The Cambridge Companion to Electronic Music

Musicians are always quick to adopt and explore new technologies. The fast-paced changes wrought by electrification, from the microphone via the analogue synthesiser to the laptop computer, have led to a wide diversity of new musical styles and techniques. Electronic music has grown to a broad field of investigation, taking in historical movements such as musique concrète and elektronische musik, and contemporary trends such as electronic dance music and electronica. A fascinating array of composers and inventors have contributed to a diverse set of technologies, practices and music. This book brings together some novel threads through this scene, from the viewpoint of researchers at the forefront of the sonic explorations empowered by electronic technology. The chapters provide accessible and insightful overviews of core topic areas and uncover some hitherto less publicised corners of worldwide movements. Recent areas of intense activity such as audiovisuals, live electronic music, interactivity and network music are actively promoted.
The Cambridge Companion to

Electronic Music

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Nick Collins and Julio d'Escriván
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Nicholas Collins studied composition with Alvin Lucier, worked for many years with David Tudor, and has collaborated with soloists and ensembles around the world. He lived most of the 1990s in Europe, where he was Visiting Artistic Director of Stichting STEIM (Amsterdam), and a DAAD composer-in-residence in Berlin. He is a Professor in the Department of Sound at the School of the Art Institute of Chicago, and Editor-in-Chief of the Leonardo Music Journal. Recent recordings are available on PlateLunch, Periplum and Apestaartje. His book, Handmade Electronic Music – The Art of Hardware Hacking, was published by Routledge in 2006.

Julio d’Escriván is a composer who uses music technology, both for concert music, and in its applications to the moving image. He has twice won prizes at the International Electroacoustic Music Competition of Bourges, France. His electroacoustic music has been recorded, broadcast and performed in Europe and the Americas. He has worked extensively in music for TV advertising, documentaries and film with
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**Sergi Jordà** (1961), digital luthier (*FMOL*, *reacTable* . . .) and improviser, likes to invent new digital musical instruments without forgetting to make music with them. His music has been released on various labels and compilations (Hazard Records, SGAE, MIT Press . . .), he has composed for different instrumental setups (including a brass band) and for films, but he prefers the immediacy and volatility of free improvisation. During the 1990s, he worked extensively in performances and installations in collaboration with other artists (La Fura dels Baus, Marcel.Lli Antúnez . . .). He holds a Ph.D. in digital communication and is a researcher of the Music Technology Group of the Pompeu Fabra University, where he teaches computer music, audio programming, HCI and interactive media arts. He has written many articles and two books, and has given workshops, lectured and performed through Europe, Asia and America.

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Ge Wang received his B.Sc. in computer science from Duke University in 2000 and is a Ph.D. candidate studying with Perry Cook in Computer Science at Princeton University. Ge conducts research in computer music languages, interactive systems for sound synthesis/analysis and musical composition/performance, visualisation of sound, interface design, new performance ensembles (e.g. the Princeton Laptop Orchestra), live coding, and methodologies for education in computer science, computer music, and new media. Ge also composes and performs via various electroacoustic and computer-mediated means.
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Chronology

