. a radio receiving an analogue signal), and there is a 'media-archaeological short circuit between otherwise historically clearly separated times' (240). By this, Ernst is suggesting that there is not necessarily a difference in its functional technical operation in the past and now. An algorithmic event undermines its own historicization.

33.4 Microtemporality and Time-Criticality

Under techno-epistemological conditions, it becomes clear that something other than a conventionally executed history of technical inventions is at stake. As previously explained, the media archaeological ear can short-circuit historical implications, and consequently it becomes necessary not only to understand time and cultural memory at a macro level, but to include the micro-level temporalities, or the time-critical elements which are crucial to both digital and mechanical technologies. 'Critical' in this context is not be understood as in, for example, critical theory, but as in criticality as the decisiveness of the temporal events that happen from the engineers' point of view (Parikka 2011b, 59), meaning that priority is given to the nonsemantic signals of technology; to some extent suspending the cultural or social implications. This media temporality or time-criticality is experienced by experimenting with the physical media themselves (Ernst 2009b). Thus the reenactment of the experiments conducted by Pythagoras on the monochord enables us, according to Ernst, to experience the relationship between integer numbers and harmonic musical intervals (2009b). Of course we are not in the same historical situation as Pythagoras, and even our mode of listening must be considered to be very different, but as Ernst claims, the monochord operates as a time machine: 'it lets us share, participate at the original discovery of musicological knowledge' (2009b).

Time-criticality or microtemporality is how modern technical media has manipulated the time axis since—for example—the Edison sound-reversing phonograph. It is the running of machines, code, and algorithms that is central to the time-critical understanding of digital media, defined by patterns of signals unfolding in time (Parikka 2011b, 59). Ernst focuses on the microtemporality, which combines technical memory with cultural memory as an active process and not just a stable permanent memory. For example, the television image is continuously being regenerated by the line-update frequency and is not just a stable image. The 'prepared televisions' of Nam June Paik, as for example his *Magnet TV* (1965), attest to the creative potential of this techno-materialist understanding, where magnetic fields interfere with the television's electronic signals, distorting the broadcast image into an abstract form. Similarly, the computer is not to be misinterpreted as a static machine with static memory but decidedly a temporal and mutable (sonic) machine.

33.4.1 Forensic Materiality

An understanding of this can be expanded through Mathew Kirschenbaum's notions of 'forensic materiality' and 'formal materiality'. Forensic materiality firmly rests upon its potential of an individualization inherent in matter (Kirschenbaum 2012, 10–11) and can be described as demonstrating how no two things in the physical world are alike; for instance the micron-sized nonconformity of the physical inscriptions on magnetic storage devices and the varying contours of the computer keyboard. Forensic materiality is positioned against the notion of formal materiality, which can be described as being how software sustains and propagates an illusion of immateriality (Kirschenbaum 2012, 11–12). This is an immateriality that is governed by the hyper-redundant error-checking routines within the hard drives' reading algorithms, which constantly minimize the possible reading errors of the physical inscriptions on the drives. Thus the formal can be understood as being concerned with restoring signals to near perfection (Kirschenbaum 2012, 133), which compensates for the reading errors of our rotating hard drives, whereas glitches in software remind us of forensic materiality (135). Forensic materiality and the physical motion and dynamics of the hard drive are demonstrated in numerous experimental artworks working with sound. *Harddisko* (2004) by Valentina Vuksic is an installation demonstrating the temporal qualities of the hard drive. Rhythmic noises are evolving from sixteen hard drives, which are orchestrated through simple power circuits. By cutting the hard disk's power in varying sequences and amplifying the peculiar sound characteristics of each drive, an unpredictable acoustic and visual interplay is taking place (Vuksic 2010). Patterns of sound are produced by the variances of manufacture, models, firmware versions, and the disk's history of usage. The physical properties of hard drives are further explored in *Analog HD1* (2011) and *Analog HD2* (2012) by Gijs Gieskes, as they are transformed into musical devices (Gieskes 2012).

33.4.2 Algorhythmics

In a similar explorative manner, a techno-materialist understanding of the algorithm allows for artistic and epistemological interventions in order to broaden our modes of listening to and analysing the inaccessible signals that occupy our experience of otherwise inaudible all-encompassing streams of communication data. Developed by Miyazaki in collaboration with artist Martin Howse, the concept of algo*rhythms* is an attempt to unfold how computation comprises symbolic *and* real physical structures, as exemplified when real matter becomes controlled by the symbolic and logical structures found in instructions and code. On the one hand, algorithms can be conceptualized as abstract symbolic step-by-step instructions, as seen in programming language, that through a compiler are translated into machine code. On the other hand, algorithms can transform data, but in the end everything can be conceptualized as microrhythmical structures,[9] a conceptualization that introduces the notion of algo*rhythm* (Miyazaki

