THOM HOLMES

# ELECTRONIC AND EXPERIMENTAL MUSIC

## Technology, Music, and Culture

Sixth Edition

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ROUTLEDGE

# Electronic and Experimental Music

*Electronic and Experimental Music: Technology, Music, and Culture*, Sixth Edition, presents an extensive history of electronic music—from its historical beginnings in the late nineteenth century to its everchanging present—recounting the musical ideas that arose in parallel with technological progress. In four parts, the author details the fundamentals of electronic music, its history, the major synthesizer innovators, and contemporary practices. This examination of the music's experimental roots covers the key composers, genres, and techniques used in analog and digital synthesis, including both art and popular music, Western and non-Western.

New to this edition:

- A reorganized and revised chapter structure places technological advances within a historical framework.
- Shorter chapters offer greater modularity and flexibility for instructors.
- Discussions on the elements of sound, listening to electronic music, electronic music in the mainstream, Eurorack, and more.
- An appendix of historically important electronic music studios around the globe.

Listening Guides throughout the book provide step-by-step annotations of key musical works, focusing the development of student listening skills. Featuring extensive revisions and expanded coverage, this sixth edition of *Electronic and Experimental Music* represents a comprehensive accounting of the technology, musical styles, and figures associated with electronic music, highlighting the music's deep cultural impact.

**Thom Holmes** is a music historian and composer. He studied composition with Paul Epstein in Philadelphia, published the magazine *Recordings of Experimental Music* (1979–85), and worked with John Cage. He has recently been a member of Composers Inside Electronics, an electronic music performing ensemble dedicated to the realization of works by David Tudor. Holmes produces a personal blog, *Noise and Notations*, writes the blog *Moog: A History in Recordings* for the Bob Moog Foundation, and originated and maintains the *Holmes Archive of Electronic Music*, a curated collection of vintage electronic music recordings spanning the years 1930–85.

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# Electronic and Experimental Music

## Technology, Music, and Culture

SIXTH EDITION

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This book is dedicated to the women and men who, as musicians, engineers, and inventors have followed their passion across cultures and norms to make electronic music a living phenomenon that continues to grow.

To John Cage, who got me started on this path.

To David Behrman and Gordon Mumma who continue to inspire me.

To Julie Martin for her contributions to the art and community, and also for her personal support and advice.

To all experimenters, everywhere.

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# Preface

> "I can't understand why people are frightened of new ideas. I'm frightened of the old ones."
>
> —John Cage[1]

When I first wrote this book in the early 1980s I was trying to put together a lucid history of the art of electronic music that would inspire artists and engineers alike. Today, more than 40 years later, the history of electronic music continues to reveal itself. The added years have brought more interest and curiosity from new generations.

I have rethought the past editions of this book with the goal of creating a more practical template for the future. The result is this sixth edition that I hope maximizes the suggestions of many who have used this text. You will note that the chapters are shorter. It is also reorganized into a more logical plan that will allow the reader to more quickly locate information. Individual chapters are concise and made more accessible through a combination of descriptive titles and section heads combined with a tighter narrative. But the stories of composers and engineers remain and have been expanded in many places to tell a fuller history of electronic music.

## NEW ORGANIZATION

In reorganizing the content of the book I was able to unify many thematic elements that had strayed apart over the years. The first nine chapters cover the fundamentals, including an entirely new chapter about how to listen to electronic music plus the basics of audio physics, synthesis, and tape composition. The stories of analog and digital synthesis have now been integrated rather than being discussed separately. In Parts 2 and 3, individual chapters are devoted to the early history of electronic music by country and world region, and by key synthesizer innovators (e.g., Moog, Buchla, EMS, ARP). Finally, the emergence of computer music, live electronic music practices, turntablism, and Eurorack modular synthesis are discussed. A new appendix provides an expansive guide to historically important electronic music studios around the globe.

In keeping with the advice of avid readers, I have reduced my discussions of pop and rock music in favor of further exploring the experimental roots of electronic music. I continue to focus on the early adopters and experimenters who pioneered the music and technology during each phase of the history of electronic music. Through interviews and readings, I bring their stories to life often using their own words. For those interested in my writing outside the scope of this current text, you might look for my papers on "The Roots of Electronic Jazz, 1950–1970"[2] and "The Sound Of Moog: Using Vinyl Recordings to Reconstruct a History of the Moog Synthesizer,"[3] or see my blogs for the Bob Moog Foundation and my own web column "Noise and Notations."

## THEMES

At its heart, this book remains an account of the history of technology, musical styles, and figures associated with electronic music, paying particular attention to:

- The invention of the key technologies of electronic music.
- The people who first explored new musical ideas using electronics.
- Key works of electronic music, their genesis, and influence.
- The cultural impact of electronic music over the years.

Women have always played an important role in the development of electronic music. This edition continues to expand the discussion of the compelling and under-reported accomplishments of women from many countries.

## IN THIS EDITION

- **New chapter plan and organization.** There are now 38 chapters focused on specific topics (whereas the previous edition had 15 long chapters). The number of chapters reflects a modular approach for the instructor. Reading assignments are easier for the instructor to identify and easier for the student to manage.
- **New Chapter 2: Listening to Electronic Music.** Listening to electronic music can be challenging, especially for those who are new to experimental forms. The rules for listening to traditional music—from classical to pop—do not always translate effectively to finding enrichment in electronic music. This guide provides an objective approach to listening and analyzing any kind of electronic music.
- **New Chapter 38: Eurorack.** This overview of contemporary modular synthesis provides a modern history and will also be of interest to anyone getting started with electronic music.
- **New Chapters 28, 29, 30, 31 on Moog, Buchla, EMS and ARP.** These chapters bring together revised and expanded material on four major, ground-breaking makers of modular synthesizers from the vintage years of analog synthesis.

- **New Chapter 21: The San Francisco Tape Music Center.** Although the SFTMC was always included in the book, bringing together and expanding the content was important for telling a complete story. As with each studio that has a separate chapter in the book, this one provides an overview of the history, equipment, and works of key composers associated with the studio.
- **New Chapter 22: Electronic Music in Canada.** A much-needed focus on telling a more uniform story of electronic music originating in Canada. The name of inventor Hugh Le Caine is closely associated with the Toronto and Montreal studios and much of this chapter reflects on his work with those institutions.
- **New Appendix I: Historic Studios of Electronic Music by World Region, 1948–70.** This guide unites and greatly expands the directories of classic electronic music studios that existed in the 1950s and 1960s. It is organized by region/country.
- **New Appendix II: Milestones.** This table lists all of the important technical achievements and artists and music found in the text, arranged in chronological order by year. The chapter location of each item is also indicated.
- **Listening Guides.** Found in many chapters, these guides provide a moment-by-moment annotated exploration of key works. Listening Guides give the background on a work and the composer, the way in which a work was composed, and a set of notes explaining how the music was produced, keyed to timings throughout a piece.
- **Listen Playlists.** Many chapters include one or more Listen Playlists, which are a collection of recommended musical tracks that are commercially available through music download sites. Four Listen Playlists were added to this edition in the chapters on Buchla, EMS, ARP, and Eurorack.
- **Extensive photos and figures.** The rich history of electronic music is made clearer with vivid images, schematics, and sample scores, all of which continue to be a hallmark feature of the book. About 70 new images have been added to this edition.
- **Glossary.** Key terms are highlighted in bold within the chapters and collected with definitions in a complete glossary at the back of the book.

## INTERNET RESOURCES

The author and publisher have created a resource at the dedicated website for the sixth edition of *Electronic and Experimental Music*. Go to www.routledge.com/cw/holmes for the streamed audio program, with interactive quizzes, additional Listening Guides, links to other resources, and a link to the author's blog.

## NOTES

1 John Cage in an interview with Arnold Jay Smith published as "Reaching for the Cosmos: A Composer's Colloquium," *DownBeat,* 44:18 (October 27, 1977).

2 "The Roots of Electronic Jazz, 1950–1970," *Jazz Perspectives*, 10:2–3 (2017).

3 "The Sound Of Moog: Using Vinyl Recordings to Reconstruct a History of the Moog Synthesizer," *Notes*, 71:2 (2014).

# Acknowledgments

Many people have contributed to the success of *Electronic and Experimental Music* over the years. I would especially like to thank the many readers and instructors who use the book and provide invaluable feedback that is helpful in planning each successive edition. Routledge has been a steadfast supporter of my book for several editions and I want to especially thank my editor Genevieve Aoki for enabling this book to be a success. Equally vital to the success of the book was assistant editor Aurora Montgomery. I couldn't be more pleased with the extremely talented and resourceful production crew. Thanks go to Kelly Somers for the superb copyediting of this edition and many fine suggestions.

For this edition, I relied time and time again on the thoughts and advice of many friends who are active in the field. Of these, I want to especially point out the contributions of Julie Martin, founder of Experiments in Art and Technology, who continues to be a force in documenting the history of music technology. Pulling me in closer to the world of David Tudor, I want to thank John Driscoll, Phil Edelstein, and Matt Rogalsky for their insight into the world of this remarkable artist. Through their invitation, I was able to become a constructing and performing member of Composers Inside Electronics in 2014–15.

A special thanks to Gordon Mumma for always being there and showing great patience in answering my questions. Many of Gordon's photos are included in this edition; some that have not appeared elsewhere.

As for my own personal exploration of music, I must also acknowledge John Cage without whose encouragement as a young composer I would not have developed such a passion for new music. It was always a pleasure to visit John, when our conversations freely drifted from new music to macrobiotic cooking. I also wish to thank Laura Kuhn, Executive Director of the John Cage Trust, who has given me access to materials in the Cage archives and has always helped me connect with composers and musicians. The first person I studied music with was composer Paul Epstein, who taught me how to compose beyond the moment and think about the process. The things I learned from Paul continue to influence the words that I write and the music that I compose. Thanks to Merceds Santos-Miller, Museum Manager at Caramoor, the estate of Walter and Lucie Rosen, for granting access to Lucie's Theremin and papers related to her work with the instrument. My history of the Theremin also benefited greatly from the help of David Miller, who has documented the story behind the Paul Tanner electro-Theremin. Finally, many thanks to Michele Moog of the Bob Moog Foundation for affording me the opportunity to contribute a blog discussing the history of Moog synthesizer recordings.

The biggest thanks of all go to Anne, for her insight, encouragement, and support, and to my daughter Shaina, for whom it is an honor to be her father.

PART 1

# Electronic Music Fundamentals

CHAPTER 1

# What is Electronic Music?

*"What we are doing now is not important for itself, but one day someone might be interested enough to carry things and create something wonderful on these foundations."*
—Delia Derbyshire (circa 1965)[1]



Delia Derbyshire at the BBC Radiophonic Workshop.
*Source:* © BBC Picture Library.

*Electronic and Experimental Music* is the story of where **electronic music** came from and how it has evolved with changing technology. It is also the story of musical ideas that arose in parallel with the technology, sometimes inspired by the machine but just as frequently leading to the invention of new technology to fulfill these ideas.

Many questions about electronic music can only be answered historically. What qualities are inherently unique to electronic music? When did we first play sounds in reverse? How did the concept of a sound's envelope become part of the composer's toolkit? Why was the music of early practitioners, such as Schaeffer, Stockhausen, Tudor, and Varèse, viewed as distinctly different approaches to the medium? The answers to these and other questions have been obscured by many years of established practice in the field and a cavalcade of changing products and technologies. There is a foundation for the art of electronic music that infiltrates its entire history. Techniques first attempted in the 1930s are still practiced today even though the underlying technology has been completely transformed. With each new generation of technology also come new techniques that are added to the repertoire of electronic music practices. Still, understanding the history of such developments remains essential for today's composers and listeners if we are to fully appreciate and comprehend the beauty, complexity, and scope of this thing we call electronic music.

The title of this book invites some discussion. Why "electronic and experimental music?" Why not electroacoustic, electronica, acousmatic, organized sound, computer music, or *musique concrète*? For the purposes of this book, I have long adopted the term *electronic music* because it is categorically broad and self-explanatory. I use the word "experimental" to underscore that the book is primarily about historical beginnings in the art of electronic music, both technologically and musically. These beginnings span a broad range of years and developments, from the late nineteenth century to the present. Such beginnings are always built on what has come before but can be considered new and experimental in their time. The conversation of this book is about such times, before a new idea or technique in electronic music became mainstream or old hat.