569–475 BC Pythagoras leads the elitist *mathematikoi* and *akousmatikoi*
1026 Guido d’Arezzo’s vowel-to-pitch mapping procedure for composing melodies for texts
1626 Francis Bacon describes the ‘sound-house’ in *The New Atlantis*
1734 Louis Bertrand Castel builds a prototype *clavecin oculaire*, the first light organ
1738 Jacques de Vaucanson’s flautist automaton is exhibited
1757 Johann Philipp Kirnberger’s *Allezeit fertiger Polonoiien und Menuettencomponist* (‘The always ready Polonaise and Menuet Composer’), a musical dice game
1761 Jean-Baptiste Delaborde builds the *Clavein Electrique* in Paris
1843 Lady Lovelace describes the possible musical applications for Charles Babbage’s machine in *The Sketch of the Analytical Engine*
A. Seebeck formulates the rate theory which states that neural firing patterns encode the periodic structure of auditory stimuli
1857 Leon Scott invents the *phonograph*
1864 Innocenzo Manzetti invents a ‘speaking telegraph’ for his musical automaton
1876 Alexander Bell’s (controversial) telephone patent
Thomas Edison invents the carbon microphone
1877 Co-invention by Charles Cros and Thomas Edison of the phonograph
Ernst Werner von Siemens invents the loudspeaker
1898 Valdemar Poulsen patents a magnetic *Telegraphone*, which can both record and play back sound
1899 William Duddell invents the *Singing Arc*
1897 Thaddeus Cahill patents the *Art of and Apparatus for Generating and Distributing Music Electronically*
1906 Cahill finally builds the Telharmonium
Lee De Forest invents the triode vacuum tube (which he calls the *Audion*), allowing controlled amplification; ironically, Cahill could have used this invention to make the Telharmonium much smaller!
1909 The Tel-musici Company combine a telephone exchange with a music room; they are bankrupt within a few years, just like Cahill
1913 Luigi Russolo writes his manifesto *The Art of Noises*
1919 Lev Termen invents the Theremin
1924 Ottorino Respighi combines a phonograph playing alongside an orchestra in *Pini di Roma.*
Chronology

1928 Fritz Fleumer invents the magnetic tape recorder in Germany
   Maurice Martenot invents the Ondes Martenot

1929 Friedrich Trautwein invents the Trautonium

1931 First electroacoustic montage is created by the sound department of
   Paramount Studios in Hollywood, for the film Jekyll and Hyde

1932 In Oskar Fischinger’s film, Töndende Ornamente (Ornament Sound),
   the soundtrack is created by drawing directly onto the optical
   soundtrack

1933 The theremin is used by composer Max Steiner to expand the timbral
   palette of the orchestra in the film King Kong

1936 Varèse publishes his manifesto The Liberation of Sound

1937 John Cage delivers his lecture The Future of Music: CREDO

1938 Orson Welles’ War of the Worlds radio play successfully deceives its
   audience into believing a Martian invasion is taking place

1939 Cage begins working with live electronic sound in his piece
   Imaginary Landscape No. 1

1939 Egyptian-born Halim El-Dabh experiments by electronically
   processing recordings made with a wire recorder, a medium that
   predated tape

1944 The Schillinger System of Musical Composition is published
   posthumously
   Raymond Scott writes the patent disclosure for the 'orchestra
   machine'

1946 At the French National Radio-Television (RTF), Pierre Schaeffer
   experiments with mixing pre-recorded sources on various turntables
   and creates Etude aux Chemins de Fer. The RTF studios host the
   Groupe de Recherches Musicales (GRM)
   Claude Elwood Shannon publishes A Mathematical Theory of
   Communication

1951 Pierre Schaeffer and Pierre Henry compose Symphonie pour un
   homme seul, a landmark in musique concrète
   The Studio für Elektronische Musik at West German National
   Radio (WDR) is founded
   Percy Grainger invents the Kangaroo Pouch Machine
   The Columbia Tape Music Center, in New York, is started by
   Luennning and Ussachevsky. It would later become the
   Columbia–Princeton Electronic Music Center in 1959
   Louis and Bebe Barron compose Heavenly Menagerie in their
   studio, months before the more famous Cologne Studio is established
   Bernard Herrmann uses theremins as main instruments with the
   film orchestra in his score for The Day the Earth Stood Still
   Schaeffer investigates spatialisation with the potentiomètre d’espace

1952 Schaeffer publishes a syntax for musique concrète in the treatise
   Esquisse d’un solfège concrète
   Cage composes Williams Mix; the realisation takes a team of tape
   splicers (in reality, Louis and Bebe Barron) many months
Chronology

1953
In Milan, the Studio di Fonologia is established. In Tokyo the Electronic Music Studio for Japan Radio (NHK) is opened
Herbert Eimert composes Struktur 8