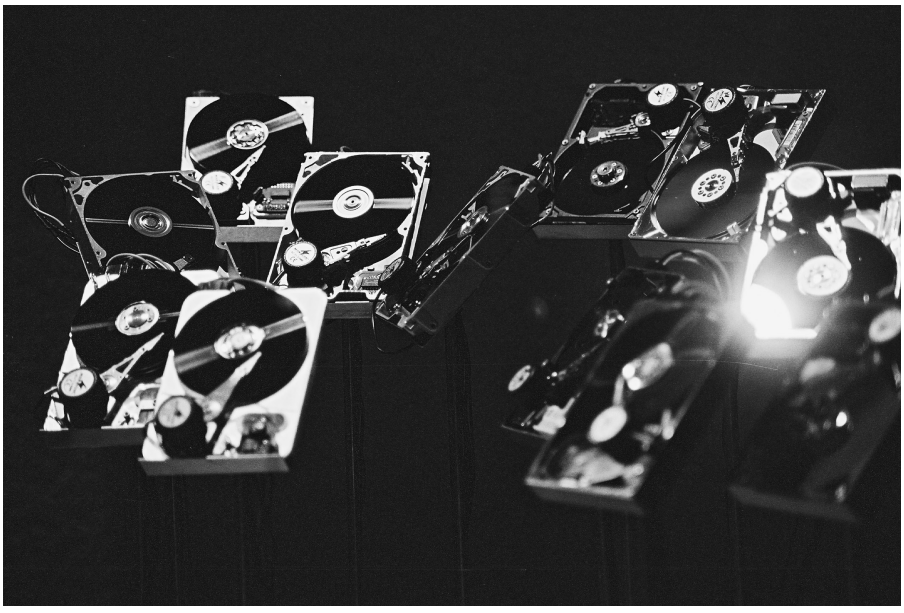

FIGURE 33.2 *Harddisko* by Valentina Vuksic, in performance at Kunsthalle, Vienna (2004). Courtesy of the artist.

2013a, 142). Through this understanding, algo*rhythms* make it possible to hear that our digital culture is not just immaterial, but instead something that performs and unfolds itself through rhythmical, performative, and sensual manifestations (Miyazaki 2013a, 135). This 'trans-sonic' (Miyazaki 2012) conceptualization opens up to a reality in which all signals that are inaudible to humans can be made audible through various media technological devices. The speeds within contemporary communication technologies rapidly exceed our human sensory apparatus, but nevertheless Miyazaki and Howse develop techniques that can be used to unfold these fast and elusive signals, as in the case of Detektor that scans the electromagnetic spectrum.

The Detektor is a small circuit developed by Miyazaki and Howse, an ongoing project that started in 2010. The fundamental design of the Detektor is based around a coil, amplifier, and headphone output, which makes it possible to listen to electromagnetic waves from 100MHz to about 5GHz. The key component in making the inaudible signals audible is the AD8313 Logarithmic Detector chip, which makes the demodulation of the electromagnetic signals possible (Miyazaki 2013b, 515). Through the circuit it becomes possible to listen to the signals of Wi-fi, Bluetooth, GPS, and the wireless signals that are distributed throughout the information ether. In addition, Miyazaki and Howse have conducted a series of workshops and alternative audio-walks in which participants are given the possibility to experience their environment through the conceptualization of deep algo*rhythmic* listening. Though these audio-walks the concept of algo*rhythm* not only provides a close reading of technical details within our communication technologies, but moreover it emphazises a need for aestheticization

(Miyazaki 2013b, 519) in order to propose alternative understandings of our digital and wirelessly distributed reality. The various transmission standards, for instance, the changes between second- and third-generation mobile phones, have profoundly different rhythmical structures, and thus expose changes in the microtemporal infrastructure that define our experience.

Making reference to a Pythagorean[10] understanding, Miyazaki's notion of rhythm proposes itself as an epistemological tool for understanding the world through musical categories (Miyazaki 2013a, 136), thus acting as a critical tool to reveal the hidden sonic structures of technology. Even though we as humans experience the rhythm from a mechanical metronome as being exactly uniform, there are in fact tiny differences which are introduced by irregularities in the wound-up spring within the mechanical metronome. There is also an inexactness present in the quartz crystal running within our computational devices, which is particularly vulnerable to temperature changes that can result in changes of the alleged stable tempo (139). As data become a stream of signals—for instance by plugging an ethernet cable into an audio mixer[11] (143)—a new operational process opens up. This becomes a process of analysing the microrhythmic Geiger-counter-like sounds, set against the rhythmical sequences of ultra-high pitches, combined with more or less melodic rhythmic noises that form continuously sound motifs (144–146).