## PERSPECTIVES ON ELECTRONIC MUSIC

Because its nature is that of a music using a new medium, the composing and performing of electronic music naturally leads to new sounds, techniques, and styles of music. During its formative years, however, the acceptance of electronic sound as music was not universal. There were several different schools of thought in the 1950s that resulted in a surprising amount of friction between the leading thinkers in the practice of electronic music. Then there were the naysayers who thought that it was not a lasting contribution at all, merely a musical drop in the pond that would eventually ripple away.

Of the initial "schools" of electronic music, the French and Germans occupied most of the headlines over aesthetics. Both were working in what we would call institutional or government-supported establishments.

> Despite the fact that electronic music is the outcome of decades of technical development, it is only in most recent times that it has reached a stage at which it may be considered as part of the legitimate musical sphere.[2]

These were the thoughts of Herbert Eimert, one of the founding scholars of electronic music. He wrote this in 1955, just 4 years after establishing the electronic music studio of West German Radio (WDR). By "legitimate musical sphere," Eimert meant that he intended *purely electronic tones* to become the new raw material for realizing serialist works in the operational style of Anton Webern. The German studio was in fact launched into prominence on the reputation of several serialist-inspired pieces consisting of purely electronic signals, recorded and edited on magnetic tape. In stark contrast were the pioneering tape works of *musique concrète* created at the Groupe de Recherches Musicales (GRM) studio in Paris under the guidance of Pierre Schaffer. The French composed more freely, modifying and recontextualizing *naturally occurring sounds* into montages that defied any stylistic precedent. The aesthetic clash between the French and Germans was short-lived due to the refusal of electronic music to be contained by any single school of thought, quickly expanding beyond the French and German "schools" by composers who made rules of their own. In 1955, French composer Pierre Boulez offered a cautionary tale of composers losing their way in the electronic music studio, their once-fixed audio limitations having become unlimited, leading to the "negative cliché" of special effects gone mad.[3] The underlying message? The taste that governs the writing of traditional music can well serve the composer of electronic music.

In 1969, looking back at the decade of the Sixties, twentieth century musical icon Igor Stravinsky commented that the most telling index of musical progress in the 1960s was,

> [. . .] not in the work of any composer [. . .] but in the status of electronic music [. . .] the young musician takes his degree in computer technology now, and settles down to his Moog or his mini-synthesizer as routinely as in my day he would have taken it in counterpoint and harmony and gone to work at the piano.[4]

For many in the mainstream, Stravinsky had reinforced the legitimacy of electronic music and its continued evolution within all musical circles.

By 1970, after 20 years of experimentation, the field of electronic music established a niche for itself founded on three cultural perspectives (see Figure 1.1):

- Technology naturally leads to *experimentation* and eventual acceptance of new sounds, styles, and techniques for making music.
- The *acceptance* of electronic music will succeed by comparing it to other forms of music, even if that comparison is unnecessary to accept electronic music as a musical form of its own.
- Composing and listening to electronic music requires *new skills*.

Electronic music is a music of *continuity* and *non-continuity*. Boulez characterized this aesthetic as "the concept of continuity which faces the composer in all directions."[5] Looking back at the extensive work of David Tudor, composer Forrest Warthman wrote that Tudor's approach was to "shape sound in all its dimensions, without limitation."[6] So it seems that we have developed a continuously expanding universe of sounds in which pitch, timbre, amplitude, duration, and envelope comprise the elemental particles with which the composer works.

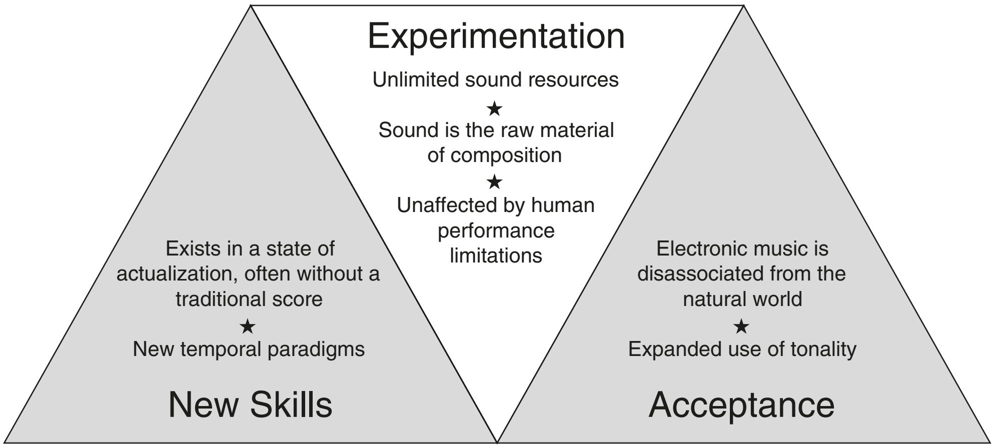


*Figure 1.1* Perspectives and traits of electronic music.

## THE DEBATE OVER TERMINOLOGY

The evolution of electronic music technology has always been shadowed by a debate over what to call the music. This debate is important in that it refers to specific approaches to making the music or to a stylistic tendency for which there is an existing body of works. The debate over what to call electronic music can also serve as a kind of lightning rod for discussion about the nature and goals of composing with technologically produced sounds. The background information on terminology that follows may help readers who have encountered this debate.

When viewed from the standpoint of history, it is possible to understand each term within the context of its own time and place, but oftentimes they do not translate to the present day in a meaningful way. Take Pierre Schaeffer's term ***musique concrète***. For Schaeffer, this was a work conceived with the recording medium in mind that was composed directly *on that medium* and was played *through that medium* as a finished work. In *musique concrète*, therefore, one worked directly with the modification of sound material, often obscuring beyond recognition the identity of the original source. The use of untreated, natural sounds in a composition was generally unacceptable to Schaeffer, who was so fixated on the transformative aspect of *musique concrète* that he apparently expelled one of his own understudies, Luc Ferrari, from the Paris studios in 1964 for having allowed many of the natural sounds in his material to remain recognizable.[7] Schaeffer's stubborn insistence on a rigid doctrine for *musique concrète* ultimately led to the disuse of the term by most other studios. Schaeffer himself later displaced the term *musique concrète* with the term *acousmatique* to embrace a wider variety of sound sources and treatments.

In Germany, the composers in the Cologne studio insisted on the term ***elektronische Musik*** to describe what they were doing. For the briefest of moments in 1951 there may have actually existed a technological distinction between these two schools of thought: *musique concrète* embracing the manipulation of recorded natural sounds and *elektronische Musik* comprising only electronically generated tones. However, composers working in these rival studios were much less interested in the debate than in the fantastic sounds they were making and soon realized that, once a sound was recorded, no matter what the original source, a sound was simply a sound like any other. Once composers had essentially broken all the rules of their institutional mentors, the razzle-dazzle surrounding the terms *musique concrète* and *elektronische Musik* disappeared.

The earliest electronic music of all was named for the communication wires over which it was distributed. The output of the Musical Telegraph was sometimes known as *telegraphic music* and the output of the Telharmonium was referred to as *telharmonic* or *telephonic music*.[8] During the 1950s, Varèse sidestepped the entire debate of the French and Germans and referred to his own electronic music as *organized sound*. Cage adopted similar terminology, but considered "sound" to consist of unpitched noise as well. By 1960, the general term *electronic music* had been widely adopted in America to describe any and all music produced using recorded sound, tape machines, and sound generators, whether for movies, television, stage, dance, or in the halls of academic music studios. In the United Kingdom during this time, the term ***radiophonic*** was used to describe the programmatic electronic music produced by the BBC for broadcast purposes, a carryover from the history of sound work for radio to produce sound effects.

During the 1970s the use of general-purpose music synthesizers simplified the production of electronic music and the debate over terminology gradually became decoupled from the technical means used for producing the music. The terms *electronic* and *electroacoustic* music became widely used and referred more to a style of music than to the instruments used to create it. A hiccup in terminology occurred once more with the introduction of digital instruments and the use of personal computers to create music. This advance in technology was significant because it gradually took the tape medium out of the picture and led to the development of software and digital circuitry for electronically creating virtually any style of music. Until about 1985, the term *computer music* was used to describe new instruments and experiments in the creation of electronic music. After that, most music has been produced with the aid of a computer and we return to the naming of various genres or styles of music.

Following is a quick assessment of many of the most familiar terms that have been used to describe electronic music. Some are based in the history of technology, others in an attempt to describe a style or aesthetic of the music.

- **Telegraphic and telephonic.** Dating from the late nineteenth and early twentieth centuries, these terms refer to the electrical means for distributing early experiments in electronic music using telegraph wires and telephone lines.
- **Telharmonic music.** For a brief period around 1900, electronic music was named after an impressive instrument designed to create it—the Telharmonium.
- **Organized sound.** Varèse's general term for his musical compositions, whether they were electronic or instrumental. This is generally understood to be the creation of music intended for a concert hall or other audience situation, such as the Philips Pavilion at the Brussels World's Fair.

- ***Musique concrète.*** Schaeffer's term for a work conceived with the recording medium in mind that was composed directly on that medium and was played through the medium as a finished work. This term is often synonymous with early tape music.
- ***Elektronische Musik.*** Beyer and Meyer-Eppler's term for music comprised entirely of electronically generated sounds. This term is also synonymous with early tape music.
- **Acousmatic.** Schaeffer's later term for tape music—*acousmatique*[9]—is generally considered synonymous with *musique concrète*, and was preferred by composers who wanted to avoid being associated with earlier debates over terminology.[10] The term is widely used in academia to refer to contemporary works of *musique concrète* using digital media and whose source material consists primarily of pre-recorded sounds. The term *electroacoustic* is often used synonymously with *acousmatic*.
- **Electroacoustic.** This is music for which the primary content consists of electronically modified acoustic sounds.[11] Electroacoustic techniques vary widely from working with the manipulation of previously recorded sounds to the treatment and modification of instrumental sounds in real time. The term is often used synonymously with electronic music, although to many it refers to art music incorporating electronic effects.
- **Radiophonic.** British term referring to electronic sound effects and music for radio and television programming. The composition techniques closely parallel those of *musique concrète*. The BBC Radiophonic Workshop was a sound laboratory and studio created by the BBC in 1958 for the production of electronic music.
- **Sound art.** Electronic music not necessarily intended for the concert hall, but might be used as an audio installation in a gallery or other environmental context.
- **Computer music.** Music made with the aid of computers. Today, this term is largely synonymous with the term *electronic music* because most music is generated using digital tools. Prior to the availability of laptop computers, computer-based electronic music was made using large mainframe and minicomputer systems, usually at the audio laboratories of telecommunications corporations (e.g., Bell Labs, Siemens) or university-based data processing centers (e.g., University of Illinois, MIT).
- **Electronica.** A contemporary term that covers a wide range of electronic music styles. Generally referring to popular music relying heavily on electronic sonorities, beats, and sound manipulations, it may be intended for dancing or for private listening. *Electronica* may stand alone as a purely electronic form of music, or its elements may be combined with those of rock and pop bands and vocalists.
- **Electronic music.** A broad term encompassing any form of music that incorporates largely electronic elements, whether originating as acoustic source material or purely electronic tones. One of the first uses of the term as we understand it today was found in an article by B. F. Miessner called "Electronic Music and Instruments," published in 1936.[12]

This book will use these terms in the context of history while adopting the term *electronic music* as the most universal when applied across all of electronic music history.