1950–4
Varèse composes Déserts, which combines an ensemble of live instrumentalists with tape

1955–9
Lejaren Hiller and Leonard Isaacson experiment with using a mainframe computer to algorithmically generate musical scores, composing the Illiac Suite for string quartet in 1957
Iannis Xenakis publishes The Crisis of Serial Music, critiquing integral serialism on psychological and statistical grounds

1955
Iannis Xenakis publishes The Crisis of Serial Music, critiquing integral serialism on psychological and statistical grounds

1956
Louis and Bebe Barron create the first purely electronic film score for Forbidden Planet
In The Netherlands, the Center for Electronic Music is established within the Philips Research Laboratory
The BBC Radiophonic Workshop is founded
Stockhausen’s Gesang der Jünglinge combines concrète and elektronische
Xenakis completes the first granular study – Analogue B

1957
In Warsaw, the Studio Experimentalne is established at Polish National Radio
The Bell Telephone Laboratories host the first digital music experiments: Max Mathews programs the first sounds ever generated by a digital computer and creates MUSIC I, the earliest programming environment for sound synthesis

1958
Xenakis designs the Philips Pavilion at the Brussels World’s Fair for which Varèse composes Poème électronique; Xenakis also provides Concrète PH for the interludes between shows
In Santiago de Chile, the Laboratorio de Acústica is used for the earliest electronic music work done in South America
Scott invents and begins development of the Electronium, an algorithmic composing machine without a musical keyboard
In Toronto, the University of Toronto Electronic Music Studio is founded

1958–60
Stockhausen works on Kontakte
Andrej Markowski creates, at the Experimental Studio in Warsaw, electronic music and sound design for The Silent Star, directed by Kurt Maetzig
Raymond Scott composes a completely electronic soundtrack for the Vicks: Medicated Cough Drops commercial
The Norsk Rikssringkasting (NRK) in Oslo allows its studios to be used for the earliest experiments in electronic music in Norway
Kelly and Lochbaum design an algorithm to simulate the human vocal tract
James Tenney creates the plunderphonic tape piece Collage #1 (Blue Suede), sampling and manipulating a famous Elvis track
xvii Chronology

1962 In Buenos Aires, the Laboratorio de Música Electrónica associated to the Instituto Torcuato di Tella is founded; in Ghent, Belgium, the Institut vor Psychoakoestiek en Elektronische Muziek; in East Berlin, the Experimentalstudio für Künstliche Klang und Gerauscherzeugung, Laboratorium für Akustisch-Musikalische Grenzprobleme

1963 Gottfried Michael Koenig’s Projekt 1 program is devised, for automatic aleatoric serial composition

1964 Stockhausen composes Mikrophonie I for amplified and processed tam-tam

Jean-Claude Risset visits Bell Labs for the first time and uses MUSIC IV to investigate the timbre of trumpets

1965 Steve Reich creates his first phase piece: It’s Gonna Rain

Alvin Lucier creates his Music for Solo Performer, the first live electronics piece to use amplified alpha brainwaves

1967 In Gordon Mumma’s composition Hornpipe (1967) an analogue device analyses and amplifies the resonances of the hall in which a performer is playing the French horn, thus predating interactive machine-listening systems

John Chowning discovers Frequency Modulation sound synthesis

1968 MUSIC V becomes the first computer music programming system to be implemented in FORTRAN

Tudor composes the first of his Rainforest pieces, featuring a multitude of objects acting as loudspeakers dangling directly from their cables

Raymond Scott invents the first ‘drum machine’, Bandito the bongo

artist

Jean-Claude Risset creates a catalogue of computer-generated sounds at Bell Labs including guidelines to synthesise different musical instruments using MUSIC V; Risset also composes Computer Suite from Little Boy, utilising auditory illusions

Wendy Carlos’s Switched-On Bach achieves popular success, promoting Robert Moog’s modular synthesisers