This forensic approach further resonates with the work of Kittler, who argues for combining material conditions and epistemology, for example, in acknowledging the software used to write a particular chapter like this (Kittler 1995) to highlight how the

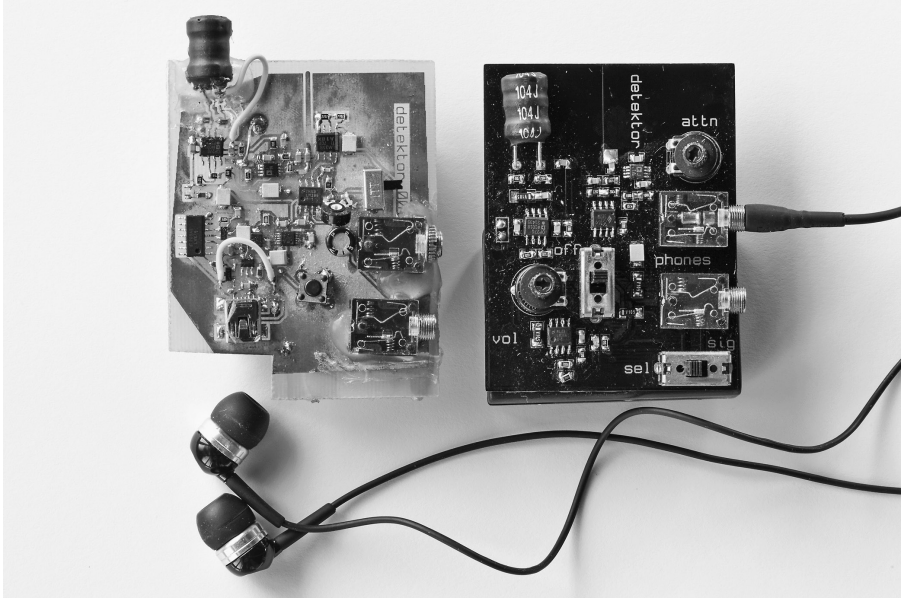

FIGURE 33.3 Detektors (2010–) by Shintaro Miyazaki and Martin Howse. Photograph by Samuel Hanselmann.

inscription tools are registered as part of the work itself. The deep listening techniques operating beyond human perceptual registers also offer epistemological challenge to what we know and how we know what we know, extending Foucault's *Archaeology of Knowledge* in seeking hitherto undiscovered knowledge, emergent knowledge forms, and their relation to forms of power. This is an important issue, as it helps to establish a better understanding of techno-material conditions and a politics of knowledge across human and nonhuman spheres.

33.4.3 Why Is Microtemporality Political?

That politics is necessarily related to a conception of historical time is clearly now a contestable position, as we have noted earlier, but the broader point we wish to make here is that the problem of temporality remains a political issue regardless of the position one takes or the scale of operation (Osborne 1995). As also established, the microtemporal aspect is important for its stress on relatively hidden knowledge as part of wider, complex socio-technical assemblages. In order to operate, algorithms exist as part of assemblages that include data, data structures, and bodies, together part of a process of automation that tries to reduce all aspects to the behaviours that can be controlled and determined. As a consequence, politics can be understood to no longer operate simply on a macro socio-economic level or in ideology alone but increasingly from mutations at a micro-scale or molecular level. In other words, there is a dynamic between micropolitics and politics in general, and algorithms modulate between the details of microtemporal processes and larger totalizing data sets like history or society.

For Deleuze and Guattari, the micromolecular offers 'lines of flight' from the overcoded machine organization of society, but can also develop into something which later becomes conceptualized within a macropolitical framing. An example of this could be the student revolution in France in 1968, a situation that started as a molecular operation, and developed into a macropolitical overcoding machine. Deleuze and Guattari outline a conceptualization of events in which micropolitics is not defined by the smallness of its elements, but instead by the nature of its mass—understood as the difference between a quantum flow and a segmented line. Through this perspective, the quantum flow always implies that something eludes or escapes the overcoding machine, because the segmented line implies a substitution of faltering perspectives in favour of totalitarian overcoming lines (Deleuze and Guattari 2005, 217–219). The micropolitical thus becomes a shift of perspective away from high-level totalitarian decision makers, and instead provides focus on how power is exercised at the minute level of individual subjects and through 'everyday techniques that form perception, desires and judgments of individuals' (Scherer 2007, 564).

The execution and distribution of power within the microtemporal structures of algo*rhythmic* listening can be exemplified by focusing on how different parts of the signals impose a stronger audible fingerprint than other parts, as for example with the

relationship between ethernet clock frequency, encoded bit streams through digital base-band modulation, and the self-clocking line code used in the 10Base-T protocol called the Manchester Code (Miyazaki 2013a, 143). These three layers of signals transmitted through ethernet cables provide a different notion of temporality, which goes against a totalizing and unifying understanding of what data and algorithms are ontologically. By conducting microtemporal analysis it becomes evident that the otherwise stable clock frequencies that constitute our information society in fact come attached with a multitude of inaccuracies due to changes of temperature, humidity and the physical materiality of cabling.