## HOW IS ELECTRONIC MUSIC DIFFERENT THAN OTHER MUSIC?

We need to remember that electronic music is not about a specific style or genre—it can literally be realized in any genre, from children's music, to jazz, to rock, to soundtracks. Electronic music can be all of these. It is instead distinguished by the techniques and instrumentation used to create the music. For the purpose of history, it happens that the initial uses of electronic music in any given genre have tended to be experimental in nature, which are the works we will explore. This is not so much about how electronic music is changed by other kinds of music but about how it influences and changes existing musical styles and genres. Here are seven principle traits of electronic music that make it unique:

1 **The sound resources available to electronic music are unlimited.** New sounds can be constructed from the raw material of electronic waveforms. The composer not only creates the music, but composes the very sounds themselves. Eimert explained the potential of electronic music in the following way:

> The composer, in view of the fact that he is no longer operating within a strictly ordained tonal system, finds himself confronting a completely new situation. He sees himself commanding a realm of sound in which the musical material appears for the first time as a malleable continuum of every known and unknown, every conceivable and possible sound. This demands a way of thinking in new dimensions, a kind of mental adjustment to the thinking proper to the materials of electronic sound.[13]

The composer can invent sounds that do not exist in nature or radically transform natural sounds into new sounds. For *Thema–Omaggio a Joyce*, Berio used tape manipulation to transform the spoken voice into a myriad of sound patterns eerily laced with the tonalities of human communication. In the piece *Luna* (1984), Wendy Carlos *(b. 1939)* modeled a digital instrument that could be modified in real time as it played, metamorphosing from the sound of a violin to a clarinet to a trumpet and ending with a cello sound. This sound could not be possible in the world outside of the computer, but became possible with her library of "real-world orchestral replicas" that the GDS and Synergy synthesizers allowed.[14] For *Beauty in the Beast* (1986), Carlos took this experimentation a step further by "designing instrumental timbres that can't exist at all, extrapolated from the ones that do exist."[15]

2 **Electronic music can expand the perception of tonality.** On one hand, the invention of new pitch systems is made easier with electronic musical instruments. Microtonal music is more easily engineered by a composer who can subdivide an octave using software and a digital music keyboard than by a piano builder. On the other hand, electronic music also stretches the concept of pitch in the opposite direction, toward less defined tonality into the realm of noise. All sounds may be considered equally important increments on the electromagnetic spectrum. Varèse sensed this early on and introduced controlled instances of noise in his instrumental

and electronic music. Cage accepted the value of all sounds without question and let sounds be themselves:

> Noises are as useful to new music as so-called musical tones, for the simple reason that they are sounds. This decision alters the view of history, so that one is no longer concerned with tonality or atonality, Schoenberg or Stravinsky (the twelve tones or the twelve expressed as seven plus five), nor with consonance and dissonance, but rather with Edgard Varèse who fathered forth noise into twentieth-century music. But it is clear that ways must be discovered that allow noises and tones to be just noises and tones, not exponents subservient to Varèse's imagination.[16]

3 **Electronic music exists in a state of realization.** Igor Stravinsky *(1882–1971)* wrote:

> [I]t is necessary to distinguish two moments, or rather two states of music: potential music and actual music [. . .] It exists as a score, unrealized, and as a performance.[17]

In the world of electronic music there are many works that *cannot* be accurately transcribed and reproduced from a printed score. The underlying reason for this is that electronic music is a medium in which the composer directly creates the performance either as a recording or a live performance. There is rarely a need for somebody else to interpret or read a score other than the composer; nor is it practical to do so. But this does not make the works any less valuable. Many works are realized directly only one time using electronic media for the purpose of creating a recording. This is not to deny attempts made by composers to score electronic music. But scoring often results in a composer devising a unique form of notation to define the elements of a work that is especially suited to whatever sound-generating technology is available to them.

*Experiencing* electronic music is a part of its actualization. The term **realization** was adopted by electronic music pioneers to describe the act of assembling a finished work. A work of electronic music is not real—does not exist—until a performance is realized, or it is played in real time. Other than assisting the composer in making notes for the realization of a work, reasons for creating or publishing a score include providing an example that might be instructional for others, copyrighting a work, and providing instructions for instrumentalists when a work can be performed live.

4 **Electronic music has a special relationship with the temporal nature of music.** Stravinsky said, "Music presupposes before all else a certain organization in time, a chronomony."[18] The plastic nature of electronic music allows the composer to record all of the values associated with a sound (e.g., pitch, timbre, envelope) in a form that can be shifted and reorganized in time. Traditional instrumental music, once recorded, benefits from a similar control over the manipulation of a real-time performance. The equivalency between space and time that Cage attributed to the coming of magnetic tape recording—and which can be extended to any form of analog or digital sound recording, MIDI control signals, or even a performance

sequence outlined in Max/MSP—has the liberating effect of allowing the composer to place a sound at any point in time, at any tempo.

5 **In electronic music, sound itself becomes the material of composition.** The ability to get inside the physics of a sound and directly manipulate its characteristics provides an entirely new resource for composing music. The unifying physics behind all sounds—pitched and unpitched alike—allow a composer to treat all sounds as being materially equal.

6 **Electronic music does not breathe: it is not affected by the limitations of human performance.** As Robert Ashley once said to me, electronic music "can go on as long as the electricity comes out of the wall."[19] The ability to sustain or repeat sounds for long periods of time—much longer than would be practical for live instrumentalists—is a natural resource of electronic music. In contrast to its sustainability, electronic music can play rhythms too complex and rapid for any person to perform. The composer is freed from the physical limitations of human performance and can construct new sounds and performances of an intricacy that can only exist when played by a machine.

7 **Electronic music often lacks a point of comparison with the natural world of sounds, providing a largely mental and imaginative experience.** Hearing is a "distance" sense, as opposed to the "proximal" senses of touch and taste. The essence of electronic music is its disassociation with the natural world. Listening engages the intellect and imagination to interpret what is heard,

> [providing] only indirect knowledge of what matters—requiring interpretations from knowledge and assumptions, so you can read meaning into the object world.[20]

Having little basis in the object world, electronic music becomes the pulse of an intimate and personal reality for the listener. Its source is mysterious. "It is thought, imagined and engraved in memory. It's a music of memory."[21] In these ways, the human being becomes the living modulator of the machine product; the circuitry dissolves into the spirit of humanness that envelops it.

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CHAPTER 2

# Listening to Electronic Music

*"Wherever we are, what we hear is mostly noise. When we ignore it, it disturbs us. When we listen to it, we find it fascinating."*
—John Cage (1937)[1]



Inside the Mirror Dome in the Pepsi Pavilion at Expo 70, Osaka. Listening to electronic music can be immersive, as in this groundbreaking experiment. Thirty-seven speakers were mounted overhead behind the mirror and sounds could be directed to them in real time. Visitors were also equipped with wireless handsets for listening to sounds emanating from sound loops played through the floor.
*Source:* Fujiko Nakaya. Courtesy E.A.T.

Many styles of electronic music use structures and sounds that are familiar to the ear, but the more experimental varieties can bear little resemblance to the music to which we often listen. Each is uniquely electronic, drawing sounds from timbres and tonalities that are not immediately identifiable. The ability of a composer to create a musical experience by applying unexpected and new sonic contours is one of the fascinations of electronic music. Add to this the ingredient of *how* electronic music can be made—from tape composition, amplified objects, analog synthesizers, computer algorithms to laptops—and you see that there is no end to the creativity shown by musicians for originating the sounds of electronic music.

The listener is equally challenged by electronic music. They are tasked with finding an effective listening style to maximize one's enjoyment of the music while acknowledging that electronic music is innately different in so many ways to other types of music.

In this chapter, we'll explore the elements that make-up the listening experience and consider their relevance to electronic music. Here we discuss basic listening techniques that can be applied broadly to any piece of electronic music. An approach to listening will be explored and options suggested for your consideration. Note that additional Listening Guide boxes are provided throughout this book to offer supplementary insight into the makings of specific musical works of influence.

## THE MANY WAYS OF LISTENING

Does music speak for itself? The answer depends on whom you ask. You do not need a textbook to tell you how to listen. The difference between "hearing" and "listening" is generally understood by anyone interested in sound. *Hearing* is an involuntary act but *listening* requires an engaged mind. When it comes to music—sound sequences created to stimulate human thought and emotion—we generally know what it means to listen. The composer Pauline Oliveros explored the difference between hearing and listening in her work, writing:

> To *hear* is the physical means that enables perception. To *listen* is to give attention to what is perceived both acoustically and psychologically.[2]

She connected listening to consciousness and taught others how to become more aware during the listening experience; a practice she called *deep listening*.

If we unpack Oliveros' ideas about deep listening, we soon find that it is rooted in a long backstory involving the history of music criticism, theory, and practice. We also realize that there are several choices you can make when it comes to listening to electronic music. Knowing these options and choosing among them will increase your enjoyment of music.

In music theory, there is the dichotomy between *formalists* and *expressionists* that form two sides of a debate as to whether music engages the *intellect* or the *emotions*. **Formalism** holds that the only meaning in music arises from the mindful processing of the relationships among musical elements in a work—the notes, meter, and forms that comprise a piece. For the formalist, then, the meaning in music is intellectual. In

**expressionism**, the same musical content that is held in such objective regard by the formalists is also capable of "exciting feelings and emotions in the listener."[3]

Formalism is the idea that music contains a form or strategy that "exists independently of our experience of it."[4] According to this theory, one can analyze a piece of music independently of the effect it has on the listener. In some kinds of music, working in pure form is the objective of the composer. The twelve-tone (Schoenberg, Webern), serial (Babbitt, Stockhausen), indeterminate (Cage), and stochastic random probability distribution (Xenakis) are examples of composition approaches that embody rules of form and typically do not resemble human expressive behavior. Works of computer-generated music often follow rules established by a program of routines. Some say that works composed using these methods "have a limited capacity to arouse and represent emotion."[5] However, the listener may very well find satisfaction in listening to this music because of its purity of form, its apparent lack of emotional intent, and listening for the purpose of uncovering the mystery of the organization and arrangement of sounds as the work moves along. One could say that these pieces are written especially "for a purely intellectual appreciation"[6] and enable the listener to play the **hypothesis game**, a term recently used by scholar James O. Young. The hypothesis game is a mode of intellectual engagement in which "interested listeners will be able to form hypotheses about how a composer will solve the compositional challenges"[7] presented by the innate form of the composition.

Expressionists believe in the emotional power of music. The way in which this emotional response takes place is debated by music theorists, but nobody really denies that music can inspire a reaction that could be deemed emotional. To deny that it does is contrary to the way in which most humans experience music. "To many," wrote music theorist Ciaran Kamp, "the thought that we might value the experience of a piece of music without any reference to emotion is quite counter-intuitive."[8]

## Listening with Objectivity *and* Emotion

Traditional music appreciation texts, such as Roger Kamien's long-time bestseller *Music: An Appreciation*, provide an introduction to the elements of music so that the listener can build a musical foundation. This much-imitated approach begins with an overview of pitch, dynamics, and timbre; discusses the nature of various musical instruments of the orchestra; and then moves on to discuss in detail rhythm, musical notation, melody, harmony, key, musical texture, and musical form.[9] This is the foundation for listening to classical and other written music, but bears little relation to what one encounters when experiencing experimental electronic music. If you want to identify and isolate elements that comprise electronic music, you need a different approach to the fundamental elements of music.

Since my early days of listening to electronic music I have borrowed John Cage's approach to understanding sound. How Cage himself arrived at this approach followed several stages during his early music making. By 1937, he had realized that music fit within a greater environment of audio experience, writing,

> Wherever we are, what we hear is mostly noise. [. . .] We want to capture and control these sounds, to use them not as sound effects but as musical instruments."[10]

In 1948, while composing S*onatas and Interludes for Prepared Piano*, Cage used a composition process consisting of "structure" (the division of the whole into parts) and "method" (the process of choosing each note, the "note by note procedure").[11] He later said to me that during this exploratory phase in the late 1940s, he "wrote the *Sonatas and Interludes* actually improvising at the piano in a predetermined structure."[12] Next came his discovery of chance operations (early 1950s) and by 1957 he viewed his work as taking place within a "total sound-space" in which *all sounds*—musical and non-musical, notated and not notated—were equal. At this stage, he often broke from the use of traditional musical terminology and introduced terms for understanding sound from the field of physics. This was suitably objective because he was increasingly working to keep his personal taste out of his music.

