

*() sound as a technological medium*

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## Preface

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*() Sound as a technological medium* follows the studies in **curating new media**. It includes the discovering and fascination for **electronic art** developed during the 60's: the expanded field of **video art, electromagnetic experiments with CRT, new media communications, radio art, broadcasting and live stream**. Those opened an interest in the field of research that occupies the **history of art**. Dedicated studies to **curating and cultural management in art and new media** will give a better understanding of the institutions that facilitate the development of that kind of practices, **AE Ars Electronica** or **ZKM**. Different ranges and types of artworks represent **new media art: net.art, software-based art, video art, stream art, database art, code art, sonic art, interactive art, intermedia art**. There is a strong connection with the **institutions and universities** dedicated to the study and research of new media. **MAH Media Art Histories** or **Leonardo Society**, are among the foundational pillars. Professors and curators are **Christiane Paul, Edward Shanken, and Roy Ascott**. Other organizations are **ISEA, V2, ICC... Media art** is dedicated to curating exhibitions of media art and **electronic art** and the development of conferences and symposiums about **digital art and media preservation**. Because of these practices it is required a further development of **media labs or sound labs**, as well as **digitals art department**. It is a step forward into educational institutions that require supply humanities studies with all these novelties. *() Sound as a technological medium* will present **innovation and historical referents from radio art to eat (experiments in art and technology), new media development techniques', interactive installations, uses of sensors or software-based art**. It will give examples of artists involved in the development of **new media** through the uses of **sound as a technological medium**, where sound is a source for cross disciplines studies and practices. It will also give examples of artworks where the final results are a response to understanding phenomena such **non-verbal communication**. The entire and exhaustive research will be an incredible experience of knowledge and creation, presenting awareness of the constant evolution of **new media development, progress in technology, and preservation or ontology**. It pretends to be a useful tool for the development of further **practices, exhibitions, courses, seminars and conferences in colleges, universities and museums**. It pretends to stress and give new signification to the definition of **media art**, amplifying its sources of research on the relation between **art, science and technology**. It gives a new dimension of what **media art** is. This research will resolve which technical developments are expressing the intentions of **media art**, and which are not. **Media art** will consider **sound practices** that contribute to the relations in **art, science and technology**. Participating in disciplines such **physics, neuroscience, cybernetics, technologies of recording and reproduction, software-based art and media and new media communication techniques (streams, live broadcasting, radio, iphone)**. The research will develop theories of media art based on media technology, cultural studies, media ecology or media literacy. *()sound as a technological medium* includes studies in new media curating, **computation, engineering, cybernetics, neuroscience or physics; synesthetic and multisensory aspects, taxonomies of sound, sonic constructions of ontologies or interaction of senses**.



## ( ) sound as a technological medium

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### A definition of sound:

Sound can be described as **invisible**, like a **translucent** image of thought and represented by **waves**. Sound is the **mechanical disturbance** of a media provoked by an element in **vibration**. Its presence is subject to the existence of a media, such as gases inside planetary atmospheres. **Vibrations** that travel through the air or another medium that can be heard once reach a person's or animals ear are also sound. **Continuous and**

**regular vibrations produce sound.** Emit or cause to emit sound is synonyms **to resonate, resound, reverberate, blow or blare**. Once referring to the sound, it conveys a specified impression when heard. In **physics**, sound is a vibration that propagates as a typically audible mechanical **wave of pressure and displacement**, through a medium such as air, gas or water. In **physiology and psychology**, sound is the reception of such waves and their **perception by the brain**. Theories of systems

have achieved an influence from many theoreticians and artists. For example, **John Cage** controls on **indeterminacy and immateriality of sound**.

**Debord** in *Disclaimer about situationist*, altogether with lettrists or the Danish/German breakaway faction of the situationists, worked with **recordings**. Working in this media, **Gil Wollman** like **Debord** in *Hurlements* track (a 35mm print with optical sound and lots of clicks and pops, plenty of **voices** as well as a preponderance of **silence**) represent the **critique of separation**; an alignment of **metaphysics** and open processes of resolving matters concerning being. Most parts of **Debord** works are with **voice over** and music separated. Having the music in the background and the short length of the sample, **Debord** works come from a French radio show. **Debord's** copious extracts from soundtrack films show "creaking sounds" and "strange glitches" during the silent parts of it.