That the micropolitical quantum flow always escapes totalitarian lines further resonates with the idea of counterhistory proposed by Foucault and his description of forms of power as plural and decentralized. Accordingly, contingency and power relations need to be understood at all scales, as well as how algorithms execute a logic of command and control over these processes. These shifts of scale suggest that action can no longer be attributed to individual agents but to distributed action throughout more complex assemblages that indicate how algorithms need to be understood as 'relational, contingent, contextual in nature' (Kitchin 2017, 18). Microtemporality reminds us that politics is not simply human-centred but also involves nonhuman entities such as algorithms that express not only new forms of power that dictate how certain events unfold but also new lines of flight.

33.5 Tactical Algo*rhythmics*

Under informational capitalism, automation of industrial production is accelerated by hidden algorithms to the extent that processes of control and command are hard to identify, let alone to exert control over. Importantly although, like contemporary forms of power, algorithms are everywhere and nowhere—anywhere perhaps—and they operate as part of larger assemblages that include data and infrastructures, software and hardware, programmers and other living entities, forms of knowledge, behaviours, and actions at micro spatio-temporal levels of operation.

As mentioned previously, tactics are required to adapt to any concrete situation, as opposed to strategy, which involves long-time planning often distanced from its actual execution. In this way tactical media's tactics are somewhat like the experimentation of Cardew, amongst others, inasmuch as they play with the spatio-temporal determinants of compositional assemblages as emergent forms of political organization. Algorithms are already tactical in this sense with respect to the way they operate relationally and contingently. Such an approach offers a conceptualization that corresponds very well to a microtemporal understanding of the algorithm, as we cannot reduce the algorithm to a set of predetermined instructions or rules, but we instead need to include an understanding that incorporates the wider apparatus and its execution in time. Through this tactical perspective the algorithm becomes very different

from its otherwise prevailing conceptualization as something that governs data and processes our lives. Instead it shifts attention to something that in fact is dislocated from these strategic overcoded perspectives—because of its temporality and its constant and ever-changing embodiment within physical technology and its wider social context. This conceptualization resonates well with Deleuze and Guattari's understanding of the abstract machine—a machine that can be both an overcoding totalitarian machine and at the same time a decoding detotalitarian machine that flows and emits new quanta, something that is constantly changing on a molecular level (Deleuze and Guattari 2005, 223–224).

'Tactical' in this context might also be coupled with Walter Benjamin's notion of 'technique' in his essay *The Author as Producer* (1934), proposing and recasting the difference between overcoded political action and a more tactical politics that operates on the ground at the level of production. He writes: 'An author who has carefully thought about the conditions of production today … will never be concerned with the products alone, but always, at the same time, with the means of production. In other words, his [or her] products must possess an organizing function besides and before their character as finished works' (Benjamin 1998, 98). Thus, Benjamin recommends that the cultural producer intervene in the production process, in the manner of an engineer. Again the point is that this is where social relations are operative and where techniques can be developed in order to change the apparatus. The spirit of this is captured more recently in the *Critical Engineering Manifesto* that similarly foregrounds the tactical potential of engineering: 'The Critical Engineer notes that written code expands into social and psychological realms, regulating behaviour between people and the machines they interact with. By understanding this, the Critical Engineer seeks to reconstruct user-constraints and social action through means of digital excavation.'[12]

33.5.1 Tactical Media Archaeology

'Tactical media archaeology' becomes operative at the point where media and more specifically the nondiscursive realm of technical infrastructures and algorithmic processes become active archaeologists of knowledge (Ernst 2011, 239). The work of Miyazaki and Howse exemplifies this approach as introduced above, but we would like to end this chapter with another work by Howse to stress our argument here through epistemic practice. Dark Interpreter (2015) is a noise instrument that takes its name and inspiration from the writings of Thomas de Quincey: 'The truth I heard often in sleep from the lips of the Dark Interpreter. Who is he? He is a shadow, reader, but a shadow with whom you must suffer me to make you acquainted' (Quincey 1891, 7). Dark Interpreter comes in three incarnations: Mater Lachrymarum, Our Lady of Tears, for complex granular sampling, is particularly suited for vocal reprocessing; Mater Suspiriorum, Our Lady of Sighs, has skin control and code entry to generate harsh noise with relinquished control; Mater Tenebrarum, Our Lady of Darkness, is an algorithmically designed, gold-plated skin breakout board and skin/EEG amplifier

worn on the head or placed in the earth to produce harsh noise or granular processing with divined control.[13]

The overall project is an attempt to reveal the hidden dark forces of the electromagnetic spectrum that remain imperceptible to the human sensory apparatus. Howse describes it thus: 'The Dark Interpreter is modelled as a set of leaky, overlapping medieval village spaces within which various plague simulations run, and through which a motley of villagers (grains) wander, steered by electric fingers and touch' (2015a, unpaginated) It interprets the contemporary noise instrument as a 'dark symbolic mirror', placing control of parameters on the skin, and strapping a 'psyche/plague village interface' to the head. Howse describes the technique as 'modern live coding with no screen, no keyboard and little conscious control'. With the *Dark Interpreter* you are interfacing directly with the circuit, andby touch, your skin functions as an integrated resistor within the mechanism, thus altering resistor-capacitor time constants (Earl, 1977, 61–62), which introduces changes in the instrument's frequency response. A resistor-capacitor time constant is calculated by the time it takes a capacitor to charge and discharge its levels of voltage through a resistor. By changing the capacitor and/or resistor values it is possible to change the frequency response of a system. It takes time to charge or discharge a capacitor through a resistor. At low frequencies, there is plenty of time for the capacitor to charge up to practically the same voltage as the input voltage. At high frequencies, the capacitor has time to charge up only a small amount before the input switches direction.