> The situation made available by these means is essentially a total sound-space, the limits of which are ear-determined only, the position of a particular sound in this space being the result of five determinants: frequency or pitch, amplitude or loudness, overtone structure or timbre, duration, and morphology (how the sound begins, goes on, and dies away).[13]

These parameters of sound, along with his indeterminate approach to selecting sounds, were at the core of Cage's composition process for the rest of his life. Whether composing for instruments or electronic processes, he generally began by making selections from this list of parameters using chance operations. Other composers have adopted the same approach over time. As for using these parameters as a guide to listening, I am not alone in imagining how this might work. One recent study by Erik Christensen positions these same elements at the core of his nine dimensions of listening.[14] This approach was also directly translatable to computer music, long a parallel development to electronic music. Max Mathews was creating code by the late 1960s to include these five elements, and he wrote in 1969:

> Parameters specifying each sound are punched on a computer tape. At least five numbers—the instrument to be played, the starting time, duration, frequency, and amplitude—are necessary to specify a single note.[15]

For the purposes of my listening plan, I have adopted Cage's parameters as follows:

- Frequency
- Amplitude
- Duration
- Timbre
- Envelope

Within this scheme, meter and accent are functions of durations and amplitudes.[16] Cage argued that we no longer need to measure music in meters and rhythms because "magnetic tape music makes it clear that we are in time itself, not in measures of two, three, or four or any other number."[17] When incoming sound connects to your brain, these five sensations comprise what you are able to perceive, identify, and analyze. Music is, after all, merely a time-sequence of sound that the mind immediately reconstructs upon listening.[18]

One of the most difficult challenges in writing reviews or critiques of music is the description of sound. How do you describe in words what something sounds like? One approach often used in music reviews is to describe what a piece *reminds one of* or *sounds like*, which is more of a subjective approach than an objective one. But it serves the purpose of discussing music by comparing it to something with which the listener is probably familiar. While taking a more objective approach to describing a piece might be more valued in terms of getting into how it works and is structured, describing a piece as objectively as this might not make for very interesting reading. However, being able to listen with an open mind and objective temperament can reveal much more than can a typical music review.

The degree to which these parameters are present in music is variable. It is conceivable that you may encounter a piece that is absolutely dominated by one of these five parameters. More commonly, these five traits of sound work together to form the overall arc of a piece. This plan for listening emancipates you from thinking of note values and allows you to hear the range, movement, and flow of frequencies. Once perceived, the analysis begins, which brings us to the final stage.

In addition to the extremes of formalism and expressionism, an intermediate view also emerged as to how humans respond to music. The Austrian musicologist and theorist Victor Zuckerkandl *(1896–1965)* broke away from the bipolar views of formalism and expressionism as early as 1956, but his ideas were little recognized until the 1990s. Zuckerkandl succinctly explained a middle-ground between formalism and expressionism when he made the following observation about human response to musical sensations:

> Tone sensations, of course, are subject to the same law as all other sensations: they, too, are always colored by feeling. We do not hear flute tones or trombone tones; we hear *charming* flute tones, *solemn* or *threatening* trombone tones. Low tones sound *serious*, high tones *gay*, and so on. Now, whether we interpret the emotional tone as something contributed by the hearer or as a quality of the tone itself, one thing is certain: *the musical tone cannot be adequately described in terms of these two components, the physical and the psychic*.[19]

Zuckerkandl concluded that yet a third dimension of the musical tone was present and comprised our reaction to it. He described his construct as a simple linear progression. The incoming audio signal was the "trigger" that led to perception, after which the analysis or interpretation of the sound manifested itself as an "after-effect." He further explained:

> The two components, then, are present—the *physical*, the acoustical tone, and the *psychic*, the emotional tone; but the melody, the music, as we know, is in neither of these.[20]

Zuckerkandl called the middle listening stage the "dynamic process."

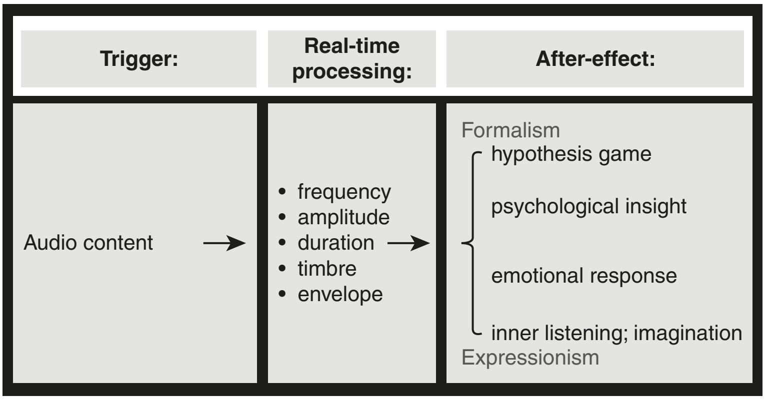


*Figure 2.1* Plan for listening to electronic music.

Another term for this phase between the trigger and the after-effect is the more familiar **active listening** stage in which *real-time cognitive audio processing* is being carried out in the mind. This becomes a state of mindfulness to the sounds that you hear. How the listener chooses to treat what she or he hears becomes a kind of post-processing feature of the after-effect.

How does Zuckerkandl's theory relate to listening to electronic music, a type of music that he did not mention when writing in 1956? In as much as electronic music can be radically different than conventional music in tonality, timbre, and structure, Zuckerkandl's reduction of the listening process to these three steps introduces an approach to listening that we can apply to electronic music.

In Figure 2.1, I have made an attempt to assimilate these aspects of the listening experience into a plan that works for electronic music. How does the plan in Figure 2.1 translate into actions while listening? Looked at quite simply, it reminds one that there are both objective and subjective aspects to the listening practice. Being able to recognize a sequence in which objective perception feeds the subjective thought process provides awareness that one can call active listening. Following is a breakdown of the process, step by step.

## Active Listening—A Step-by-Step Guide

1 **Trigger.** The sound begins and continues. Objectively listen to the audio signal, recognizing structural elements and the way a work unfolds over time.
2 **Real-time processing.** "Processing" in this context means the way that the human brain assimilates audio content. Objectively identify parameters of the sound using the suggested categories: frequency, amplitude, duration, timbre, and envelope. Recognize major trends and patterns in the sound. Are there pitches that rise slowly? Is the duration broken up with any regularity with beats, or is it continuous? What qualities of the instrumental voices do you hear? Describe these aspects of the music with scientific clarity and notice how these parameters might vary over the course of the work. Do the five parameters appear to be working in unison and with similarity, or do they individually change and contrast? This real-time processing may require several listening passes.

3 **After-effect.** This part of the process represents the subjective analysis of the music. The first two stages represent objective stimuli; this stage represents your mindful reaction. Go with the flow. See which tendency—from the intellectual to the emotional—dominates your response to the sound. One good practice is to find appropriate adjectives to describe your reaction as a piece moves along. Stringing together a series of adjectives corresponding to the changing motions of a work results in a diary of your impressions.

In Figure 2.1, my spectrum of after-effects is organized along a scale of the two extremes: *formalism* at the top and *expressionism* at the bottom. Within this range I find several natural stopping points given the piece of music, the receptiveness of the listener, and the listening environment. These are not intended to be the only possibilities, just a few stops along a range from emotional to intellectual listening. Here is an explanation for each of these:

- **Hypothesis game.** Listening for the rulebook that forms the hypothesis for a work. Does the work orbit around a theory of composition? Is the piece based around the capabilities of a piece of equipment, such as a computer program or controls on a synthesizer? If you find yourself predicting or anticipating what the composer does next, you may be onto the hypothesis game.
- **Psychological insight.** Listening as a predominantly intellectual experience. Does the music trigger thoughts or a psychological response? Does it contain signifiers loaded with meaning? Does it suggest intellectual processes other than the cognitive recognition of audio input and patterns?
- **Emotional response.** Listening that is leaning toward an emotional response, and away from an intellectual response. Does the music primarily evoke an emotional response? Does the music contain familiar and recurring motifs, effects, and sound essences that strike a common chord in your emotional make-up as an individual?
- **Inner listening: imagination.** Listening as a form of concentration and transformation, where cause and effect become elevated to the level of imagination. Do you let the sounds suggest what should happen next, as opposed to recognizing a hypothesis? Are you subsumed by the music intellectually and emotionally? Does the musical experience "drive consciousness forward to new perceptions and perspectives?"[21]

In reality, the listener may blend any or all of these after-effects to whatever degree is suggested by a piece of music, the intellectual or emotional state, or the listening situation. But the point I am trying to make is that you can listen to electronic music with new ears if you find an approach that works for you.

## WHAT TO EXPECT OF LISTENING

Your perspective on listening somewhat depends on your role with the music. You might be listening from the point of view of an electronic music composer in search of new ways of imaginatively putting sounds together. Or, you might be a musician seeking a way to understand a piece that you just volunteered to play at a recital. By far, most of you will be informed listeners of music who want to know how to appreciate electronic music to the fullest. Of course, you may be able to listen from all of these perspectives. The point being that the perspective you choose will affect the way you want to hear electronic music.

The plan for listening that I have just described is adaptable to any listening perspective. Suggested outcomes you can expect to fulfill include:

- **Recognizing and applying the five parameters of sound to any piece of music.** What are the five parameters of sound and how can they be used to understand a work of electronic music?
- **Understanding the context of a work within the history of electronic music and the evolution of technology.** How does available technology influence the work of the composer? Recognizing contrasts and similarities in works from different periods.
- **Communicating with clarity your experience with electronic music.** Whether for a live performance or a recording, one hope for this book is to provide a lexicon of terms and a vocabulary for describing what you hear.

Finding the best words to accurately describe your listening experience is a way to take the listening experience from the realm of pure emotional reaction to a more mindful description of the listening transaction. Having a vocabulary for describing sound and personalizing the experience is one of the great individual pleasures of listening. This chapter has discussed objective and subjective ways to describe what you hear.

Describing sound objectively uses vocabulary that is generally dispassionate and exact. It assigns relative values to sound based on what might be thought of as measurements. For example, in describing the pitch or frequency of sound, you can choose descriptors that have no emotional connection, such as high, medium, low, sliding, repeating, and wavering. Each of these values could be subject to a clearly defined measure. In contrast, an emotional vocabulary might draw upon words that are fuzzy and imply values, such as screeching, squawky, sharp, piercing, pleasing, or sweet. There is a place for each kind of word—the objective and the subjective—in documenting your listening experience. The subjective description of sound naturally follows the objective observations. In practice, this is the stage where you mindfully assimilate the incoming audio and respond on a sliding scale from the intellectual to the emotional.

Finding the words to describe an emotional response to music is also a worthy exercise. While basic reactions are easy to articulate, you might expand your vocabulary to more effectively capture the nuances that music may contain. Furthermore, if we can assume that the expressivity of music affects most listeners in a systematic, consistent way, it should be possible to ascribe a certain set of adjectives to explain the emotional states of music. In fact, this psychological approach was thoroughly mapped-out and tested by music psychologist and scholar Kate Hevner in 1935. In her article, "Experimental Studies of the Elements of Expression in Music," Hevner created the *adjective circle* and contributed much to our ideas about how people react emotionally to music.[22] The adjective circle is of interest to us because it provides a baseline vocabulary for describing music to which one listens. This vocabulary is essentially universal in that it spans the entire spectrum of emotional reactions. Although Hevner was not at all referring to electronic music, her descriptors for emotional reactions to music provide some granularity and nuance that fans of the experimental can appreciate. Her work has been revived in the era of computer-based mood classification for music. Such widely used programs as iTunes, Pandora and Spotify make assumptions about the emotional classification of music that borrow from work such as Hevner's. Figure 2.2 shows Hevner's adjective circle. You can draw upon this list for finding words to describe what you are hearing.

Being an active listener means that you are entirely engaged while listening, both intellectually and emotionally.

6
merry
joyous
gay
happy
cheerful
bright

7
exhilarated
soaring
triumphant
dramatic
passionate
sensational
agitated
exciting
impetuous
restless

5
humorous
playful
whimsical
fanciful
quaint
sprightly
delicate
light
graceful

8
vigorous
robust
emphatic
martial
ponderous
majestic
exalting

4
lyrical
leisurely
satisfying
serene
tranquil
quiet
soothing

1
spiritual
lofty
awe-inspiring
dignified
sacred
solemn
sober
serious

3
dreamy
yielding
tender
sentimental
longing
yearning
pleading
plaintive

2
pathetic
doleful
sad
mournful
tragic
melancholy
frustrated
depressing
gloomy
heavy
dark

*Figure 2.2* Hevner's adjective circle of emotional responses.
*Source*: From *American Journal of Psychology*. Copyright 1936 by the Board of Trustees of the University of Illinois. Used with permission of the University of Illinois Press.

## Creating a Listening Diary for a Work of Electronic Music

Some people make restaurant diaries for the places at which they eat out. In a similar vein, you can make *listening diaries* for the works of electronic music you want to remember. Taking into consideration the listening plan and Hevner's adjective circle, we can examine how this works in practice with an actual recording of electronic music. The following applies this listening approach to the work "Kaze" by Japanese composer Tetsu Inoue: first, I discuss its history, and then some notes I made while listening to the parameters and noting my emotional responses.

"Kaze" was released in 2007 as part of the album *Inland*. It is 7:26 long. Inoue's music has evolved over the years from his long soundscapes of the 1990s to his shorter, glitch-based computer composition of the early 2000s. *Inland* was a blend of ambient and glitch, resulting in short sound etchings combining new sounds with familiar emotional ambience.