**Theodor Adorno** started a cultural revolution regarding the use of **technology** as an improvement of **human conditions**, but with the rape of the **environment** (pollution and nuclear destruction). Even **modern techniques** reduce the time in working over exposing leisure activities; there is an **instrumental reason** that turns technology into a bureaucratic mind transforming

nature and human to be manipulated objects. As seen in history, it causes **annihilation** and **slavery**. **Totalitarian regimes**, such Adolf Hitler's Nazism, operate hierarchy as a **functional logic** in administration. Reich becomes a **superstructure of control** pointing to enemies. Gas chambers become **apparatus of death**. **Technological** solutions conform the state-machine. The **instrumental rationality** part of the **modern bureaucracy** consists in the **institutionalization**. Moreover, it turns the holocaust style solutions, possible and reasonable. When instead it is, **dark, intolerable, a failed promised of progress, the cause of pollution, bombing, and destruction**. Against reason, mechanical systems and the truth in science, irrational practices, alternative medicine, crystal therapy, astrology, shamans and doctors of natural religion establish another order. A **new age** spirituality is based on metaphysics, transhumanism, practices where the self operates an achievement of definite ideas about the fundamental truth founded on **existentialist theories** of empty and nothingness and the des-centered self. Meanwhile, the industrial production is still affecting the artwork and the social development.

In *Anti-Oedipus: capitalism and schizophrenia*, by **Deleuze/Guattari**, schizophrenia is

used as a **sonic medium** in processes of **thought** to achieve an experience of **knowledge**. Schizophrenia is a disease, something that occurs when coherence of consciousness is **disturbed**. It is defined as a **chaotic** surge of energy. It is also a chaotic electro-chemical activity that causes **interruptions** on the smooth surface of the brain. Schizophrenics interrupt the coherent quantum field, have no order neither in thoughts or meaning. Its perception of the world is fragmented in parts. Its reality is like a fragmented dream, suffering from phenomena such hearing voices and seeing visions. They constitute reality through dissociated parts of its personalities. In **physics**, while condensation gives coherence; less energy produces fragmentation. Energy has no direction, no time. Moreover, conscience is a fundamental quantum mechanism.

According **indeterminate Schrodinger wave function**, when a **system collapse** it is impossible to measure it, unable to be observed, captured or perceived. This definition approaches the idea of many possibilities into one reality. Processes in physics are unable to be understood once they **collapse**. It is part of **non-linear processes** or systems characterized by stochastic nature. **Unmeasurable, non-linear, stochastic** and **non-simple processes** are

part of the so-called **quantum state**. Its main features are **non-deterministic** process, **randomness**, analysed through **probabilistic theory** and planning under **uncertainty**.

In 1927, the physicist **Werner Heisenberg** published his **uncertainty principle**, upon which he built his philosophy. **Heisenberg** was awarded in 1932 the **Nobel Prize** in **physics**, although being his research helpful for the development of the **atomic bomb**. His research contributed to the creation of quantum mechanics describing turbulence flows, hydrodynamics, atomic nucleus, cosmic rays and other variable phenomena. **Uncertainty principle** is a **heuristic argument**, so **experimental, speculative** and a **non-rigorous argument**.

Approximation to physics contributes to developing the philosophy of what is called "**alive**", dedicated to the study of **multiplicity, experimental** and pragmatic concepts. Processes of **knowledge** through **thought** consider different phenomena to achieve a definition of **being** and the idea of the **original**. **Metaphysics** is then processed in various narratives. **Identity** and **logos** are paths to understanding the nature of **being**. **Being** in **Heidegger** is considered the origin of all. Through **thought, narrative processes** are built for the **explanation of being**. In **sound, process**

of **knowledge** that express the **metaphysical being** include phenomena such **inner voices, silence, performance, recording and physics. Thought** is a **pre-state of language** where **content and expressions** appear as **disaggregated** forces of creation and **sound** appears as a nomadic model of thought. **Being** is a **pre-state** before the message or idea. The study of this **previous subjective experience** of thought through **sound** will be analysed here.

According **Taoism** and **oriental philosophy, being** could only be perceived as a **preconceived phenomenon**, a state of balanced forces in between in/out, active/negative and content/expression. **Dissociation** from the self and negativity of the subject are common phenomena to approach the idea of **being** in **oriental philosophy**. In its continuous resolution in between **technique and content**, the cultural expression of **being** will serve as an example to build models and policies of **conservation** and resources for **preserving** humanity among dangerous, thrilling and awareness conditions. **Sonic phenomena** will be an approach to these processes of **non-verbal communication**. Because, there is no resolution; its formulation accepts **dynamic relations, complexity, dualism, multiplicity, and stochastic processes**.