FIGURE 33.4 Dark Interpreter: Mater Tenebrarum, Our Lady of Darkness (2015), by Martin Howse. Photograph courtesy of the artist.

The output goes up and down only a small fraction of the amount the input goes up and down. At double the frequency, there's time for it to charge up only half the amount—which then gives us the cut-off frequency determined by the resistor-capacitor time constant.

By focusing on these microtemporal changes modulated by human skin,[14] an awareness is raised to the dramatic effect that even the tiniest delays have on the timbral expressions within our sounding technology. Through this conceptualization, the tactical media archaeological algorithm not only develops time-critical perspectives on the discursive computational processes but also draws attention to the nondiscursive operations and their techno-epistemological conditions. Through sound, these techno-epistemological forces are cast in terms of medieval belief systems with contemporary environmental significance, in which the effects of algorithms can be understood as part of broader ecologies. Algorithms in this sense manage to operate across both discursive and nondiscursive registers and offer the potential to compose alternative musical and political epistemologies—beyond conventional anthropological notions of what constitutes music. Furthermore, the relation between sound and music does not make ontological sense either as an algorithm does not recognize the distinction.

The term 'dark' in Dark Interpreter could also be referencing the 'object-oriented philosophy'[15] of Timothy Morton and his notion of 'Dark Ecology'[16] (Morton 2007), which redefines the notion of ecology to become a way of collapsing the subject-object division, giving rise to a sense of coexistence and connection with other objects. The role of this dark ecologically aware art then becomes a way of 'attuning' to the inconsistency within and between objects, as a process that is always slightly out of phase, and which recognizes its fragility and thereby also its own uncanny strangeness (Morton 2013b, 177). Morton's key concepts of inconsistency, fragility, and strangeness additionally extends the tactical media archaeological perspectives on the macro and micro levels of computational culture. Thus the algorithm becomes something that is impossible to be reduced to consistent overcoding semantics, and instead develops into a fragile inconsistent 'hyperobject' (Morton 2013a), massively distributed in time and space as it transcends spatiotemporal specificity. Morton argues that in the age of the anthropocene (Morton 2011, 154; Whitehead 2014), the dark ecological perspective is not only important within analysis, but also in the creation of sounding pieces. This is because art is forced to relate to the current state of affairs concerning the human-made ecological crisis (Morton 2013b, 20, 22).

Connecting the aesthetic to the causal dimension through dark ecological art forces us to coexist with a vast plenum of nonhuman objects, such as algorithms, and helps us explore our own fragility and sense of contingency. Doing so collapses the belief that we can distance ourselves from the world through formal procedures, just as algorithmic music cannot separate itself from the world around us. Our claim is that algorithms need to be understood as part of temporal, relational, and contingent operations that are sensitive to their conditions and future trajectories. Only in this way can algorithmic music begin to make sense—politically at least.

