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 range 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. This book, winner of the 2009 Nicolas Bessaraboff Prize, brings together researchers at the forefront of the sonic explorations empowered by electronic technology to provide accessible and insightful overviews of core topics and uncover some hitherto less-publicised corners of worldwide movements. This updated and expanded second edition includes four entirely new chapters, as well as new original statements from globally renowned artists of the electronic music scene, and celebrates a diverse array of technologies, practices and music.

Nick Collins is Reader in Composition at Durham University. His research interests include live computer music, musical artificial intelligence, and computational musicology, and he is a frequent international performer as composer-programmer-pianist or codiscian, from algoraves to electronic chamber music.

Julio d'Escriván is Senior Lecturer at the University of Huddersfield. He researches in film and audiovisual music composition and is himself a composer of music for the screen. His work spans electroacoustic and orchestral music, electronica, film music, commercials, live coding and improvisation.

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The Cambridge Companion to

Electronic Music

EDITED BY
Nick Collins
University of Durham

Julio d'Escriván
University of Huddersfield

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Illustrations and Figures

Notes on Contributors

Monty Adkins is a composer, performer and Professor of Experimental Electronic Music at the University of Huddersfield. He has created installations, concert and audiovisual works, and collaborated with contemporary performers, writers, painters, video artists and photographers. His recent work since 2008 has been released by Audiobulb (UK), Cronica (Portugal) and empreintes DIGITALes (Canada). Adkins is also active as a writer and concert curator. He completed his first book in 2011 (co-written with Pip Dickens) on the relationship between art and music (*Shibusa – Extracting Beauty*) and has edited two books on the music of Roberto Gerhard (Ashgate 2013 and Cambridge Scholars Press 2016). He has also contributed articles and chapters on the aesthetics of digital music to various journals (*Organised Sound et al.*) and is on the editorial board for the *Journal of Music Technology and Education*.

Amy Alexander is a digital media, audiovisual and performance artist who has also worked in film, video, music, tactical media and information technology. Alexander's projects have been exhibited and performed internationally in festivals and museums as well as on the Internet, in clubs and on the street. She has written and lectured on software art and culture and audiovisual performance, and she has served as a reviewer for both visual media and computer music events and publications. Alexander is an Associate Professor of Visual Arts at the University of California, San Diego. http://amy-alexander.com

Natasha Barrett (UK / Norway) is a composer, performer and researcher in the field of contemporary electroacoustic art music. She received her doctoral degree in 1998 from City University in London and has since followed a career predominantly as a freelancer. Her work encompasses acousmatic and electroacoustic concert composition, sound installations, theatre music, large-scale outdoor media productions, sound-architectural works and interactive art. She regularly collaborates with designers and scientists, as well as musicians and visual artists. Her work is inspired by acousmatic sound and the aural images it can evoke, particularly in terms of the evocative implications of space. Besides her compositional activities, she has been employed as a researcher at the Department for Musicology, University of Oslo, and as a professor in electroacoustic composition at the Norwegian State Academy for Music. Barrett's works are performed and commissioned throughout the world and have received a long list of prizes. These include the Nordic Council Music Prize (Nordic Countries), Giga-Hertz Award (Germany), Edvard Prize (Norway), Jury and public first prizes in Noroit-Leonce Petitot (France), five first prizes and the Euphonie D'Or in the Bourges International Electroacoustic Music Awards (France), Musica Nova (Prague), CIMESP (Brazil), Concours Scrime

(France), International Electroacoustic Competition Ciberart (Italy), two prizes in Concours Luigi Russolo (Italy), and two first prizes in the International Rostrum for electroacoustic music. www.natashabarrett.org

Nick Collins is Reader in Composition at Durham University. His research interests include live computer music, musical artificial intelligence, and computational musicology, and he is a frequent international performer as composer-programmer-pianist or codiscian, from algoraves to electronic chamber music. Many research papers and much code and music is available from composerprogrammer.com

Nicolas Collins New York born and raised, Nicolas Collins spent most of the 1990s in Europe, where he was Visiting Artistic Director of Stichting STEIM (Amsterdam), and a DAAD composer-in-residence in Berlin. An early adopter of microcomputers for live performance, Collins also makes use of homemade electronic circuitry and conventional acoustic instruments. He is a Professor in the Department of Sound at the School of the Art Institute of Chicago, and from 1997 to 2017 was editor-in-chief of the *Leonardo Music Journal*. His book, *Handmade Electronic Music – The Art of Hardware Hacking* (Routledge), has influenced emerging electronic music worldwide. www.nicolascollins.com

Julio d'Escriván is a Venezuelan composer working in music for the screen. His work since the late 1980s spans electroacoustic and orchestral music, electronica, film music, commercials, live coding and improvisation. Although most of his career has been as a freelance in the Americas, he currently works as a Senior Lecturer at the University of Huddersfield; there he lectures and researches in film and audio-visual music composition.

