Chapter 1

Introduction

Welcome to an exploration of electronic music, in many places and many guises. In societies tracking technological developments, the role of electricity in music has had a great impact on musical production and consumption, a musical influence as worldwide as the network of telecommunications. It has changed the balance of the instruments most commonly practiced, for example, toward electric guitars, turntables, and arguably the computer itself, and promoted an emphasis on recordings as the driver of mass musical contact. Yet the transformation has not been total, for traditional activities like live performance have continued in strength, albeit somewhat transfigured by such electronic factors as amplification and the Internet. Participation is not always subservient to passive reception, but is actively encouraged in such instances as musical video games and generative software for mobiles. Acoustic instruments have lost none of their charm and history, though some new history has been written by the interaction of acoustic means and the electrical transformation of sound. There always remains the option of turning off the power, but, unsurprisingly, we won't advocate that step in this book.

The term *electronic* formally denotes applications of the transistor, a specific electrical component popularized from the mid-twentieth century onward that enables the substantial miniaturization of circuits. Joel Chadabe titles his book on the history of electronic music *Electric Music* and the best terminology is sometimes contentious. You may see reference to *electroacoustic* music as an overall term: In the broadest sense, it simply means sound reproduced using electronic means, such as loudspeakers, but can be employed in a more constrained sense of highly designed electronic art music for close listening with an emphasis on space and timbre (more on this later). The connection of electronic music to *computer music* is also strong, since computers are the most general purpose and powerful electronic devices we come into contact with; however, computers themselves as everyday objects arose much later than many other electrical devices of note and aren't required in many forms of electronic music making.

Music and technology

The intricate design of acoustic musical instruments involves a practical mastery of physics as much as the newer pursuit of creating devices which exploit the principles of electromagnetism. But it is particularly the far-reaching musical consequences of the electromagnetic force that engage us in this book.[1]

Whilst static electricity – a build-up of electrical charge which is suddenly drained, the large-scale version being lightning – was known in antiquity, the full harnessing of electromagnetism was left until the scientific era. At the turn of and in the early nineteenth century, scientists were active who often went on to lend their names to the fundamental units: Volta (inventor of the battery, circa 1800), Ampère (elucidator of the relation between current and magnetism), Ohm (eponymous in the famous law relating voltage and current through resistance), and Faraday (pioneer of electromagnetic induction amongst many other experimental breakthroughs), to name four.

In the next two chapters, we will investigate recording and broadcast technologies, in the main electrical, and then early electrical musical instruments. We will encounter technologies both for the recording and manipulation of pre-existing sound, and for the direct electrical generation of new sound. In one common formulation, these two options are known as sampling and synthesis; there has sometimes been tension between these two approaches, though these days we are much more comfortable with their unification as available techniques. The chronology of these developments follows the explosion of practical applications of electricity in the second half of the nineteenth century. Table 1.1 gives a timeline of some important points in the history of telecommunications and electrical engineering technology pertaining to the book as a whole.

For now, we should note, and try to allay, some potential tensions between conceptions of music making as direct, natural, expressive, emotional, and social, and the mediations that technology can impose. It is easy to find examples of electronic music devices whose performance practice is substantially different from the traditional acoustic coupling of human body and instrument. Think of a sequencer interface as controlling musical pattern playback rather than individual events.[2] Amplification enables disproportionate human effort,[3] where a light touch of a button can have a massive stadium-filling effect;[4] indeed, in network music, this could be triggered across multiple stadia where the musician is not even physically present. Yet, however high the technology, the human hand has a presence, having established the conditions of its use, designed and programmed the system, and made musical decisions intended for human appreciation. The fast speed of technological advance is a constant tension,[5] but we trade off the stress of keeping up with the continually exciting potential of creating new art.

Table 1.1 *Timeline of some selected technological advances*

Year[a]	Technology
1822	Charles Babbage anticipates (mechanical) computing. Designs for a fully programmable Analytical Engine date from 1837, and the nongeneral purpose Jacquard Loom of 1801 used punched cards for programmability
1837	Morse telegraph patented
1876	Telephone patented (closely contested at the patent office)
1906	First public radio broadcast. The first wireless experiments date to the 1890s, and the first regular wireless service was in 1920
1926	First public television demonstration, though mass adoption of television really occurs after the Second World War
1940s	First electronic computers; some controversy over exactly which computer was the first fully programmable general purpose device
1969	Men walk on the moon and broadcast from there
1977	First mass production of pre-built home computers. There are earlier 1970s kits, and electronic music pioneer Erkki Kurenniemi released a microcomputer in Finland in 1973![b]
1989	World Wide Web protocol devised
2002	Point at which the world's archived data became more than 50 percent digital rather than analog[c]