Notes

1. Jem Finer's *Longplayer* began playing at midnight on 31 December 1999 (see http://longplayer.org/). John Cage's *As SLow aS Possible* was first written in 1987 (see https://en.wikipedia.org/wiki/As_Slow_as_Possible).
2. The exhibition 'Disobedient Objects' made a similar claim by examining the powerful role of objects in movements for social change (Victoria and Albert Museum, London, 26 July 2014 to 1 February 2015). See http://www.vam.ac.uk/content/exhibitions/disobedient-objects/.
3. For more on the Anti-University, see Jakob Jakobsen's research from 2012, http://antihistory.org/.
4. Another example of this antitotalitarian mode of organization within musical composition is Cardew's *The Great Learning—Paragraph 7* (Cox and Warner 2004, 228).
5. Tactical Media Files is a research project tracing the legacies of Tactical Media (Kluitenberg and Garcia 2008–). A book project, *Legacies of Tactical Media: The Tactics of Occupation*, was initiated in 2011 by the Institute of Network Cultures.
6. The algorithm Fast Fourier Transform converts time (or space) to frequency (or wavenumber) and vice versa. For more on this, see Roads 1996, 1075–1112.
7. For video documentation of *Steam Machine Music*, see Riis 2010. Also see Riis 2013a for an expanded exposition of the piece within a media archaeological framing.
8. For video documentation of *Opaque Sounding*, see Riis 2014.
9. Here referencing Kittler (1995) and his conceptualization that software always is reducible to the movement of electrical current in registers.
10. Media archaeology becomes a means of listening to computation through technology as sonic events—opposed to musical theory, which in the occidental tradition continues from Pythagorean epistemology of harmonic calculation, entailing that sound is not perceived as a sonic event but instead becomes a phenomenon of mathematics (Ernst 2014).
11. This way of using our auditory sense as an epistemological tool for understanding computational processes can be contextualized as a reenactment of the way debugging and error checking was done on early computers in the 1940s and early 1950s. Like all other first-generation computers from this time, the Australian CSIRAC for instance, had a built-in loudspeaker which was used for warnings and debugging, and to signify the end of a programme (Doornbusch 2004, 12). The need to use auditive feedback was due to the fact the visual feedback devices such as display monitors had not been invented at this time. The sound reproduced by the loudspeaker was the raw bit pulse from the data bus, an on/off switching corresponding to the stream of bits, alterations of electronic current sonified by the movement of the speaker membrane.
12. *Critical Engineering Manifesto*, written by Julian Oliver, Gordan Savičić, and Danja Vasiliev (2011–2017), http://criticalengineering.org/.
13. See Howse 2015a for more details. Video documentation of the Dark Interpreter 'Mater Tenebrarum' can be found at Howse 2015b.
14. Or by the moisture in soil, as when the Dark Interpreter is being used in Howse's 'Earth Coding'—a project that explores alternative links between contemporary technology and the Earth, raising the question of whether the Earth as a process can be tempted to compose software (Medosch 2014).
15. Within object-oriented philosophy, Graham Harman additionally develops the notions of 'over-mining' and 'under-mining', a construction that parallels the macro (totalization)

and micro (details) levels of Deleuze and Guattari but that develops into an understanding in which an object is not reducible to its parts (undermining) but that also implies that an object cannot be reduced to its whole (overmining) (Harman 2011, 7–18; Morton 2011, 150; 2013b, 44). Following this line of thinking, the World—including other holistic concepts such as Nature and the Environment—also ceases to exist as a neutral background or stage for humans to occupy.

16. Martin Howse and Timothy Morton are often associated together (Parikka 2015; SonicActs 2015; Tuned City 2013), as both are trying to develop alternative conceptualizations of ecology through different notions of human and nonhuman interconnectivity.

Bibliography

Benestad, F. *Musikk og tanke: Hovedretninger i musikkestetikkens historie fra antikken til vår egen tid*. 2nd ed. Oslo: Aschehoug, 1977.

Benjamin, W. 'The Author as Producer'. In *Understanding Brecht*, translated by A. Bostock, 85–103. London: Verso, 1998.

Bey, H. *T.A.Z.: The Temporary Autonomous Zone*. New York: Autonomedia, 2011.

Bumgardner, J. 'Kircher's Mechanical Composer: A Software Implementation'. Paper presented at 'Bridges 2009: Mathematics, Music, Art, Architecture, Culture'. Banff, AB, 2009.

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

Cascone, K. 'The Failure of Aesthetics'. Paper presented at the Share Festival, Torino, Italy, 2010. http://vimeo.com/17082963.

Certeau, M. de. *The Practice of Everyday Life*. Translated by S. Rendall. Berkeley: University of California Press, 1988.

Cox, C., and Warner, D.. *Audio Culture: Readings in Modern Music*. New York: Continuum, 2004.

Deleuze, G., and Guattari, F. *A Thousand Plateaus: Capitalism and Schizophrenia*. Translated by B. Massumi. Minneapolis: University of Minnesota Press, 2005.

Doornbusch, P. 'Computer Sound Synthesis in 1951: The Music of CSIRAC'. *Computer Music Journal* 28, no. 1 (2004): 10–25.

Earl, J. *Cassette Tape Recorders*. Watford: Fountain, 1977.

Ernst, W. '"... Else Loop Forever": The Untimeliness of Media'. Extended draft paper for 'Il Senso della Fine', conference. Universita degli Studi di Urbino, 2009a.

Ernst, W. 'Experimenting Media-Temporality: Pythagoras, Hertz, Turning'. Experimentation as event. Lecture manuscript. University of Lancaster, 2009b.

Ernst, W. 'Media Archaeography: Method and Machine versus History and Narrative of Media'. In *Media Archaeology: Approaches, Applications, and Implications*, edited by E. Huhtamo and J. Parikka, 239–255. Berkeley: University of California Press, 2011.

Ernst, W. *Digital Memory and the Archive*. Edited by J. Parikka. Minneapolis: University of Minnesota Press, 2013.

Ernst, W. 'The Sonic Time Machine: Explicit Sound and Implicit Sonicity in Terms of Media-Epistemological Knowledge'. Lecture given at Aarhus University, 22 May 2014.

Foucault, M. *The Archaeology of Knowledge*. Translated by A. M. Sheridan Smith. London: Tavistock, 1972.