Lee Scratch Perry sets up his Upsetter record label – the Jamaican sound system and studio scene is a fertile backdrop for the development of dub and the remix

1969 Max Mathews builds the GROOVE synthesiser, being the first to connect a computer to an analogue synthesiser

First performance of Lejaren Hiller and John Cage’s HPSCHD, for massed audiovisual forces

Luc Ferrari’s music promenade manipulated field recording

1970 Pierre Boulez founds the Institut de Recherche et Coordination Acoustique/Musique (IRCAM)

1970–2 François Bayle’s L’expérience acoustique
xviii Chronology

1971
Richard Teitelbaum’s piece *Alpha Bean Lima Brain* involves the transmission of brain waves by telephone to control jumping beans
Walter Carlos creates the electronically instrumental score for *A Clockwork Orange* by Stanley Kubrick
Hiller and Ruiz develop the first computer simulations by physical models, of instrumental sounds
John Chowning describes techniques for the computer simulation of moving sound sources that are based on the Doppler effect as well as reverberation effects
Tonto’s Expanding Head Band release the psychedelic and progressive *Zero Time*, composed with the expanded Series III Moog synthesiser

1972
Salvatore Martirano builds the *SalMar Construction*, a realtime generative electronic music instrument.
F. Richard Moore, Gareth Loy, and others at the Computer Audio Research Laboratory (CARL) at University of California at San Diego develop and distribute an open-source, portable system for signal processing and music synthesis, called the CARL System, modelled after UNIX
Eduard Artemiev produces the electronic score for *Solaris* by Andrei Tarkovsky
*Pong* by Atari becomes a mass gaming phenomenon

1973
The Composers inside Electronics collective is formed

1974
Paul De Marinis builds *Parrot Pleaser*, an automatic music composing circuit intended to be played by a bird
Curtis Roads writes a program with MUSIC V implementing granular synthesis
François Bayle establishes the Acousmonium loudspeaker orchestra
DJ Kool Herc is experimenting with turntable mixing at parties in the Bronx

1974–9
Laurie Spiegel develops the VAMPIRE (Video And Music Program for Interactive Realtime Exploration/Experimentation) system

1975
Michel Waisvisz unleashes the Cracklebox synthesiser
John Appleton produces the prototype for the Synclavier

1976
Denis Smalley writes *Darkness After Time’s Colours*

1977
*The League of Automatic Composers* is founded by Jim Horton, John Bischoff and Rich Gold.
Ben Burtt coins the term ‘sound designer’ to reflect his contribution to the film *Star Wars*

1978
Atari releases the Atari Video Music audio-visualiser
Brian Eno creates the ambient music installation *Music for Airports*
Kraftwerk create their *The Man-Machine* album, touring with robotic mannequins
xix Chronology

Space Invaders by Toshihiro Nishikado is the first game to have continuous music throughout.

Trevor Wishart composes Red Bird: A Political Prisoner's Dream

1979
Merzbow starts his Lowest Music and Arts record label to release his music on cassette

1980
 Fonction d’onde formantique (FOF) sound synthesis (or formant wave function synthesis), is developed at IRCAM by Xavier Rodet, Yves Potard and Jean-Baptiste Barrière

1981
The launch of Music TeleVision; MTV appropriates the existing term DJ for their presenters, starting a parallel use of this descriptor, later fully reclaimed by live club visual artists

1981–8
Boulez works on Répons

1982
David Jaffe’s Silicon Valley Breakdown utilises an extended version of Karplus-Strong synthesis

1983
The Musical Instruments Digital Interface protocol (MIDI) is established

The Yamaha DX7 is released and becomes the first widely accessible digital synthesiser

Double D and Steinski win a remix competition with the first of their influential cut and paste Lessons

Detroit Techno provides one historical strand amongst many of electronic dance music: Juan Atkins had been recording in the duo Cybotron since 1981, and influences included electronic, disco and funk artists such as Kraftwerk, Giorgio Moroder and Parliament