Karlheinz Essl is an Austrian composer, improviser and performer, born in 1960 in Vienna. He studied composition with Friedrich Cerha and musicology at the University of Vienna (doctorate 1989, with a thesis on Anton Webern). Besides writing experimental instrumental music, he performs on his own computer-based electronic instruments, develops algorithmic composition software and creates generative sound and video environments. From 1990 to 1994 he was composer-in-residence at the Darmstadt summer courses, and from 1992 to 1993 he worked as a commissioned composer at IRCAM/Paris. In the period 1995–2006 he taught 'algorithmic composition' at the Bruckner-University in Linz. Since 2007, he is professor of composition for electro-acoustic and experimental music at the University of Music and Performing Arts in Vienna.

Andrew Hugill (1957) is Director of the Centre for Creative Computing at Bath Spa University. Between 1976 and 1980, he studied composition with Roger Marsh at the University of Keele. After university he earned a living as a music copyist and as musical assistant at the Opéras de Lyon and Paris, before beginning his academic career in 1986. Hugill's compositions have been performed and broadcast worldwide. *Symphony for Cornwall* (1999) used the internet in a ground-breaking way. *Secret Garden* (2013) was experienced by 36,500 people during its two month exhibition in the Taipei Museum of Contemporary Art. Hugill's research is trans-disciplinary, covering composition, musicology, computer science and literature.

He is the author of *The Digital Musician* (Routledge 2008/2012) and *Pataphysics: A Useless Guide* (MIT Press 2012). He is a Principal Fellow of the Higher Education Academy.

Sergi Jordà holds a BS in Fundamental Physics and a PhD in Computer Science and Digital Communication. He is a researcher at the Music Technology Group of Universitat Pompeu Fabra in Barcelona, where he directs the Music and Multimodal Interaction Lab, and associate professor at the same University, where he teaches computer music, Human Computer Interaction (HCI) and interactive media arts. His main research interests are in the confluence of HCI, tangible, musical and physiological interaction, and is currently specially interested in bringing MIR knowledge for helping music creation and for creating empowering musical tools. He has authored more than 100 publications counting peer-reviewed conference papers, journal articles and book chapters. He is also a digital luthier and improviser, who likes to invent new digital musical instruments without forgetting to make music with them. He is best known as one of the inventors of the Reactable, a tabletop musical instrument that accomplished mass popularity after being integrated in Icelandic artist Björk's 2007–08 world tour Volta, and he is one of the cofounders of the company Reactable Systems. He has received several international awards, including the prestigious Prix Ars Electronica Golden Nica (2008).

Adinda van 't Klooster is an artist who works with drawing, sound, light, animation, sculpture and interactive audiovisual performance and installation. Her work has been exhibited, performed and screened in China, the USA, Australia, Slovenia, Spain, Scotland, the Netherlands, England, Norway and Ireland. Her research interests include emotion-aware artworks, biofeedback art, aesthetic experience, sound art, interactive art and graphical scores. She has been involved in multiple interdisciplinary projects that explore the links between music and art. Her work has received many awards and has been commissioned throughout the UK. Examples can be seen at www.adindavantklooster.com and www.affectformations.net

John Richards explores the idea of Dirty Electronics, which focuses on shared experiences, ritual, gesture, touch and social interaction. In Dirty Electronics process and performance are inseparably bound. The 'performance' begins on the workbench devising instruments and is extended onto the stage through playing and exploring these instruments. Richards is primarily concerned with the performance of large-group electronic music and DIY electronics, and the idea of composing inside electronics. His work also pushes the boundaries between music, performance art, electronics, and graphic design and is transdisciplinary as well as having a socio-political dimension. www.dirtyelectronics.org

Julian Rohrhuber is a German artist and theorist. As professor for music informatics and media theory at the Robert Schumann Hochschule in Düsseldorf, he develops the intersections between art, programming and philosophy. His art projects include compositions, installations and performances, film sound tracks, a system for interactive sound programming, and collaborative and network art pieces. He writes on topics such as philosophy of mathematics, education politics, documentary realism, distributed agency, and algorithmic time.