[a] Dates in this book have been cross-checked from multiple sources, both conventional encyclopedias and specialist textbooks; there may remain a few errors, due to disagreement in sources and ambiguities in historical texts based on such factors as dates of conception versus the granting of a patent or first performance. Some existing timelines for electronic music appear in Holmes, *Electronic and Experimental Music*; and Collins and d'Escriván (eds.), *The Cambridge Companion to Electronic Music*, as well as Mark Ballora's course notes (www.personal.psu.edu/meb26/INART55/timeline.html) and Paul Doornbusch's "A chronology/history of electronic and computer music and related events 1906–2011" (www.doornbusch.net/chronology).

[b] See the film *The Future Is Not What It Used to Be* (2002), directed by Mika Taanila; and Mikko Ojanen, Jari Suominen, Titti Kallio, and Kai Lassfolk (2007) "Design principles and user interfaces of Erkki Kurenniemi's electronic musical instruments of the 1960s and 1970s," *Proceedings of the 2007 Conference on New Interfaces for Musical Expression* (NIME07), New York.

[c] Martin Hilbert and Priscila López (2011) "The world's technological capacity to store, communicate, and compute information," *Science*, 332(6025): 60–5.

The reference to astronauts on the moon in Table 1.1 above was deliberate and was meant to illustrate the connection of new technology to the public imagination. The unfamiliarity of electronically created sound when first introduced was often used in film music as an illustration of psychological disturbance or the supernatural. Yet in the popular excitement of the space age after the Second World War (and an accompanying boom in science fiction), it perhaps found its most enduring connection. Famous examples might range from the soundtrack by Bebe and Louis

Barron of *Forbidden Planet* (1956) to the afro-futurism of Sun Ra and Parliament Funkadelic.[6] The German band Kraftwerk's main output is a series of concept albums on technological themes, and the very name "techno" espouses the technology link-up (the future as an escape compared to the troubles of everyday life can be highly attractive).[7] The annals of electronic music history are full of pieces themed around outer space or high technology; for instance, whilst Kraftwerk's *The Robots* (1978) is well known, there are a large number of precedents, including Frank Coe and Forrest J. Ackerman's *Music for Robots* (1961), Erik Nordgren's piece *Crazy Robots* (1964), and Paul Boisselet's *Le Robot* (1965).[8]

The relationship of musicians with technology continues to be an active area of theorizing and necessarily practical decision making.

Definitions and categories

We have already noted the existence of alternative overall terms in the field of electronic music. Going further, why have a separate topic of *electronic* music at all? We need to pause for a moment and consider the utility, and the danger, of categories.[9] Labels can be helpful, because they let us break down knowledge into manageable components for discussion. At the same time, they may corrupt the true picture and set up artificial boundaries where there don't have to be any.

Electronic music is not somehow expected to be self-contained. A guitarist might play an acoustic as much as an electric guitar and a composer might work with all manner of ensembles from orchestras to laptop groups. The respected computer music composer Paul Lansky decided to no longer write any music for computer in 2008 and is currently happily composing for acoustic instruments with traditional scores. A rock band might incorporate a turntablist, yet not consider themselves to be creating electronic dance music. Artists trained in the visual arts have turned to sound art, and musicians have become involved in digital art. We'll see many of these cross-currents in later chapters of this book.

One of the core terms in use in musical discourse, popular music, allows for many definitions, and leads to many confusions and tensions based on people's differing expectations. As Roy Shuker observes, we might emphasize one or more of sheer popularity, economic commercialization, the central status of recordings, and particular music theories.[10] Electronic music itself shows vestiges of these tensions, particularly between experimental artists pursuing "high art" and those who follow more commercial goals, with a generous area of ambiguity in between. For example, think of art rock projects, of commercially successful music with radical twists which popularize experimental discoveries.

So, like many authors, at least we've raised these issues, even if we cannot resolve them. Instead, we'll proceed, on the agreement that we understand the implications of choosing categories. At points, we'll confront this again, in particular in discussing the profusion of styles of electronic dance music, a situation where the producers, journalists, and fans are themselves highly active in coining labels and trying to make niches where none might have existed a week before.