### Media ontology:

In universal processes of **knowledge** or **weltanschauung** (cosmic vision or the vision of the world), the relation between **sound, art, science and technology** appears as a central field. **Technology** has a **philosophical analysis** that implies engineering or the **discourse on techniques**. Prescription and **rules** for composition (understood as **weltanschauung** narratives) determine **doctrines** and imperatives. However, it is recognized that neither rules nor techniques conform a science. Rules or prescriptions are incomplete, and **purpose or intentional mode** of thought gives its completeness. So, values such knowledge, vitality, hedonism, aesthetic, ethical, religious, justice, legal, social or economics altogether with circumstances and personal reasons may affect **propositions and rules**. It is scientifically accepted that **sound** played in individual **physical conditions** of **vibration**, produce physical phenomena affecting experience of the audiences. Physical conditions of **vibration** are a response justified by scientific descriptions of physical acoustics in addition to psychological and metaphysical. **Sound** is a complicated process in time. Composition is part of the **weltanschauung** or the vision of cosmos,

the world's existential perspective. **Sound** studies will consider scientific knowledge and cognitive processes because science cannot give a complete answer, like in **collapsed system, complex environments** or **dynamic organisms**. Phenomena strictly affected by **time** and changes are difficult to analyze according to **prescription and rules**. **Indeterminacy** and determinism is a dual binomial, like philosophy and science. Philosophy, anthropology, empirical sciences, natural sciences and human sciences will contribute to scientific knowledge. *Weltanschauung* in the relations art and technology will provide with intellectual resources, too.

Historically, there is interdependence between **art, science and technology**. Relations in art and technology appear in early expressions of culture, where art consider *tekhné* (τέχνη) a fundamental and constitutional body of it. In aesthetics, relations in between content and context appear as a binomial. In addition, the scientific revolution give to the technology a magical justification with extra-scientific hypothesis. Art and technology reflect the ideal of technology in principles and theories governing composition: scientific principles, hypothesis or humanities narratives. **Sound and science** relations appear as well as architecture and technical relations. Since the

**Pythagorean representation of the cosmic** system under the theory of the **harmony of spheres**, the correspondence among micro-cosmos and macro-cosmos has been a recurrent field of research. Ethos theory and numerology represented the harmony of numbers in cosmology and music. Music was considered cathartic, a cleansing effect, which ethical function belonging to the magic. Plato and Aristoteles considered as well the ethical function as predominant. Numerology was used to measure strings, with rules and experimentation. However, speculative means appeared together numerical proportions between frequencies. Motion affecting harmonics and differential equation of wave motion connected sound, science and technology again.

**Electronic and computer techniques** will offer same ontological solutions. Composition with electronics or computer and physical or psychological conditions will conduct **sound studies** in **science and technology**. The relation in between **sound and technology** had a brilliant period during the 1970's. Even sound has a natural origin, in its composition, labour or work acquires a value that has been misunderstood by the market. That is, why **art production** has reflected a tendency approaching **science and technology**, remaining separated from the **industry** dedicated to

recording sales. **Serious compositions** avoid market and publicity. Profoundly in sense, sound composition is considered as the **antipode of technique**. The relations in between **sound and technique** are part of the history. Sound practices have succeeded in integrating the meaning of technique enlarging the sound spectrum possibilities.

**Cultural techniques and media studies** are dedicated to understand the relations among culture and technology. Media studies analyse the median conditions of post-humanities where nonhuman materiality is considered affective. It is a turn in metaphysics. Since the present moment, metaphysics has occupied its research around the empty body. **Media archaeology** will study media and technology in relation to its **materiality**. Culture has forged civilization through the domination of the environment. Civilization transforms and **cultivates (cultivare, culture)** the **environment** through the **media or an apparatus** that is related to a **tekhné**. In that sense, **technology is culture**. It is understood that what drives culture is a technique, and in its turn it becomes a **machine, a symptomatic technical machine**. The **mechanization of technique** is because of the **technique** transform everything into a machine or an **interaction machine**. These changes in the re-

lation to the **technique** transform the behavior into an autonomous action; a new **servo-mechanism appears** based on **feedback** and requiring **responsive environments**. **Media studies and cultural techniques** are interested in the **qualities of being**: vibrations and materiality conditions. It belongs to the **self-reflective media, self-exhibiting media, introspective** artworks and the assimilation of **the media and the message**. New wave cinema, experimental video art, conceptualism, and **electronic art** are based on the **barock effect**, where technique reproduces itself, to recognize itself, and so, to replicate the **ontological** phenomena of itself. It is **media ontology**. It incorporates studies of media as spatiotemporal knowledge systems. Another contribution is the study of the **nature of techniques in media archaeology**.