Margaret Anne Schedel is a composer and cellist specialising in the creation and performance of ferociously interactive media whose works have been performed internationally. Her research focuses on gesture in music, the sustainability of technology in art, and sonification of data. As an Associate Professor of Music at Stony Brook University, she serves as Co-Director of Computer Music and is the Director of cDACT, the consortium for digital arts, culture and technology. She ran SUNY's first Coursera Massive Open Online Course (MOOC), an introduction to computational arts. Schedel holds a certificate in Deep Listening and is a joint author of Cambridge University Press' *Electronic Music.* She has been commissioned by the Princeton Laptop Orchestra, the percussion ensemble Ictus, and the reACT duo. She sits on the boards of 60x60, the International Computer Music Association, is a regional editor for Organised Sound and an editor for Cogent Arts and Humanities. In her spare time she curates exhibitions focusing on the intersection of art, science, new media, and sound.

Stefania Serafin is currently Professor with special responsibilities in sound for multimodal environments at Aalborg University Copenhagen. She received a PhD in computer-based music theory and acoustics from Stanford University in 2004, and a Master in Acoustics, computer science and signal processing applied to music from IRCAM (Paris), in 1997. She has been a visiting professor at the University of Virginia (2003), and a visiting scholar at Stanford University (1999), Cambridge University (2002), and KTH Stockholm (2003). She was principal investigator for the EU funded project Natural Interactive Walking (FET Open), Digital Reworking of Electroacoustic Music (EU Culture 2000), and Danish delegate for the EU COST Actions on Sonic Interaction Design and Wood Music. Her main research interests include sound models for interactive systems, multimodal interfaces and virtual reality, and sonic interaction design.

Mary Simoni is a composer, author, teacher, pianist, consultant, arts administrator, and amateur photographer. She is currently the Dean of Humanities, Arts & Sciences at Rensselaer Polytechnic Institute and Professor Emerita, Performing Arts Technology at the University of Michigan. Her music and multimedia works have been performed in Asia, Europe, and throughout the United States and have been recorded by Centaur Records, the Leonardo Music Journal published by the MIT Press, and the International Computer Music Association. She is the recipient of the Prize in Composition by the ArtNET Virtual Museum and named semi-finalist for the American Prize in Composition-Chamber Music. Her music is frequently recognised by Vox Novus. She has authored several books, *Algorithmic Composition: A Guide to Composing Music with Nyquist* co-authored with Roger Dannenberg and published by the University of Michigan; and *Analytical Methods of Electroacoustic Music* published by Routledge. She is a Medal Laureate of the Computer World Honors Award for her research in digital music information retrieval.

Ge Wang is an Assistant Professor at Stanford University's Center for Computer Research in Music and Acoustics (CCRMA). He researches programming language and software design for music, interaction design, mobile music, laptop

orchestras, aesthetics of music technology design, and education at the intersection of engineering, art, and design. Ge is the author of the ChucK music programming language, the founding director of the Stanford Laptop Orchestra (SLOrk), the Co-founder of Smule (reaching over 125 million users), and the designer of the iPhone's Ocarina and Magic Piano.