Historiographic issues

Much of the history of electronic music is contemporary, still resolving around us, or happened relatively recently, within a few human lifetimes. This can help the historian of electronic music; there is the chance to interview some pioneer practitioners and capture details of scenes as they emerge. At the same time, knowing what to document suffers bias based on an investigator's cultural background and geographical locale, and interviewees don't typically have a neutral opinion of themselves! New movements are exciting, but undeveloped, and their take-up and long-term significance is uncertain. The pressure to discover, whether a journalist needing a new story or an academic another article, may prematurely label phenomena and falsely exaggerate differences at the expense of connections to other developments. In biology, speciation events are not immediately recognized, but can take time to resolve; the same goes for mimetic events like the spawning of musical genres, even if the timescale of cultural replicators is much faster than genetics.[11] Choosing which narrative to follow amongst many alternatives, whether tracing the availability of technology, the role of individual personalities, or the small-scale or large-scale social and economic background, is a standard dilemma of the historical musicologist.

In understanding the historical context of developments, it is worth keeping in mind general historical events and sociological concerns. The Second World War (1939–45) in particular accelerated the development of many technologies, just as it provoked many life-changing personal experiences for those growing up to be the post-war generation of musicians. Tensions between France and Germany after the war are often linked to elements of the rivalry between the schools of musique concrète and elektronische Musik, particularly in the early 1950s; the leader of musique concrète, Pierre Schaeffer, had been in the French Resistance. The post-war years of relative peace in the more prosperous countries saw economic booms and busts in the rise of new technologies, shifts in the post-colonial world order, and radical development in societal convention. We might mention 1960s liberation, protest and civil rights movements, or the transition from tie and suit-wearing electronic music composers in the 1950s to electronic music nudists or tattoo and piercing-covered noise musicians.

Revision is part of the process of historical and scientific investigation, where theories once held are disproved. Scholarship in recent years has turned up many interesting precedents that older electronic music textbooks had not admitted, such as the wire recorder, gramophone, and optical film soundtrack experiments substantially pre-dating musique concrète. There are no doubt "facts" in this textbook that will need to be re-appraised in time, however honorable and rigorous our intentions.

Analysis

Finding a common basis for analysis that works across such a diverse set of musics as in this book is cause for concern. Even if we can agree on a set of standard musical descriptors, different works require different weights for each. Nonetheless, we need to proceed pragmatically here if we are to start investigating, and in this spirit, four fundamental candidate properties in music are as follows:

- *Rhythm*: The placement of musical events in time, usually at or near human physical gestural rates (though electronics also allow faster rates).
- *Pitch*: Resonances/oscillations in sound at identifiable auditory periodicities.
- *Timbre*: The "sound" of sound, its essential character, including many attributes such as the time-varying loudness and spectral make-up, roughness of tone, or brightness.
- *Space*: The location of sound sources, as well as the real or virtual acoustic environment.

Sonic details can be revealed over different timescales, as for example in the contrast of immediate rhythmic timings against longer-scale formal structure. Musical processes can also exhibit interactions between simultaneous actions (such as vertical correspondences at one time, local aggregates such as a harmony, and parallel streams as in counterpoint and layering) and successive events (melody within one line and events within a distinct stream).

For the benefit of succinctness, we are resolving on a common-sense view of musical attributes that may leverage the reader's existing intuitions. Nonetheless, the complexity of these musical facets can fill whole books in their own right, and music theories in electronic music bring their own concepts to bear. In particular, the notion of a *sound object* as a superset and extension of the concept of a note often appears. Imagine a sound continuously evolving, rather than a singular simple strike or ring. Such morphing and transformation can be found in acoustic sources (change the shape of your mouth while continually singing at stable pitch, for instance, shifting between vowels), but is present to a high degree of design in much electronic music.

Representations in electronic music deviate substantially from Western classical scores or pop/jazz lead sheets. Electronic music composers have found new ways to notate music as they have explored new techniques to create it; for example, time in some 1950s scores might appear measured in inches of passing magnetic tape, and sound objects have affiliated parameter trails showing, for example, their amplitude envelope (time-varying loudness).

The most general representations must deal with raw sound itself (and hopefully show something of its perceptual effect) rather than assume music is composed of a bunch of discrete note instructions.[12] Spectrograms and other time-frequency representations often appear in analyses of electronic works,[13] and will appear in this book too. Figure 1.1 is an example (or, rather, four examples); each sub-graph has time proceeding left to right and demonstrates the energy content of the signal over a range of component frequencies increasing up the vertical axis. This breakdown of sound into a large number of simultaneous channels, a filter bank, is very useful in going beyond a simple time domain view of amplitude fluctuation. It allows us to see the activity level of sound in different areas, much like a graphic equalizer display, and the physiological process of your inner ear.

Some controversies in electronic music

As a field which has in many ways mirrored social and economic developments, and which, out of necessity, has at times raised issues of access vs. institutionalization, open platforms vs. commercialization, and artistic freedom vs. standardization, it should be no surprise that the history of electronic music is full of debates and controversies. We present here two examples of themes that have arisen in the theoretical discussion of electronic music and that may help to indicate the sorts of debate you may encounter both in this book and further afield.