I would begin my listening diary with a description of the objective parameters of "Kaze" broken down by each minute as the piece proceeds (see Table 2.1).

The next part of the diary is to assign adjectives to describe how you feel emotionally while listening. I listened a second time to record my impressions for this pass in my listening diary (see Table 2.2). Note that although I only used terms that appear in Hevner's adjective circle, you could easily substitute adjectives of your own. The point being that you are trying to capture your emotional reaction to the piece.

The idea of describing how best to listen to electronic music seems simple enough. Yet it's a truly complex topic with many possible paths. Here, I've provided a solution that might suit your needs. More than anything, it is important to remember what Pauline Oliveros taught us: "Sounds carry intelligence. Ideas, feelings and memories are triggered by sounds."[23] If you can find a way to capture these ideas, feelings, and memories when you hear electronic music, you have discovered the secret to active listening.

***Table 2.1*** **Listening diary for Tetsu Inoue's "Kaze:" Notes on parameters**

| *Time (approx)* | *Notes on parameters* |
|---|---|
| *0:00 to 1:00* | *Volume fades in; steady energy; metallic gong-like sounds dominate; multilayered textures.* |
| *1:00 to 2:00* | *Droning string-like sounds enter; gong-like sounds fade; soft attacks, no sharp sounds; each textured section gradually changes to the next.* |
| *2:00 to 3:00* | *Frequency range slowly drops to low tones; high tones enter for a blend of low and highs; the piece has the rhythm of long breaths; no steady beats.* |
| *3:00 to 4:00* | *A hint of ocean sounds with the low tones; at around the midway point, the range of tones is mixed from low, medium, to high.* |
| *4:00 to 5:00* | *Faster pulsating clouds of sound begin to appear, each with its own clusters of repeating tones, echo, frequency range.* |
| *5:00 to 6:00* | *Pulsations give way to a multilayered soundscape of droning, synthesized tone.* |
| *6:00 to 7:00* | *A return to the steady energy of the opening, but without the gong-like sounds; fade out.* |

***Table 2.2*** **Listening diary for Tetsu Inoue's "Kaze:" Notes on emotions**

| *Time (approx)* | *Notes on emotions* |
|---|---|
| *0:00 to 1:00* | *dreamy—spiritual—bright* |
| *1:00 to 2:00* | *yielding—longing—plaintive* |
| *2:00 to 3:00* | *sober—soaring—restless* |
| *3:00 to 4:00* | *dramatic—serene—yielding* |
| *4:00 to 5:00* | *whimsical—satisfying—excited* |
| *5:00 to 6:00* | *yearning—tender—graceful* |
| *6:00 to 7:00* | *lofty—dreamy—longing* |

## NOTES

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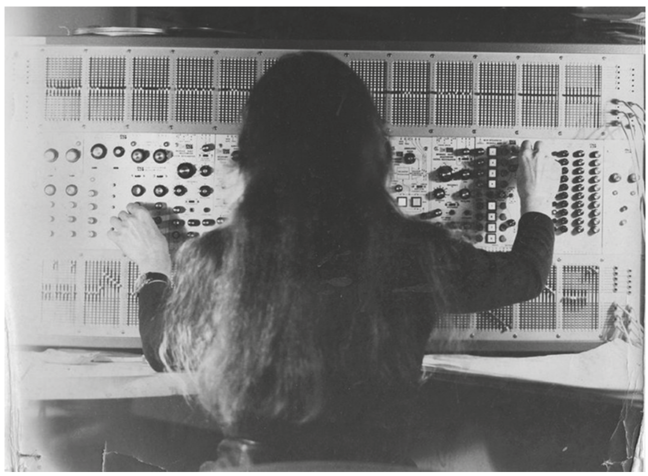
CHAPTER 3

# How Electronic Music is Composed

*"No machine is a wizard, as we are beginning to think, and we must not expect our electronic devices to compose for us."*
—Edgard Varèse[1]





Eliane Radigue at the ARP 2500, Paris, 1971.
*Source:* Arman.

Edgard Varèse reminds us that composing electronic music is partly about knowing which buttons to push and when, and also about engaging in the artistic process of creation. Composing electronic music requires, in most cases, fluency with technology and a familiarity with procedures. This can be said for every era of the discipline, from tape composition to voltage-controlled analog synthesis, and now computer composition.

The medium of electronic music presents its own unique problems for the composer. To this day, there is no standard notation used for the medium. In a field of music where no standardized method exists for notating works, traditionalists still debate the value of electronic music as music at all. Pauline Oliveros wrestled with this perception for most of her career:

> My way of composing is seen either as a substantial contribution to the field or it is dismissed as not real music because it is not written in the conventional way and cannot be judged conventionally. It is dismissed because of a lack of written notes, or because participants are asked to invent pitches and rhythms according to recipes or to respond to metaphors. Musicians accustomed to reading notes and rhythms often are shocked by the bareness of the notation compared to familiar conventional scores which direct their attention to specific pitches and rhythms which to them seem predictable and repeatable. What I value is the more unpredictable and unknowable possibilities that can be activated by not specifying pitches and rhythms. I prefer organic rhythms rather than exclusively metrical rhythms. I prefer full spectrum sound rather than a limited scalar system. I sometimes use meter and scales within this fuller context of sound oriented composition.[2]

In 1985, John Cage told me that his method for making music was always evolving, although one persistent element that never changed was the way in which chance operations influenced the outcome:

> I have found a variety of ways of making music (and I continue to look for others) [. . .] in which sounds are free of a theory as to their relationships. I do not hear music before making it, my purpose being to hear as beautiful something I have not before heard. Most of the ways I have found involve the asking of questions rather than the making of choices, and *I Ching* chance operations pinpoint among all the possible answers the natural ones to be used. [. . .] Though they [the works of music] sometimes take advantage of technological means (recording means, the activation of electronic sound systems, the programming of computer output of actual sounds), or just acoustic means, instruments over which I have no control (a music of contingency). I hear ambient sound as music.[3]

The act of composition is a highly individual one. Like a visual artist, a sculptor, or dancer, the composer forges ahead at their work partly by emotional instinct and partly by intellect and forethought. "The artist is under no obligation to theorize," wrote Gordon

Epperson; "a musician need not be a philosopher of music."[4] Many elements affect the composition of music, among them the emotional, social, cultural, religious, and political. There is no such thing as a "best" way to compose.

Most electronic works do not exist in a notated form at all. A score is of no value to most electronic music composers because the outcome is a recording or performance rather than a transcript of notes to be performed by others. Saying that, it is also true that much thought has been given to ways in which to organize the process of composing electronic music.

## COMPOSITION METHODS

One might broadly group methods of composing electronic music into several categories:

- **Sound crafting.** The composer works directly with the sound material and the most general concept of a structural plan. This method is the most intuitive and least specific approach to planning a piece of electronic music. A graphical representation of the sound, as created by Varèse for *Poème électronique*, might be employed to help the composer organize the work and make macro-level changes to its composition. Sound crafting or *sound montage* is a widely used approach to composing electronic music and had its origins in the first works completed by Pierre Schaeffer in the late 1940s.
- **Graphic or technical (schematic) score** (see Figures 3.1 to 3.4). The composer creates a detailed schematic representation of a work to a degree of specificity that can be faithfully reproduced by others. In this kind of score, non-traditional notation is used to specify frequency, amplitude, duration, timbre, and envelope of the sound. Over the years, many composers of electronic music have invented their own systems for schematically documenting their scores. Figure 3.1 is an example of a graphic score. Stockhausen's detailed graphical specifications for *Studie I* and *Studie II* left no stone unturned, providing all of the required parameters needed to create the work using any sine wave generator. For *Studie II*, Stockhausen developed a graphical score using geometric shapes representing the pitch and dynamic components of the sine waves used to create the piece. In this case, specific pitches and dynamics were determined with such precision that an accurate reproduction is possible using other media. One such faithful realization of *Studie II* was completed 52 years after the original in 2006 by German composer Georg Hajdu using the graphical programming language Max/MSP for laptop computer. In other examples, the work *Game* (1975) by Carl Michaelson was written for two flutes and ring modulator; the flutists perform notes prescribed using a conventional score and their output is modulated using a ring modulator with settings noted by the composer. Pierre Henry's schematic score for *Antiphonie* (1952) provided specific measurements for the duration and envelope of given sounds, although the sound sources themselves could vary (see Figure 3.2).

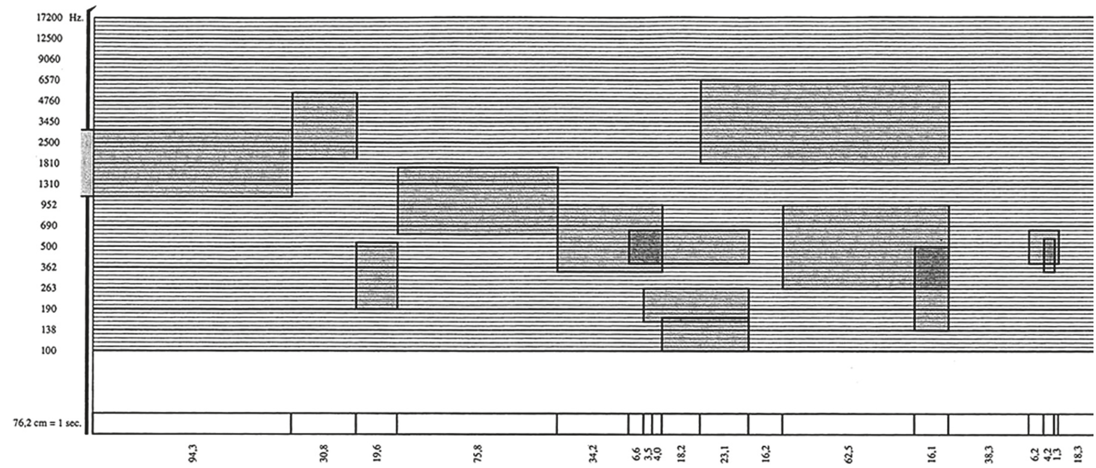



*Figure 3.1* Graphical score: close view of *Studie II* (1954) by Stockhausen visually depicting specifications for the amplitude, duration, and frequency of sine waves used in the piece.
*Source:* Stockhausen Verlag.

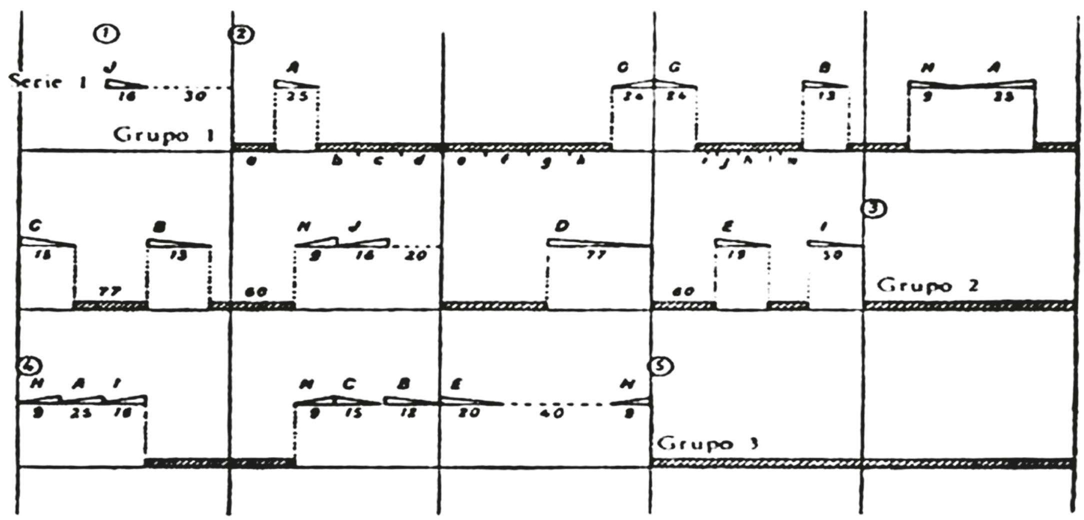



*Figure 3.2* Score for *Antiphonie* (1952) by Pierre Henry.