**Sound studies** are incorporating **signal analysis**, physics, engineering and computation. According to **Shannon and Weaver**, **signal analysis** is the principle to understand all processes in information theory. This process follows the schema: sing - storage - transmission. So, **self-perceptual techniques** connect body with engineering. Understanding the relations in between **sound and media technology**, we achieve to realize that composition and method are related and hollowed on

the **inside of the technique**. Here the media are the message, and it is a primordial practice in experimental electronic sound art.

**Sound** as a source for **new media** will be part of participatory networks, interactive environment, cybernetics machines and computational engineering devices. A new science-based in the development of structures that display knowledge and universalism is urged to be reinvented according communication technologies that highlight the importance of **non-verbal** and embodied expressions as a substrate of cultural diversity. Following the concept of difference and heterogeneity, certain phenomena are being undermined by the homogenizing impact of the current information technologies. New communication technologies developed by **interactive and multisensory laboratories** of perception and movement have a positive resolution in matters of understanding being and processing communications among different subjects. **Interactive processes**, such human-human or human-machine, are integrated becoming an experimental resolution. Interaction is the cause of the development of tools in embodied social network forming a **metabody**, a new technological paradigm under the influence of formal definitions of **unpredictability**, movement and change. According to the **metabody**, **non-verbal communication** is the

origin of embodied cultural expressions. It is known that 93 percent of our expressions is **non-verbal communication**. This **metabody** will consider interactive media as a new multidisciplinary communication and opposed to the culture of prediction and control (surveillance and power). Sonic arts, architecture, spatial arts, performance, dance and body arts, visual and media arts, kinetics, philosophy, cognitive sciences, theories and histories of affects and emotions, alternative mathematics, (post-)queer, postcolonial and disability theories, embodiment theories and social activism are part of the **metabody**. The **metabody** will also include philosophy, art, science, technology, metacultural studies, meta histories, meta humanities, post-feminism, post-humanism, transhumanism and critical sensory processes for the awareness of danger and totalitarianism. It will be ruled by indeterminacy principle and will configure experimental communication systems and practices based on **Simondon's transduction**, where an activity generates its conditions of possibility. It has to be added, Erin Manning's relational movement as a theory supporting metacognitive studies. **Biofeedback and biopotentials** in electronic sound systems will operate a change towards the cyberethics and the affective capitalism.

## Auditory Anthropology:

The **ontological dimension of sound** as a media will be used in new media curating practices. However, responding to the **auditory anthropology**, sound as a media is used as well in environmental practices, artistic expression and community practices. Supernatural phenomena and mysteries of **origins** will be presented in methods that use sound as a media, in addition to creations with expressions of ceremony or **ritual**. The magical rituals of the origin are usually composed of sounds and expression where sound is used as a media and contributes to the formation of cultural expressions, such as primitivism, exotics, indigenous. Those sound phenomena relating to ritual and origins are also subjected to preservation policies. Another primary focus on cultural expressions and artistic works in which sound is used as a media are soundscapes, where natural and artificial are differentiated. The studies on the impact on the environment by **Murray Schafer** are stressing the opposition to western culture's primacy of the visual, defined by **Marshall McLuhan**. Schafer in the studies of **auditory anthropology** describes the expression of the artistic as metaphysical and social. Culture is an expression of identity, individually or socially. Using the

sound as a media in the manifestation of cultural life understands the identity formation in a glocal (global - local) level. So, museums must cover all the possible expressions of cultural **soundscapes**, in order to preserve and build heritage. Covering culture opens to **ritual** and performative expression of cultural identities, accepting the diverse and the difference. **Ontology** and **auditory anthropology** appear as an expression of praxis in performance. **Preservation** policies of heritage and museums will include works that sound appears as a media. These policies will be based on **auditory anthropology methodology**, **ethnomusicology** and **sound studies**. The interpretation of **sound** as an opposition to western visual primacy will contribute to **ontological processes of knowledge**. In addition, **ethnography** will approach to consider sound as a sensorial process. So, in **sensory ethnography**, sound studies are considered instead of the visual. Sound studies are incorporating **interdisciplinary media** where the symbiosis of sound with other categories such as anthropological theory enriches the field of knowledge and ontological experience in cultural expressions. Applied **auditory anthropology** to theory and conceptualism will be a field of research in **preservation** policies. It will also consider