Mass participation

Professional musicians, critics, and other stakeholders in musical life sometimes have an uneasy relationship with amateur musicians whose sole income is not derived from music. Yet electronic music is replete with examples of prominent figures who had multiple careers, whose experimental work was a noncommercial sideline, or who simply enjoy the act of creation, whether or not it leads to any wider recognition. The early days of electronic music studios saw restricted access, given limited facilities and high expense. Although some private individuals did set up their own facilities (such as the Barrons), the 1950s was mainly a time of privileged clubs clustered around particular facilities, with many "name" composers

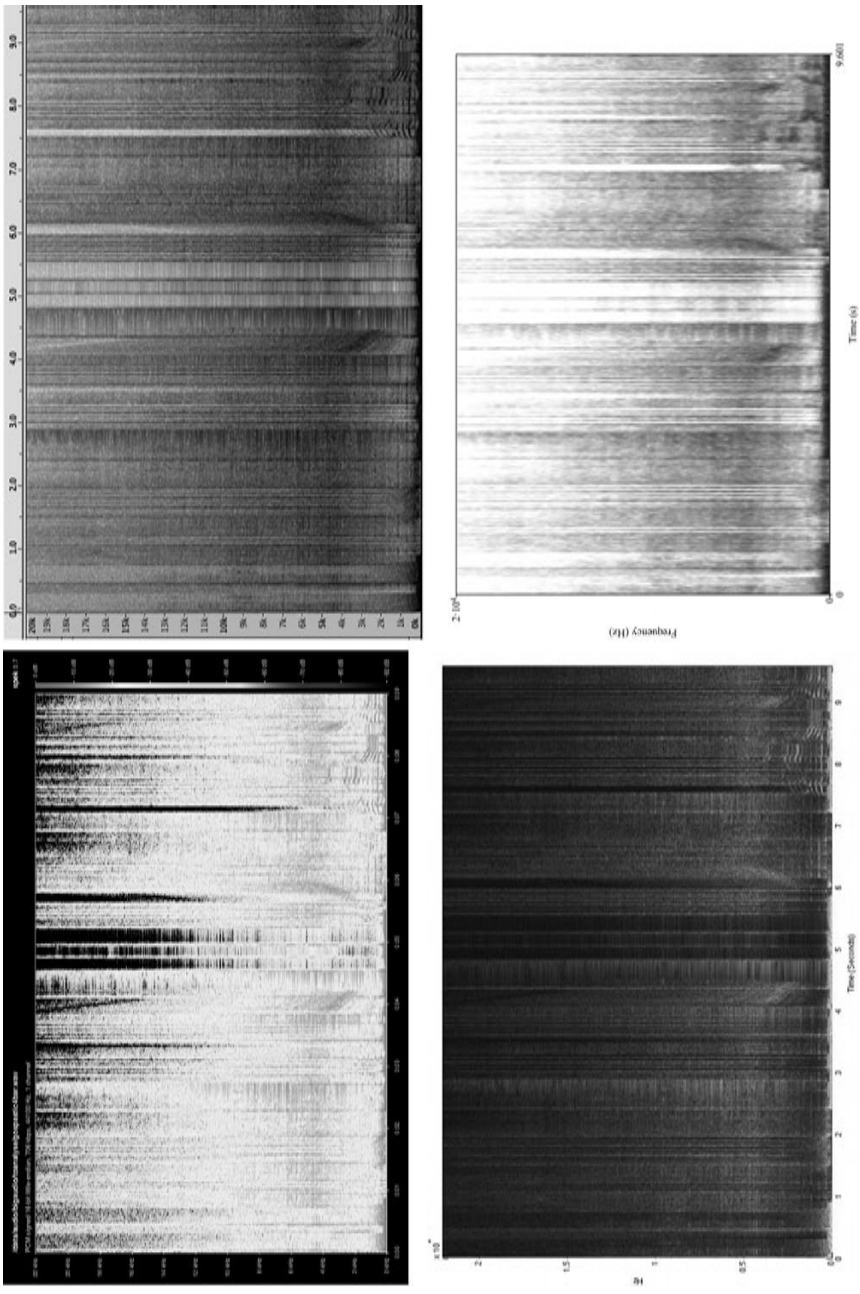

Figure 1.1 Four spectral analyses from four programs of the same extract; four percussive bars from Squarepusher's *Go! Spastic* (2001). All the frequency axes cover the whole human hearing range linearly, so use a quarter of their screenspace on the most musically salient range for fundamental frequencies (up to 5 kHz). From the top-left clockwise, the software which produced the spectrograms was Spek, Audacity, Praat, and MATLAB. Percussive hits are visible as vertical bars; an instance of speech near the end appears as the horizontally co-fluctuating formant curves in the lower part of the plot.

from the instrumental field being those invited to take part in electronic exploration. Fortunately, this situation eased as prices came down; analog synthesizers became affordable for musicians in the 1970s, and digital hardware and cheap computing made electronic music highly accessible (at least in wealthy countries) from the 1980s onward.