- **Electronics with other instruments** (see Figures 3.5 and 3.6). Electronic sounds, either pre-recorded or performed live, can be combined with music played by classical instrumentalists. This was an early approach developed by Luening and Ussachevsky at Columbia University and continues to be developed. In such a work, a score is generally provided for the instrumentalist that specifies some concurrent activity generated electronically. An example that combined magnetic tape with instrumentalists is *Synchronisms No. 6 for Piano and Electric Sounds* (1970) by Mario Davidovsky, in which

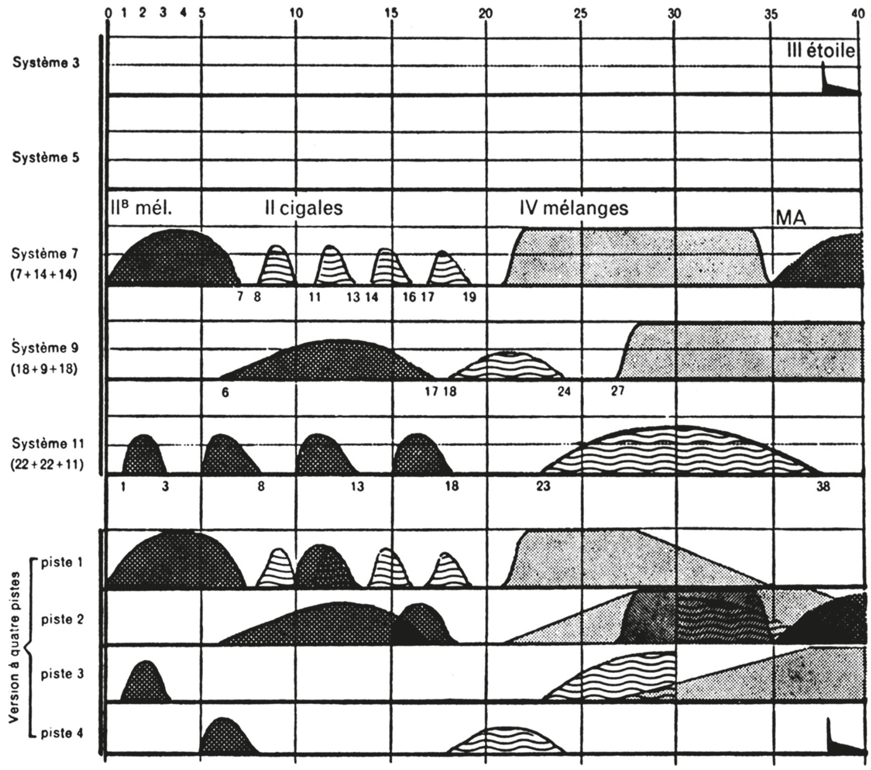



*Figure 3.3* Example technical score with graphical elements: *Eclipses musique électronique pour quatre colonnes sonores* (1964), for four-track tape, by Swiss composer Werner Kaegi.

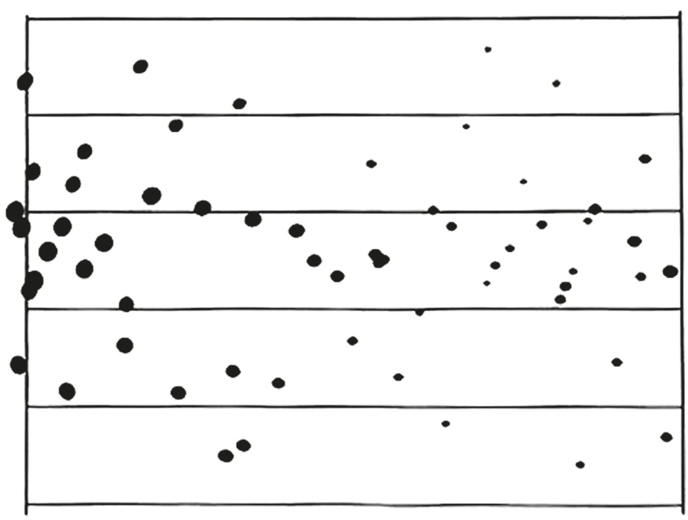


*Figure 3.4* Example of graphical score: *Transicion I* (1959) by Mauricio Kagel.

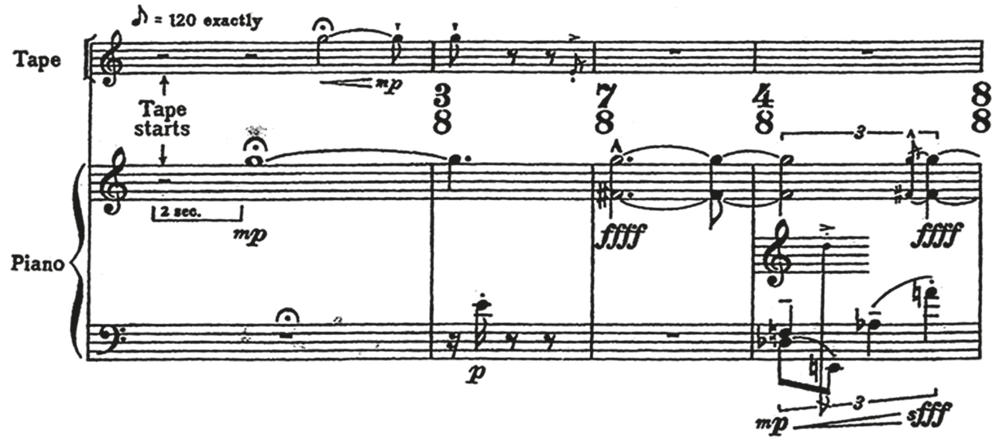



*Figure 3.5* Example of score for electronic tape and instruments: excerpt from *Synchronisms No. 6* (1970) for piano and electric sounds on tape by Mario Davidovsky.
*Source:* E.B. Marks Music Corp.

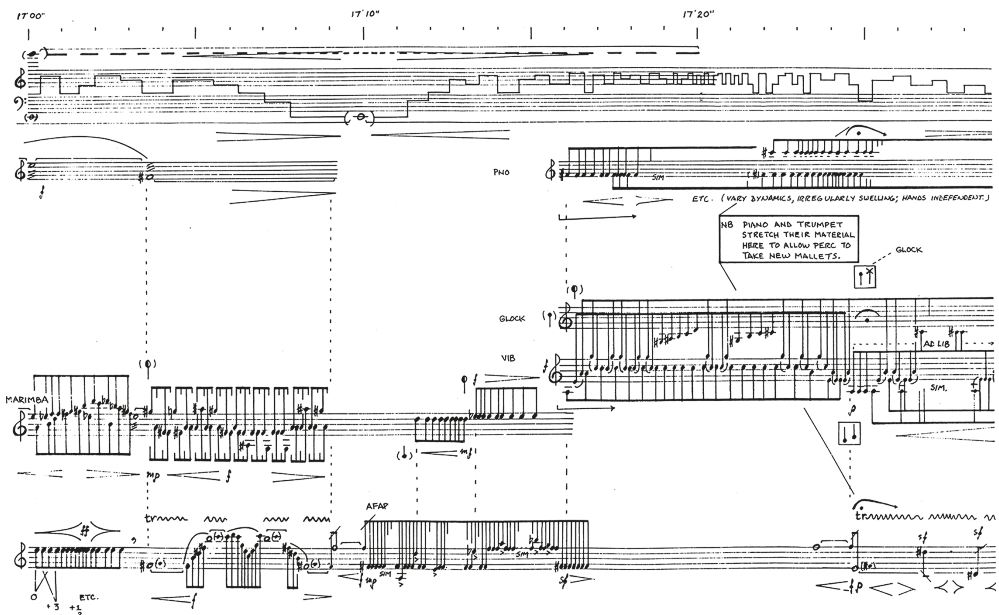



*Figure 3.6* Example of score for electronic tape and other instruments: excerpt from *. . . the serpent snapping eye* (1978) for trumpet, percussion, piano, and computer synthesized tape by Roger Reynolds.
*Source:* C.F. Peters Music Corp.

instructions are provided on the musical score for starting and stopping a pre-recorded tape (see Figure 3.5). Another example, specifying pitches and timings for electronically generated sounds on tape, can be seen in Figure 3.6, an excerpt from an innovative score by Roger Reynolds *(b. 1934)*. The piece *Superior Seven* (1988) by Robert Ashley, for solo flute and MIDI orchestra (1988), provides written music for a flute player and pianist, and audible cues that trigger the engagement of MIDI instrumental functions controlled by a participating electronic musician.

- **Instructional composition.** Some electronic works are realized by following written instructions that are not specific to any particular sound source, but provide a detailed framework for completing the work. Cage's *Williams Mix* provided detailed instructions for the editing and assembling pieces of magnetic tape. Any realization of that work would utilize the same tape editing techniques and durations specified by Cage, even though the sources of sounds could vary from realization to realization. At the other end of the instructional spectrum are works for which only the most general of instructions are provided. Annea Lockwood's *From the River Archive* (1973) instructs the performer as follows:

> Find a brook or fast flowing river in as isolated a place as you can reach. Placing the microphone(s) near the surface at a spot where the water is creating a richly textured sound, make a tape recording at least a half-hour long. Note the name of the river, the place and date.
>
> Play the tape back on a cassette recorder, in some public place, for one person at a time (using headphones). Turn the listener's head very gently from side to side, tilted toward one shoulder, then toward the other as he or she is listening. Suggest that the listener closes his or her eyes to listen. Tell each other personal experiences with rivers/brooks/etc.; dreams involving them; memories.[5]

- **Computer methods.** Algorithmic and generative methods of composing electronic music, widely used today, offer distinct advantages in the organization of electronic sound and the creation of complex audio output. These methods are explored in depth later in this chapter.

There are some examples of electronic music works that have crossed the boundaries once placed by technology. Computers have allowed composers to adapt and realize works that were once intended for analog technologies. *I Am Sitting in a Room* (1969) by Alvin Lucier *(b. 1931)* was an experiment in the degenerative effects of recording and re-recording the same sound using a microphone and two tape recorders. The basic sound material was a written text passage provided by the composer. The instructions consisted of the procedural steps needed to record and re-record the sound "through many generations" and instructions for splicing them together in chronological order to "make a tape composition the length of which is determined by the length of the original statement and the number of generations recorded."[6] But even such a seemingly straightforward set of instructions will have widely varying results depending on the acoustical properties of the room in which the piece is recorded, the fidelity of the tape recording equipment, and the number of generations of the passage recorded. Originally intended as a recorded tape piece, a live, real-time realization was performed in 2000 by Christopher Burns using a program called Pure Data (Pd) for the creation of interactive computer music. In his interpretation, Burns chose not to fix the duration of the performance ahead of time because he was "unsure of how quickly the process would unfold when the intended performance space was filled with an audience."[7]

LISTEN

## VINTAGE EXPERIMENTAL ELECTRONIC MUSIC

1 *Antiphonie (1953) by Pierre Henry*
Early serial tape composition

2 *Poème électronique* (1958) by Edgard Varèse
Classic tape composition using montage

3 *Concret PH* (1958) by Iannis Xenakis
Modified and amplified small sounds

4 *Sound Patterns* (1961) by Pauline Oliveros
Voices and electronic modification on tape

5 *White Cockatoo* (1966) by İlhan Mimaroğlu
Tape composition using abstract sounds applied to sonata form

6 *Telemusik* (1966) by Karlheinz Stockhausen
Tape composition using world music recordings; also a component for live performance

7 *Hymnen* (1966–67) by Karlheinz Stockhausen
Classic tape composition

8 *Rainforest IV* (1973) by David Tudor
Sound objects, transducers, and contact microphones

9 *Points* (1973–74) by Ruth Anderson
Synthesis using sine tones

10 *Adnos I–III* (1973–80) by Eliane Radigue
*Minimalist drone music for synthesizer*

## CONTEMPORARY PRACTICES IN COMPOSING ELECTRONIC MUSIC

Technology poses a unique challenge to the composer who may find it difficult to separate the acts of conceiving and writing music from analyzing and processing sound, recording, sampling, synthesizing, performing, and even networking music. It is all too

*Figure 3.7* Vicky Chow performs *Surface Image* by Tristan Perich for piano and 40 loudspeakers playing 1-bit synthesis. Roulette, New York City, 2013. *Source:* Doron Sadja.

easy to put the technology first and then try to make a piece out of it. Composer Steve Reich says, with great clarity, "You want to use technology because you have a musical idea."[8] Without the idea, the odds are against making a piece of music that is worthwhile. This section focuses on how computers are being used to aid the composing process. In the examples given here, the computer is integral to the conception, composition, organization, and presentation of the music.