Foucault, M. 'Nietzsche, Genealogy, History'. In *Language, Counter-Memory, Practice: Selected Essays and Interviews*, edited and translation by D. F. Bouchard and S. Simon, 139–164. Ithaca, NY: Cornell University Press, 1977.

Futureretro. 'Zillion Sequencer. 2014. http://www.future-retro.com/products.html#!/Zillion-Sequencer/p/50667567/category=0, accessed 30 June 2017.
Gieskes, G. 'Analog HD'. 2012. http://gieskes.nl/instruments/?file=analog-HD-p2.
GlobalNoise. 'GlobalNoise'. 23 September 2012. http://www.tacticalmediafiles.net/campaigns/6446/GlobalNoise;jsessionid=FC75EB4798A76597DB4EB918D2C22E41.
Goffey, A. 'Algorithm'. In *Software Studies: A Lexicon*, edited by M. Fuller, 15–20. Cambridge, MA: MIT Press, 2008.
Goodman, S. *Sonic Warfare: Sound, Affect, and the Ecology of Fear*. Cambridge, MA: MIT Press, 2010.
Harman, G. *The Quadruple Object*. Winchester: Zero Books, 2011.
Hecker, F. *Triadex Muse Treks*. Berlin: Neuer Berliner Kunstverein, 2012.
Howse, M. 'The Dark Interpreter'. *The Dark Interpreter*, 6 September 2015a. http://www.1010.co.uk/org/darkint.html.
Howse, M. 'Dark Interpreter Simple Setup/Tutorial 001 No-input'. *Matrixsynth*, 16 March 2015a. http://www.matrixsynth.com/2015/03/dark-interpreter-simple-setuptutorial.html.
Huhtamo, E. 'From Kaleidoscomaniac to Cybernerd: Notes toward an Archaeology of the Media'. *Leonardo*, 30, no. 3 (1997): 221–224.
Huhtamo, E., and Parikka, J. *Media Archaeology: Approaches, Applications, and Implications*. Berkeley: University of California Press, 2011.
Kendall, G. S., Haworth, C., and Cadiz, R. F. 'Sound Synthesis with Auditory Distortion Products'. *Computer Music Journal* 38, no. 4 (2014): 5–23.
Kirschenbaum, M. G. *Mechanisms: New Media and the Forensic Imagination*. Cambridge, MA: MIT Press, 2012.
Kitchin, R. 'Thinking Critically about and Researching Algorithms'. *Information, Communication and Society* 20, no. 1 (2017): 14–29
Kittler, F. A. 'There is No Software'. *CTheory.net*. 18 October 1995. http://www.ctheory.net/articles.aspx?id=74.
Kittler, F. A. *Gramophone, Film, Typewriter*. Translated by G. Winthrop-Young and M. Wutz. Stanford, CA: Stanford University Press, 1999.
Kluitenberg, E., and Garcia, D. *Tactical Media Files*. 2008–. http://www.tacticalmediafiles.net/.
Loopmasters. 'Ambient Glitch Vol. 1'. 2012a. http://www.loopmasters.com/product/details/539/Ambient-Glitch-Vol-1.
Loopmasters. 'Circuit Bent Sounds Vol. 1'. 2012b. http://www.loopmasters.com/product/details/311/Circuit-Bent-Sounds-Vol1.
Loopmasters. 'Glitch Hop'. 2012c. http://www.loopmasters.com/product/details/1276/Glitch-Hop.
Medosch, A. 'Kunst Fields: Wild Ontologies in the Service of Activating History'. *Kunstradio—Radiokunst*, 30 November 2014. http://kunstradio.at/2014B/30_11_14en.html.
Miyazaki, S. 'Algorhythmics: Understanding Micro-Temporality in Computational Cultures'. *Computational Culture* 2 (2012). http://computationalculture.net/article/algorhythmics-understanding-micro-temporality-in-computational-cultures.
Miyazaki, S. 'AlgoRHYTHMS Everywhere: A Heuristic Approach to Everyday Technologies'. In *Off Beat: Pluralizing Rhythm*, edited by J. H. Hoogstad and B. Stougaard Pedersen, 135–148. Amsterdam and New York: Rodopi, 2013a.
Miyazaki, S. 'Urban Sounds Unheard-of: A Media Archaeology of Ubiquitous Infospheres'. *Continuum: Journal of Media and Cultural Studies* 27, no. 4 (2013b): 514–522.
Morton, T. *Ecology without Nature: Rethinking Environmental Aesthetics*. Cambridge, MA: Harvard University Press, 2007.

AQ: Please give up-to-date link for "Gieskes, G. 'Analog HD'. 2012".