1984
Paul Lansky develops Cmix, later to become RTCmix, an extension for realtime use created by Brad Garton and David Topper

Yasunao Tone begins ‘wounding’ CDs through the application of perforated Scotch tape

First attempts at automatic accompaniment systems from Roger Dannenberg and Barry Vercoe presented at the International Computer Music Conference at IRCAM

The Wabot-2 score reading and keyboard playing robot is completed, the first of a series of musical robots produced at Waseda University

1985
Laurie Spiegel develops Music Mouse

Paul Lansky’s Idle Chatter

1986
Csound is originally authored by Barry Vercoe and colleagues at the MIT Media Labs

George E. Lewis begins working on the Voyager interactive music system

The Akai S900 becomes one of the first (and possibly the most accessible) commercially available sampling modules for mass consumers

1987
The Hierarchical Music Scoring Language (HMSL) is authored by Polansky, Rosenboom and Burk
Chronology

1988 Miller Puckette publishes his paper *The Patcher*; at IRCAM he develops this visual patching system into an interactive computer music programming environment called Max

1989 Public Enemy’s album *Fear of a Black Planet* demonstrates the power of their sampled hiphop production allied to strong political messages

John Oswald releases the *Plunderphonic* EP and is later forced to ‘recant’, destroying all remaining copies, by the litigious music industry

1990 Max (later Max/MSP) is released commercially, becoming available to non-academic musicians

1991 Nic Collins creates the piece *Broken Light* by hardware hacking CD players

*Common Lisp Music* (or CLM), a sound synthesis language is written by Bill Schottstaedt at Stanford University

1992 Reed Ghazala starts publishing articles on ‘Circuit Bending’ in the journal *Experimental Musical Instruments*

1993 Björk’s *Debut* is the first example of her many collaborations with electronic dance music producers

1994 Autechre’s *anti-EP* (particularly the third track, ‘Flutter’) is designed not to repeat in such a way as to confound recent anti-rave legislation

1995 The *Synthesis Toolkit* (STK), a collection of building blocks for realtime sound synthesis and physical modelling, for the C++ programming language, is authored by Perry Cook and Gary Scavone

1996 James McCartney develops *SuperCollider*, an environment and programming language for realtime audio synthesis

Miller Puckette releases *Pure Data*, a freeware program with a similar environment to Max/MSP

1997 Coldcut release *Let Us Play*, an extended CD including the live AV sampling demo *Timber*

Maurice Methot and Hector LaPlante start streaming algorithmic music live on the internet with *The Algorithmic Stream*

Introduction of the *Open Sound Control* (OSC) network music connectivity protocol

Ryoji Ikeda releases *+ / −*

1998 Atau Tanaka and Kaspar Toeplitz install *Global String*, uniting space with cyberspace

The gameboy *Nanoloop* sequencer is created by Oliver Wittchow

Chris Watson releases *Outside the circle of fire*

2000 Tabletop tangible musical controllers such as *SmallFish* and *Jam-O-Drum* begin to develop; they would be followed by others such as the *reactTable* and the *Audiopad*

Radiohead’s *Kid A* openly assimilates electronica influences

2000–3000 Jem Finer’s *LongPlayer* installation intends to run for a thousand years

2001 Chris Chafe’s *Network Harp* uses network latency for sound synthesis
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2002</td>
<td><em>ChucK</em>, an audio synthesis programming language, is created by Ge Wang and Perry Cook. The <em>Shazam</em> mobile phone-based automatic music track recognition service is launched.</td>
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<td>2004</td>
<td>The <em>Firebirds</em> installation by Paul de Marinis reignites the use of gas fire loudspeakers.</td>
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<td>2005</td>
<td>Nintendo and Toshio Iwai release the <em>Electroplankton</em> interactive musical video game.</td>
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<td>2006</td>
<td>The <em>Lara Croft: Tomb Raider Legend</em> game widely promotes adaptive audio techniques.</td>
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