phenomena such **inner voices, imagined music** or **auditory hallucinations**. Western think is based on visual physicality, but **animism** and **ontologies** are based in discontinuous interiority; mind, soul, monadic existence, too. **Animism** and **ontological systems** are founded on **interiority perception**. Human bodies are inherent perceptual organizations forming diverse cultural behaviour. Festivities and **ritual** have its origin on it. **Naturalism** and **animism** are cultural constructions based on the physicality of the body and the soul interiority, and most of them are connected with sound. One extended phenomena is voice, physical and interior. **Ontology** is then formed by **sonic structures of thought**, like **voice in rituals**. **Sound ontologies** will oppose visual primacy to sound, where **auditory phenomena** are its focus of research. **Sound ontologies** will use ritual, performances, myths, hearing, not seeing expressions, and auditory ethnography, to **prevent** from dangerous and unpleasant consequences, imminent dangers and awareness of vulnerable lo-fi soundscapes. It will contribute to a **sound ontology**-based in **trans-specific soundscapes** where indigenous, shamans, medicos or

doctors communicate through spirits in magic rituals in order to understand the **sonic being**. This process of identity formation in cultural expressions is a form of communication constructing knowledge, transmitting ontology through sound perception. Through hearing and sound, being is revealed ontologically to develop myths, narratives and modes of expression. **Auditory anthropology** considers part of the sonic phenomena, the perception of rainforests, naturalism and atmospheric ambiances, practices. Following the concept of auratic (aural, aura) in **Walter Benjamin**, the sound ontology in **Paracelsus**, **Tao Te Ching**, **John Cage** or **animist thinking** are considered **auditory anthropology studies**. The **transpecific soundscapes** consider the use of devices, sound chambers in exhibitions and spaces for acoustic experience, where high, mid and low frequencies are displayed through loudspeakers, subwoofers, reverbs. Here **innovation, technology and progress** meet **preservation**. **Soundscapes** presented in museums should represent the impact of **media through** a transparent and pure conservation. The idea of a **sounding museum** will help to develop new media curating practices.

The screenshot shows a Pure Data patch and its terminal output. The patch consists of three objects: 'dumpOSC 7770', 'route /gpredict/sats', and 'print'. The terminal output displays the following data:

```

print: CO-58 123,159 -53,9153 707,48 7,5009
print: CUTE-1,7+APD II (CO-65) 229,173 -60,473 634,925 7,54383
print: FO-29 359,246 -66,0231 848,025 7,53579
print: ISS 116,732 -70,7868 358,091 7,69515
print: ITUPSAT 1 159,958 -75,417 741,502 7,4841
print: SEEDS II (CO-66) 289,551 -24,5025 632,307 7,54277
print: SO-50 48,3838 -18,5418 705,171 7,48674
print: SO-67 264,38 -56,4115 512,613 7,60599
print: SWISSCUBE 114,978 -76,3763 736,968 7,48502
print: VO-52 307,124 -28,1362 636,447 7,54036
print: AO-27 31,1113 -65,0968 803,477 7,44826
print: AO-51 157,741 1,38554 796,987 7,43653

```

Below the terminal output, a list of installed packages is shown:

```

pd
pd-diff      pdf2ps      pdfinfo     pdf2oabw
pdb          pdextended pdffonts    pdfopt      pdf2html
pdb2.6      pdf2dsc     pdfimages   pdf2texi2dvi pdf2oppm

```

*Gpredict open software tracking satellites' movements*

## sonic landscape

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### Variable space:

Sound is analysed as **acoustic phenomenon**. Acoustics explores the relation sound-space. Using acoustic space as a live element in the creative process, the study of acoustic phenomena is influenced by techniques such ear cleaning and acoustic ecology, a concept developed by **Murray Schafer**. A soundscape is also a tool to map the city; a counter mapping ideology opposed to surveillance. Sound practices in **public space** defence the connections between the place, the

identity and the memory, refusing the commodification of non-places and the unifying non-symbolic landscape proposed by capitalist architecture. Since the surveillance has turn into merchandise, artists and medialabs transform the public space into a more sociable place within the implication of alternative strategies for communication that use geophysical instruments such sensors or lasers. Surveillance designates a society based on pre-

dictable systems, operating through control and exercising power over the citizens. Most of the predictable systems are based on linear reception devices that do not include an immediate response or interaction with the receptor.