In the current era, innumerable artists and releases across multiple media compete for bandwidth, and the impression is of a joyously unstoppable mob of activity. For example, 1,000 dubstep tracks are uploaded to SoundCloud per day, Last.fm lists 65 million songs, and listening to all the music released each week would take a music critic a lifetime longer than he or she would have available to write reviews. So the filters of advertising budget and trusted information sources tend to dominate still, despite some opportunities to go viral.

This makes the study of electronic music joyful and challenging. When more music is released each week than you could comfortably listen to in a year,[14] in studying electronic music, you will continually encounter artists you have never heard of before. Two human beings can always find different parts of the information network to share with one another, so two scholars will always have slightly different personal perspectives on the musical field.

DIY record releases are not new, and accelerated particularly in the post-punk period from 1978 or so onward, aided by organizations such as Rough Trade, with many independent labels being established.[15] Although the recording industry these days is often attributed to a few big record labels that have eaten up many smaller concerns, independent releasing still goes on, particularly now in the digital domain through net labels, digital distribution-only packages, and music services enabling anyone to release work for sale (CDBaby, Tunecore, and the like).

Gender and international involvement

Ideally, human activities would always show a fair mix of practitioners reflecting the statistical make-up of human populations. Unfortunately, electronic music has often seen a greater concentration of male adherents, particularly in previous decades. It is not that there aren't plenty of examples of important female artists active in the 1950s and 1960s, such as Elaine Radigue, Else Marie Pade, Alice Shields, Bebe Barron, Pauline Oliveros, and more. The BBC Radiophonic Workshop was set up by 1958 (not without initial resistance!) after a great deal of lobbying from Daphne Oram. Following the precedent of British wartime employment practices, it had a fairer mix of female sound designers including the much-feted Delia Derbyshire, but still bucked the trend of mainly male employment elsewhere in the BBC reclaiming jobs after the war.[16] In recent years, women have actively challenged all stereotypes of male musical thrust; Björk Guðmundsdóttir in particular has

provided a clear and leading international role model. Despite significant liberations, it remains important to acknowledge the existence of such issues in order to avoid future discrimination. There are various initiatives in progress to celebrate female contributions to electronic music; an interesting, if US-centric, starting point is the book *Pink Noises*, which collects perspectives from many creators.[17]

International involvement in electronic music is also a concern. Fortunately, there have been many historical worldwide connections (Theremin's Russia and Halim El-Dabh's Egypt, for example), and the spread of the technology is relatively wide. Admittedly, some developments are concentrated in particular nations where technology is first honed: The US in particular was home to much early computer music research, though Australia and Britain, with their own contributions to early computing, sneaked in some 1951 computer music of their own.

In later chapters, we shall encounter many further themes and issues, including the extended compositional worlds opened up by electronics, the concerns of intellectual property, or what it means to perform live. There is a huge amount to investigate in electronic music and there is a mass of musical activity ongoing; there are also dangers, like the obsolescence and maintenance issues with fast-paced technology development. We hope that this dynamism will come across in the pages ahead and that your own appetite for investigation will be suitably whetted by what you read.[18]

Further listening

Each chapter implicitly suggests listening in featuring the work of many diverse artists; we can only suggest starting points, given that there is much more great music to discover than space. There are books specifically dedicated to annotated discographies of electronic music, for example, Dave Henderson's *Journey to a Plugged In State of Mind*.[19]

Online sources are a great way to discover music these days, including many rare releases (Jean Michel Jarre's *Music for Supermarkets* (1983) is an LP with a limited edition of one copy, but, having been played once on Radio Luxembourg, has made its way to YouTube . . .). Depending on availability in your Internet locality, Spotify, Pandora, Last.fm, Deezer, Grooveshark and more offer legal streaming services. Charity shops and thrift stores may be good sources for original LPs and cassettes if you own the necessary earlier analog equipment. In many cases, music has been re-released on CD, is available for download, or, for more recent music, was inherently a digital release in the first place. There are a host of online record labels (net labels) to explore, and many releases have begun to deviate from fixed recordings entirely, in