Morton, T. 'Objects as Temporary Autonomous Zones'. *Continent* 1, no. 3 (2011): 149–155.
Morton, T. *Hyperobjects: Philosophy and Ecology after the End of the World*. Minneapolis: University of Minnesota Press, 2013a.
Morton, T. *Realist Magic: Objects, Ontology, Causality*. Ann Arbor, MI: Open Humanities Press, 2013b.
Nechvatal, J. *Immersion into Noise*. Ann Arbor, MI: Open Humanitites Press, 2011.
Nierhaus, G. *Algorithmic Composition: Paradigms of Automated Music Generation*. Vienna: Springer, 2009.
Osborne, P. *The Politics of Time: Modernity and Avant-Garde*. London: Verso, 1995.
Parikka, J. 'Mapping Noise: Techniques and Tactics of Irregularities, Interception, and Disturbance'. In *Media Archaeology: Approaches, Applications, and Implications*, edited by E. Huhtamo and J. Parikka, 256–277. Berkeley: University of California Press, 2011a.
Parikka, J. 'Operative Media Archaeology: Wolfgang Ernst's Materialist Media Diagrammatics'. *Theory, Culture and Society* 28, no. 5 (2011b): 52–74. doi: 10.1177/0263276411411496.
Parikka, J. 'Mutating Media Ecologies'. *Continent* 4, no. 2 (2015): 24–32.
Quincey, T. P. de. *The Posthumous Works of Thomas De Quincey*. Edited by A. H. Japp. London: William Heinemann, 1891. http://www.gutenberg.org/files/23788/23788-h/23788-h.htm.
Raley, R. *Tactical Media*. Minneapolis: University of Minnesota Press, 2009.
Reynolds, S. *Retromania: Pop Culture's Addiction to Its Own Past.* New York: Farrar, Straus and Giroux, 2011.
Riis, M. 'Steam Machine Music'. *Vimeo*, 2010. http://vimeo.com/16995143.
Riis, M. 'The Media Archaeological Repairman'. *Organised Sound* 18, no. 3 (2013a): 255–256.
Riis, M. 'Systemics #2: As We May Think (Or, The Next World Library)'. 21 November 2013b. http://seismograf.org/systemic-2-as-we-may-think-or-the-next-world-library-0.
Riis, M. 'Opaque Sounding'. *YouTube*, 9 August 2014. http://www.youtube.com/watch?v=nzybYC5nqJM.
Roads, C. *The Computer Music Tutorial*. Cambridge, MA: MIT Press, 1996.
Scherer, M. *Micropolitics: Encyclopedia of Governance*. Thousand Oaks, CA: Sage, 2007.
Sloane, S. *Digital Fictions: Storytelling in a Material World*. Stamford, CT: Ablex, 2000.
SonicActs. 'Sonic Acts: The Geologic Imagination'. 26 February to 1 March 2015. http://www.sonicacts.com/2015.
Tuned City. 'Documentation'. *Tuned City*, 2013. http://www.tunedcity.net/?page_id=4594.
Vesikukka, T. 'Hacking Finance'. *Robin Hood*, 2015. http://www.robinhoodcoop.org/.
Vuksic, V. 'Harddisko'. 2010. http://harddisko.ch/, accessed 30 June 2017.
Whitehead, M. *Environmental Transformations: A Geography of the Anthropocene*. New York: Routledge, 2014.
Yuill, S. 'All Problems of Notation Will Be Solved by the Masses'. *Mute*, 23 May 2008. http://www.metamute.org/editorial/articles/all-problems-notation-will-be-solved-masses.

AQ: There isn't an item with this title at this link in "Vesikukka, T.". Please clarify.

AQ: There is nothing on the website that gives any sort of date for "Vuksic, V. 'Harddisko'. 2010". Please advise.

CHAPTER 34

ALGORITHMIC MUSIC FOR MASS CONSUMPTION AND UNIVERSAL PRODUCTION

YULI LEVTOV

34.1 Introduction

Historically, an individual performance of music has always been experiential and transient in form, with the performer and listener occupying the same physical space at the same time. Musicians were intrinsically connected to their surroundings, both physically and emotionally, making each rendition of a piece of music unique and, in some way, responsive to its immediate environment. If considered on this wider timeline, it is actually only recently (the last 100 years or so, compared to 39,000 years since the existence of the first musical instruments[1]) that we have been able to mechanically record and reproduce sound, and therefore capture the essence of an individual performance. It is even more recent that these recording methods have been developed and formalized to provide us with digital formats such as the MP3—currently the most common format for music (Sterne 2014). As such, it is remarkable that every music listener currently alive in the developed world will have grown up with these recorded formats as their defaultfor music consumption, whether it was via radio, vinyl, CD, digital download, or streaming. These 'static' music distribution media have given birth to incredible advances in the art form as a whole, resulting in a worldwide industry, and making possible countless careers such as session musician, recording engineer, and promoter, not to mention the new musical genres that would simply not exist were it not for recorded, reproducible sound. However, the widespread formats of today have one particular defining characteristic that is fundamentally at odds with the experiential, transient nature of live music or indeed algorithmic music; once their sonic content is defined, they are designed to sound identical at every hearing. External factors that make a live performance unique, such as the physical characteristics of the venue, the