## Conceptual Foundations in Electronic Music Composition

Stockhausen has told a story about one of his earliest experiences composing when, as a teen at a music conservatory in Cologne, he was given a composition exercise.

> [At the time] I had not thought of ever becoming a composer. I showed it to my teacher: it was two measures of a great many notes in a small amount of time. And he said, who is going to hear that? Who can hear these notes? You don't control what you are writing. You see, what's the point in writing notes if people can't hear them? I said, oh well, I don't want you to count them. He said, well, what do you mean? Look at all these notes here. I said, I want this: frrp! He said, well just put one note; be precise, it's better.[9]

What Stockhausen was hearing in his head was not practical to score. Soon after this incident, he discovered that tape composition using electronic tones could produce that sound. But he needed to invent his own scoring conventions to plan and execute such works using oscillator tones, audio filters, and tape effects.

## Scaling Composition to the Technology

The paper score is a product of past music. It denies music that is beyond what is visible on the "first tier"[10] of composition. Conventional music is composed on a musical staff with bars, measures, and a host of markings to denote the desired elements of sound over time: notes, voices, rhythms, organization, and other dynamics. Many twentieth-century composers stretched the bounds of music by adapting new methods for the paper score including radical new rhythms, structures, textures, tonal systems, and scales of time. But the emergence of electronic music during the late 1940s pushed the limits of what they were able to do with a score. The *first tier* of traditional compositional practices was no longer adequate when composers became able to dabble with the microstructure of every musical element, from tones and noises, to beats and the broad manipulation of time and timbral spectra of music.

Electronic music adds at least two more tiers of audio processing fidelity and control to the hierarchy of compositional practices. The *second tier* is analog composition, using electroacoustic sound devices and the material properties of vinyl discs and magnetic tape. The *third tier* is that of contemporary computer composition, the subject of this section (see Figure 3.8).

Significant advancements have occurred within the third tier of compositional practices since the early years of mainframe computer music experiments. Once upon a time, the human–machine interface for programming a computer was limited to mechanical inputs and huge time lags in processing the information. That process was mostly about the machine. Because today's computers are affordable to anyone and process information swiftly in real time, the experience of composing music using computers has entered the world of tangible, interactive human experience. Today's computer music process is more about the human experience of music than about the machine.[11]

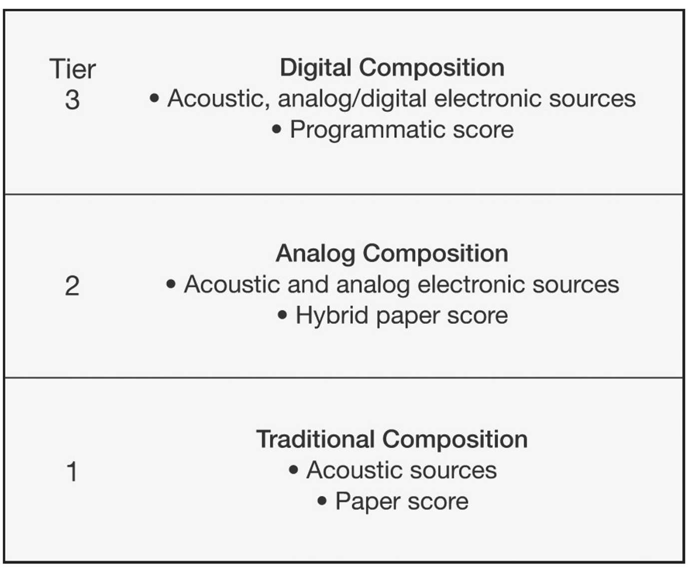



*Figure 3.8* Three tiers of music composition.

## Xenakis: A Framework for Composing

Among the composers who foresaw most clearly the application of the computer as a compositional tool was Iannis Xenakis. He explored the use of mathematical procedures in composition in the late 1950s and extended this interest to computer applications of music. In 1962, Xenakis was composing stochastic works for acoustic instruments using an IBM mainframe (e.g., *ST/48 – 1,240 162 for orchestra of 48 instruments*, *ST/10 – 1,080 262 for string quartet*, *Morisma–Amorsima (ST/4 – 1,030 762) for 10 instruments*). In 1972, he completed the electroacoustic piece *Polytope de Cluny* for which the musical calculations were derived from a stochastic computer algorithm and the data output converted to analog electromagnetic sound signals on tape. He is credited with introducing the term **microsound**[12] to the vernacular of electronic music as early as 1971, a concept that Curtis Roads has painstakingly explored as the basis for that branch of electronic music centered on the practice of granular synthesis. By 1996, Xenakis had witnessed several generations of computer-aided composition as information technology, from mainframes to laptops, evolved. Writing at that time, he categorized the broad palette of programmable compositional options drawing from his experience with computers:

- repetition and variation;
- ordered structures;
- symmetry;
- multidimensional space (where an individual "point" of sound is represented by the intersection of all of the dimensional elements of a sound, e.g., time, pitch, dynamics, disorder, density).[13]

These categories of composing choices are significant not only because they are broadly platform-independent, but also because of what they *do not* include. There was no mention of MIDI and no requirement to employ specific programs or instruments, even though Xenakis was familiar with many. His view was compositionally and instrumentally agnostic. Instead of detailing the traditional elements of music, such as pitch, timbre, duration, envelope, and tempo, he grouped them all into the category of "multi-dimensional space"—his "sandwich" of simultaneous sound elements, as he liked to describe it:

> Music is like a multiple sandwich, but a transparent one [. . .] Whilst in the middle of it, one can see at the same time lower or higher levels everywhere.[14]

Xenakis's other elements were fittingly organizational, describing the ways in which one composes the form and structure of a piece, all of which is made easier by the computer. Though generalized, these characteristics provide a broad conceptual framework for any composition situation involving a computer.

I focus on what Xenakis thought because his set of options proves to be an excellent starting point for any composer of electronic music. From this foundation, it is easy to leap to the next level of detail embodied by a variety of common practices in composing today. Those who have developed contemporary software solutions for composing music, using programming languages such as Max, have often been inspired by the work of Xenakis.[15] The compositional characteristics he described remain entirely pertinent today in the use of computers to organize, manage, and synthesize music.

## Approaches to Composition using Computers

Computers and software fill several possible roles for the composer, including composition, scoring, synthesis, audio analysis, processing, sampling, and networking with other devices. Computational thinking has always been a component of the composer's method, no matter what the era, style, or genre of music.[16] What separates the composition of electronic music from traditional instrumental music is the added dimension of discovering the hidden life of sounds. In electronic music, one has the opportunity not only to compose but also to pioneer new audio experiences. While the computer is a reliable number-crunching machine for processing musical data, it is also a dependable partner in the planning and the performance of a piece of music.

The composer may choose to work with ready-made, off-the-shelf software for producing music (such as Reason, Ableton), or the virtual analog synthesizers from many companies such as Arturia. These offer excellent solutions for composers most interested in creating conventionally scored music. But composers interested in experimenting with new sounds, structures, and ways of managing them usually turn to coding in a music programming language. Using these programming languages requires a higher degree of technical know-how. Although becoming a programmer may not be the first thing one associates with composing music, learning to code in a music environment opens many new doors. Some of the programs used for this purpose are Max, SuperCollider, Pd, Csound, athenaCL, ChucK, and Plogue Bidule. Max is a good example of a widely used music-compiler program built around a graphical interface and a block diagram structure that allows a composer to design instruments as objects on the computer screen. Using this interface, the composer can create connecting paths on the screen to organize objects and design a piece without having to repetitively program every underlying command represented by the objects.

## General Terms and Concepts in Computer Composition

An **algorithm** is a procedure that can be written in a programming language as a set of instructions for a computer. In addition to instructions for the execution of tasks, algorithms are a component of decision-making processes. A traditional use of computer algorithms is to solve problems. Overall, such programmatic instructions and problem-solving requirements can take advantage of the three general ways in which algorithms can be applied: for organizing data; for calculating numeric data solutions; and for the manipulation of data structures. In the context of music you can generally see how widely a computer may be applied to the process of composition when the term "data" is substituted with "music." Algorithms serve many functions when it comes to music, from ordering sound sequences, detecting and responding to sound input, triggering the synthesis and processing of sounds, or even introducing random data factors divorced from human interaction. What is most important to remember, however, is that behind every algorithm is a composer's idea or paradigm upon which the parameters of a piece will be constructed. It is not only about the computer. According to computer scientist Terry Winograd,

> The machine must be thought of as a mechanism with which we interact [. . .] not a mathematical abstraction which can be fully characterized in terms of its results.[17]

Sometimes the computer coordinates the behavior of human performers, and sometimes it is manipulated by a person in real time; or the computer may make decisions based on human input in a way that effectively joins the individual with the computer as a composing partner.

Electronic music produced with the aid of a computer may engage a wide range of algorithmic approaches, from **stochastic** ("random") to **deterministic** ("prescribed") choices and any point on the continuum between these two extremes. There is no such thing as a purely random choice, of course, because the composer makes choices throughout the process as regards the way in which an algorithm will work. So, even when an algorithm requires nothing more than to be set into motion to batch process an entire piece, the outcome is still the product of the composer who drafted the procedure.

**Algorithmic composition** is the creation of a set of computer instructions for composing music. This practice is by no means restricted to the use of a computer. Important precedents arose long before the computing age. Rhythms and patterns of repetition inherently lend themselves to algorithmic considerations, as do tones, durations, and any dynamic element of music that can be represented by a number value. Algorithmic composition without the use of a computer was perfected during the twentieth century in the Western preoccupation with 12-tone systems and serialism, each an approach mathematically guided in the selection of pitches, duration, rhythm, timbre, and structure of a work. Cage's introduction of chance operations to apply randomness to the selection of musical elements could be viewed as an algorithmic approach, and this, too, was done by flipping coins or tossing yarrow sticks before Cage had access to computers. Hiller, Xenakis, Brün, Babbitt, Tenney, and Koenig were some of the first composers of electronic music to gravitate toward computational solutions to automate and exploit the potential of algorithmic compositional procedures.

One of the main advantages of using computers in this way is the speed and accuracy with which calculations can be made. This makes a trial-and-error approach to testing an algorithm entirely practical. A composer using algorithmic composition techniques can work recursively, beginning with an initial set of programmed instructions, then revising and testing them repeatedly until they meet the desired outcome.

Algorithmic composition has, over time, come to mean virtually any music composed in part using a music programming language, whether fully automated and self-running (batched), edited in real time during a performance, or used interactively with other musical instruments and performers. Broadly speaking, musical algorithmic functions may be used to:

- synthesize sound;
- produce whole compositional structures;
- produce smaller parts of a composition that are then manually integrated;
- create guidelines, contexts, or situations for human music making, for example algorithmically derived composition for instrumentalists.[18]

In addition to generating individual sounds, algorithms can be used to mix sounds, retrieve and edit sounds, detect pitches, set in motion a sequence of audio processing steps in real time, and almost anything you can imagine in the way of shaping, making, organizing, and manipulating sound and sound files.

Composers often turn to non-musical statistics, equations, and programmatic structures as a source of content for their algorithmic compositions. Such **data modeling** algorithms borrow directly from mathematical phenomena (e.g., the Fibonacci series), systems (e.g., Markov chains, cellular biology), and functions (e.g., Gaussian functions) and have been widely adapted to musical applications. Genetic algorithms use a structure that mimics the process of biological evolution. Linguistic programs replicating the structure of language have been translated into musical grammars that follow similar procedural rules. A composer can conceivably adopt mathematical content from any discipline for musical purposes. Another intriguing case in point is the field of **data sonification**; the process of representing information through music. At the high end of the computing scale are sonification programs such as the Digital Instrument for Additive Sound Synthesis (DIASS) from the University of Illinois at Urbana-Champaign, running in C code in a distributed computing environment. This program is used to translate scientific data into sounds, and was conceived as a composer's tool.