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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 Polonoisen und Menuettencomponist* ('The always ready Polonaise and Menuet Composer'), a musical dice game
1761	Jean-Baptiste Delaborde builds the *Claveçin Electrique* in Paris
1843	Lady Ada 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 *phonoautograph*
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
1881	Clément Ader demonstrates stereo broadcast with the premiere of his Théâtrophone, conveying music from the Paris Opéra to the World Expo
1897	Thaddeus Cahill patents the *Art of and Apparatus for Generating and Distributing Music Electronically*
1898	Valdemar Poulson patents a magnetic *Telegraphone*, which can both record and play back sound
1899	William Duddell invents the *Singing Arc*
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*
1920	Lev Termen invents the Theremin
1924	Ottorino Respighi combines a phonograph playing alongside an orchestra in *Pini di Roma*.
1928	Fritz Fleumer invents the magnetic tape recorder in Germany Maurice Martenot invents the *Ondes Martenot*
1929	Friedrich Trautwein invents the *Trautonium*
1930	Walter Ruttman's *Weekend* is an early precedent in juxtaposition of fragments of recorded sound, Paul Hindemith and Ernst Toth hold a multiple turntable concert of *Grammophonmusik* in Berlin, with young exchange student John Cage in attendance
1931	An 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, *Tönende 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 Johanna Beyer's *Music of the Spheres* is composed, with parts for three electrical instruments and two percussion instruments
1939	Cage begins working with live electronic sound in his piece *Imaginary Landscape No. 1*
1944	Egyptian-born Halim El-Dabh experiments by electronically processing recordings made with a wire recorder, a medium that predated tape
1946	*The Schillinger System of Musical Composition* is published posthumously Raymond Scott writes the patent disclosure for the 'orchestra machine'
1948	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 eventually 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 seule*, a landmark in musique concrète The Studio für Elektronische Musik at West German National Radio (WDR) is founded in Cologne Percy Grainger invents the *Kangaroo Pouch Machine*

	The Columbia Tape Music Center, in New York, is started by Luenning 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 concrete*
	Monique Rollin's *Étude Vocale* (1952) is an early musique concrète study
	Cage is composing *Williams Mix* (completed by 1953); the realisation takes a team of tape splicers (in reality, Louis and Bebe Barron) many months
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 1956
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
	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 1*, the earliest programming environment for sound synthesis
1958	The BBC Radiophonic Workshop is founded, after years of effort from Daphne Oram in particular
	Xenakis designs the Philips Pavilion at the Brussels World's Fair for which Varèse composes *Poème électronique*; Xenakis also provides *Concrèt PH* for the interludes between shows

	In Santiago de Chile, the Laboratorio de Acústica is used for the earliest electronic music in South America
	Raymond 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*
1960	Andreij 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
1961	The Norsk Rikskringkasting (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
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 Kunstliche 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* 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
	David 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' *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 system 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*
1971	Richard Teitelbaum's piece *Alpha Bean Lima Brain* involves the transmission of brain waves by telephone to control jumping beans
	Wendy 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
	DJ Kool Herc is experimenting with turntable mixing at parties in the Bronx

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
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*
	Hildegard Westerkamp creates *Lighthouse Park Soundwalk*
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
	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 VJ 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*
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

Early Chicago House recordings from Jesse Saunders, amongst others

1985 Laurie Spiegel develops *Music Mouse*

Paul Lansky's *Idle Chatter*

Detroit Techno provides one historical strand amongst many of electronic dance music: Juan Atkins had been recording in the duo Cybotron since 1981, and released his first Model 500 tracks in 1985; influences included electronic, disco and funk artists such as Kraftwerk, Giorgio Moroder and Parliament

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

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 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, then later still just Max again) is released commercially, becoming available to non-academic musicians

Public Enemy's album *Fear of a Black Planet* demonstrates the power of their sampled hip hop production, allied to strong political messages

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 *reactable* 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
2002	*ChucK*, an audio synthesis programming language, is created by Ge Wang and Perry Cook The *Shazam* mobile phone-based automatic music track recognition service is launched
2004	The *Firebirds* installation by Paul de Marinis reignites the use of gas fire loudspeakers The *Vocaloid* singing voice synthesiser software is first released
2005	Nintendo and Toshio Iwai release the *Electroplankton* interactive musical video game
2006	The *Tomb Raider: Legend* game widely promotes adaptive audio techniques Daft Punk's stage pyramid show is revealed at Coachella
2007	The iPhone is released, paving the way to low latency audio processing smartphone applications
2009	Björk's *Biophilia* is both interactive app and music release

2010	The Turner Prize is given to sound artist Susan Philipsz
2011	Amon Tobin's ISAM stage show maps audio synchronized graphics onto a large on-stage sculpture
	The *Oramics to Electronica* exhibition opens at London's Science Museum
2014	The HTML 5 specification is finalized; an era of realtime web browser audio applications has already begun
2016	Daphne Oram's *Still Point* (1949) for double orchestra, pre-recorded sound and electronic processing via microphones is finally premiered, at the *Deep Minimalism* Festival in London