A subdiscipline within algorithmic composition is **generative music**. A generative music system is, essentially, a self-running algorithm that, once initiated, creates the musical outcome unattended or with some managed degree of human interaction. This approach is conceptually similar to process music, as described earlier, in the context of the analog technologies of tape loops and delays. In the context of computer science, a generative program will take advantage of the *recursive* nature of programming:

> [. . .] the possibility of defining an infinite set of objects by a finite statement, [wherein] an infinite number of computations can be described by a finite recursive program, even if this program contains no explicit repetitions.[19]

The academic pursuit of generative music methods was pioneered by a number of computer musicians, including Curtis Roads (1975), Steven Holtzman (1980), and Kevin Jones (1981), who applied phrase-structure grammars from language studies to composition.[20] Using this approach, a program can be written to include a set number of defined musical structures (building blocks) that can then be combined using endless permutations. Outside of academia, composer and producer Brian Eno is probably the best-known practitioner of this approach and is credited with having coined the term "generative music." Eno is well suited as a spokesperson for this method because his experience bridges the gap between analog process music (*Discreet Music*, done with tape delay) and self-generating computer music systems. Eno composed a series of "ambient" recordings beginning with *Ambient 1: Music for Airports* (1978) that were constructed primarily by mixing and remixing tape loops. The recorded loops were the building blocks—or grammars—of this music. In the 1990s, Eno began working with program developers on computer systems for creating generative music, one of the first of which was *Koan* (1990–96) developed by Peter and Tim Cole. In 2008, Eno collaborated with developer Peter Chilvers on *Bloom*, a generative music application for the Apple iPhone and, later, the iPad. The program can self-generate ambient-style soundscapes or the user may interact with it by touching the screen. In Eno's view, a generative music program is one that "specifies a set of rules and then lets them make the thing."[21] Generative music typically has a different outcome each time it is executed. The composer's role is to define the rules that create the music. Being self-generating, this style of algorithmic composition is frequently used for unattended music installations.

The use of algorithmic composition and computer synthesis in live performances has grown exponentially since about 2000 with the advent of more affordable, portable computer technology. This has led to the practice of **live-coding**, another subdiscipline within algorithmic programming. Live-coding, or on-the-fly programming, generally involves interaction with a computer programming environment during a performance, to adjust such elements as the direction of a piece, the interaction of a computer with other performers (e.g., musicians or dancers), the spatial projection of sound, and the timing and triggering of possible musical events. For the most part, live-coding does not refer to the use of off-the-shelf performance applications such as Ableton Live or Reason, but to graphical programming tools such as Max or interactive music scripting languages available through music programs such as Perl, Ruby, SuperCollider, and ChucK. In general practice, composers develop sections of code or patches ahead of time and test them prior to live performance. Live-coding adds versatility to performances and may be the basis for improvisational music in which the modification of code in real time becomes an aspect of the performance. There is a passionate community involved in live-coding, including the UK-based organization TOPLAP, the Transnational Organisation for the Proliferation of Live Artistic Programming, founded in 2004. TOPLAP has its own informal manifesto of guidelines and it sponsors conferences and live jamming events throughout the year. Pioneering live-coding composer–performers that started working before 2005 (and are still active) include Perry Cook (*b. 1955,* United States), Fabrice Mogini (*b. 1965,* France), Julian Rohrhuber (*b. 1973,* Germany), Nick Collins (*b. 1975,* United Kingdom), and Ananya Misra (United States).

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## CONTEMPORARY EXPERIMENTAL ELECTRONIC MUSIC USING COMPUTERS

1. *Kash (2001)* by Matt Rogalsky
   Generative and interactive music
2. *Thirty-Seven Farewells* (2012) by Stephan Moore
   Generative composition
3. *SOTO* (2014) by Asha Tamirisa and Caroline Park
   Generative work for live performance
4. *OCTAVLUV* (2014) by Caroline Park
   Generative composition
5. *Surface Image* (2013) by Tristan Perich
   Solo piano and 40-channel, 1-bit electronics
6. *Cut and Clicks* (2000) by Tetsu Inoue
   Computer composition for digital sound fragments
7. *Bubble Chamber* (2017) by Curtis Roads
   Computer-generated sound
8. *So Long* (2018) by OG Lullabies
   Computer-generated sound and instruments
9. *Plastic Snakes* (2018) by Dismaze (w. Akemi Fujimori)
   Computer synthesis
10. *Avenoir* (2017) by Ramsha
    Computer synthesis

## *Artikulation*—The Story of a Composition

György Ligeti *(1923–2006)* was born in Transylvania, Romania, to Jewish parents. During World War II, he survived a forced labor camp but lost his brother and father to the Holocaust. Living in Hungary after the war, he completed his studies and became an instructor in music theory. But once again his life was disrupted when the Soviet Union violently struck down the Hungarian revolution for independence in 1956 and became an occupying force. Ligeti and many other artists fled the country. He went to Austria and eventually became an Austrian citizen. This displaced composer found sympathetic artists in Cologne, where he began composing avant-garde instrumental compositions.

In 1957, an encounter with Karlheinz Stockhausen and Gottfried Michael Koenig of the electronic music studio of West German Radio would change his approach to writing music forever. Ligeti became immersed in the physical analysis of sound and its application in shaping the sound of musical works. Although Ligeti only completed three short works of electronic music before returning to instrumental composition—*Glissandi* (1957), *Pièce électronique* (unfinished, 1958), and *Artikulation* (1958)—it seems clear that he could not have conceived some of his later works had he not learned the techniques of composing with slowly modulating textures and timbres that came with producing tape music. Each of his best-known instrumental works, *Atmosphères* (1961) for orchestra and *Lux Aeterna* (1966) for 16 voices, was a highly textural piece that one can imagine being produced electronically. In fact, when heard today, the sweeping, microtonal harmonies of these works have more in common with modern spectral composing than any conventions in use in the 1960s.

Ligeti's best-known electronic work is *Artikulation*. He composed this piece for tape in early 1958 under the tutorship of engineer and composer Koenig and British composer Cornelius Cardew *(1936–81),* who was Stockhausen's assistant at the time. In composing *Artikulation*, Ligeti took a path that diverged from Stockhausen's serial approach, in which every minute detail was managed by an overall schema. Instead, Ligeti combined chance operations in the selection of specific sound passages while maintaining a general plan for the overall structure of the work.[22]

Ligeti planned the work and collected recorded sounds during January and February of 1958 and assembled the tape piece during February and March. It was premiered on the radio in Cologne on March 25 of the same year. The work was an extension of Ligeti's interest in phonetics at the time, specifically the spectral properties of noise in vocal sounds and the nature of phonemes in spoken words and phrases. *Artikulation* was conceived as a work that would be composed of artificial speech: electronic sounds imitating the spectral properties and dynamic characteristics of the spoken word. Taking this approach he hoped to establish "conditions of aggregation," beginning with individual categories of sounds and gradually combining and recombining them in mixtures, or articulations, of artificial phonemes, words, and sentences. He described his plan of attack in this way:

> First I chose types with various group-characteristics and various types of internal organization, as: grainy, friable, fibrous, slimy, sticky and compact materials. An investigation of the relative permeability of these characters indicated which could be mixed and which resisted mixture.[23]

Ligeti electronically created a collection of artificial phonemes in the studio and then categorized them into 42 types of basic materials. Some of the sounds were longer than others. Because he did not want any category of sound to dominate the piece, he devised a formula to determine how much of a given sound could be used so as not to favor those that were longer. His notes for the piece included tables spelling out the durations and number of instances for each of the 42 categories of sound materials. These tables provided values for cutting up the magnetic tape recordings into small pieces matching the prescribed lengths. Ligeti then placed snippets of sounds with similar sonic characteristics into separate bins. The process of assembling the work proceeded in five successive stages during which he blindly selected bits of tape from

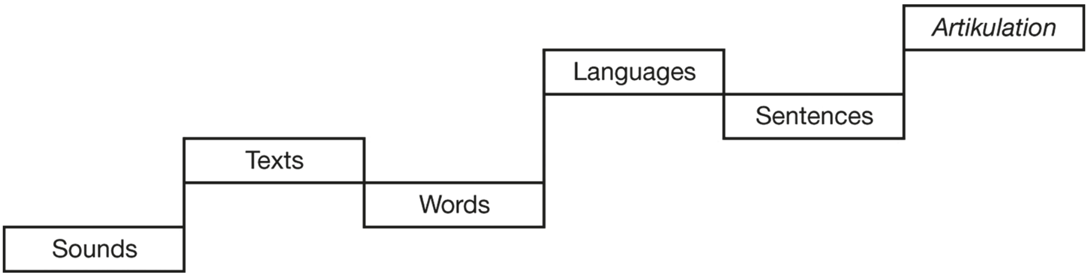


*Figure 3.9* Ligeti's staged process for composing the tape piece *Artikulation*.

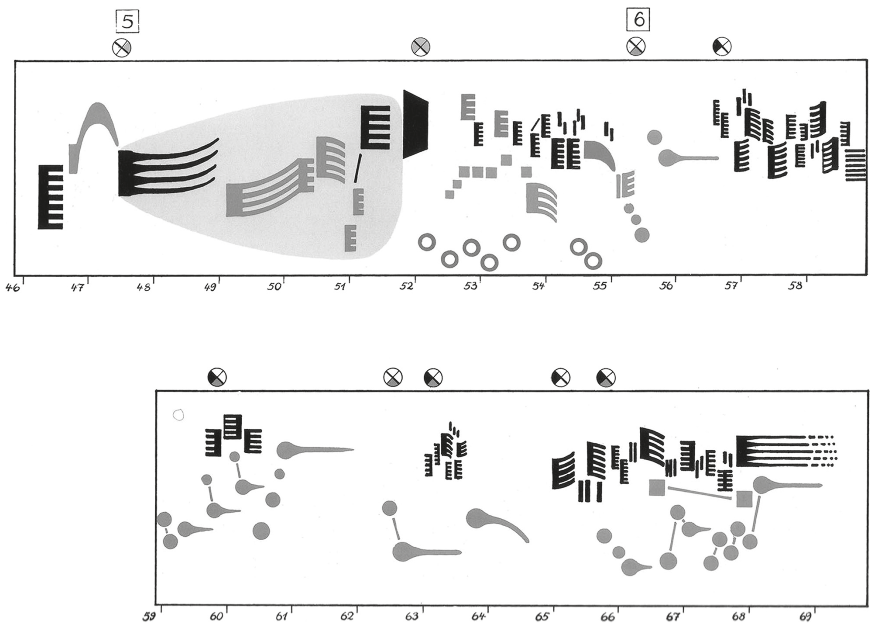


*Figure 3.10* Rainer Wehinger's "score for listening" for Ligeti's tape piece *Artikulation*, a small section of which is shown here, provides the listener with a visual roadmap of the piece. This aural score contains a key to various symbols used in the graphic to depict pitch ranges and other dynamics of the tape sound. *Source:* Schott Music, 1970.

the bins, edited them together into longer pieces of tape, and divided them up again by cutting them in half. The shortest snippets, which he called "sounds," were spliced together to become longer segments called "texts," which, after being divided in half, became "words," and so forth. Figure 3.9 illustrates Ligeti's staged process for composing *Artikulation*. At each step of the process, some of the sounds would be further modified through studio techniques such as filtering and reverberation. The completed piece was intended to be heard using four channels, two in front of the listener and two in the rear.

Ligeti's notes and tables for producing *Artikulation* resemble the elements of a technical score, but they are not complete enough for any other person to reproduce the work from scratch. An idea related to the technical or schematic score is the **listening score** (see Figure 3.10), a visual aid to the listener for studying the structure and form of a piece of music. Interestingly, in 1970, music educator Rainer Wehinger of the Academy of Music in Stuttgart created a "score for listening" (*hörpartitur*) for *Artikulation*, a section of which is shown in Figure 3.10. Wehinger's aural score attempted to provide the listener with a visual roadmap of the piece, and used graphic symbols to represent a variety of sound parameters, from pitch range and filtered noise, to subharmonic waves and pulses. The aural score included a time scale along the bottom so that one could follow along while listening to the recording. The artistic value in visualizing this work of electronic music is plain to see, but it becomes even more vivid when one follows along to any of several available YouTube videos that track the score while listening to the work.

## NOTES

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12 Iannis Xenakis, *Formalized Music: Thought and Mathematics in Composition* (Bloomington: Indiana University Press, 1971), Chapter 9.
13 Iannis Xenakis, "Determinacy and Indeterminacy," *Organised Sound,* 1:3 (1996), p.143–55.
14 Ibid., p.146.
15 There are many examples of Xenakis's influence in contemporary programs, such as: Spencer Russell, "gendy~ PD + Max/MSP object and libgendy 0.6.0 released!" (http://ssfrr.com/2010/05/17/gendy-pd-maxmsp-object-and-libgendy-0–6–0–released/); Sergio Luque, "Stochastic