Acoustics focuses on **reverberation** and architectural sound. Reverberation depends on time and size of the room. However, the primary intention of the study of the acoustic phenomenon belongs to the perception of the space through sound. The shape of the cave is recognized as a cavity that creates resonances. It has been influent in **Stockhausen, Werner Kaegi, Barry Blesser and John Butcher**, among others. Resonant spaces such water reservoirs have been used in audio works. The power station in **Doncaster** was used as a resonant space for the sonic work by **Thorpe Nash**. **Athanasius Kirchner** in *Phonurgia Nova*, written in 1675, described how elliptical ceiling or anechoic chambers where more satisfactory to transport sound. Curved architectures imply better communication. It adds to the semiotic theory of media a spatial-dimensional in interaction between the listeners and the speaker. In acoustics is used microphones and loudspeaker to amplify frequencies and create a loop.

**Peter Parkin** adds feedbacks screeching the sonic qualities of

real space. In contemporary studies, the acoustic phenomenon is composed of chambers where the dimensions of the space are synthesized through electronic composition. Sometimes in experimental acoustic, white noise is a common effect. It is known how white noise reflects the area. Sometimes the instrument is part of the audio work and the sonic silence, too. The real-time sonic interaction within the instrument, the space and the audience produces an audio feedback. The result is a balanced audio work in between audio-input and audio-output.

Because of the influence of the uncertainty principle in physics, where the saturation of the systems makes impossible its rationalism or calculation or perception, post-studies affected by interaction comprehend sound as an ecosystem. This point is far from quantum physics and adds a biological dimension to "**alive**" sciences, where systems are continually under conditions of openness, movement and flow. Through the development of computer techniques, the sound could be perceived as an audible ecosystem. **Peter Ablinger** demonstrates this in his work. The acoustic dimension is experienced through the use of loudspeakers, microphones or **DSP digital signal processors**. It is the case of **Audible Ecosystems, work made by** the artist

**Agostino di Scipio.** The audio work synthesizes the room, the network and the feedback with the performance. In achieving this step, sound sources and resonances of acoustic space implement the relation machine, human, environment. The principle of **interaction** becomes a unique part in the **generative work**. The results are noise amplified rooms, saturated sounds, discontinued and restarted pieces.

The interactivity changes modern physics. The aesthetics and the computer techniques in sound achieve a high range in calculating amplitude, density and spectral frequency, offering a profound analysis about the acoustic metabody in creative processes. Acoustics techniques also use electronic recordings and stereophonic recording to heighten the features of architectural space. New methods of acoustics recordings (such microphones, artificial reverberations, amplification procedures with different frequency ranges, and other technical devices) allow more definition, transparency and balance. New sound structures generate a new phenomenon and a new experience of artificial architecture of sound. Recording techniques go beyond traditional **3d space**, and it becomes a new frame of spatial reference. Electronic music manipulates the **acoustic space** with

reverberations, intensity, timbre, balance. It proposes a new way of perceiving acoustics. The surrounding space and the immateriality of the environment and the **architectural void** build a strong relationship between **sound and space**. **Multichannel installations** have developed a better sound systems using from 2, 3 or 6 loudspeakers to multichannel environments, surrounding the listener on all sides (including below and above). Some references could be found in peep shows, a new type of theatre, where a new relationship between public and stage is established. Multi-channel installations and freeing the stage of visual elements helps to empty the space with a naked phase. **Multivariable spaces** created by electronic control or **binaural techniques** are creating imaginary spaces or producing the experience of the **space within the space**. According to **Stockhausen** in *Music and Space*, including equipment that electronically controls reverberation, electro-acoustic give a new aesthetic category; that is **variable space**. Interdisciplinary and variability reinforce the immaterial aesthetics that historically have reached the psychology of perception as a process in mind. It implies an answer of the listening process in the subject. **Jean Piaget** in *La Representation*

*de l'Espace chez L'Enfant* suggests different typologies of acoustic spaces: autistic spaces (self-equals space); egocentric (focus on surroundings); projective space (enlargement and differentiation based on emotion); Euclidian space (quantified space in stages); and **non-euclidean space** (modern physics). Relations in art and science, experimental art, intermedia art, new media, film and TV, are all influenced by variable aesthetics and non-Euclidean space. In *Moving Picture and Electronic Music* by **John Whitney**, the non-Euclidean space is a response to indeterminacy of processes. It produces depth and perception. **Cyberception**, in **Roy Ascott**, where there is no space, but a multi-mediated reality with multiple crossed messages.

**Binaural recording** is a technology that stresses the differences between the recorded and the real. The recorded space once reproduced acquires the dimension of a variable space, a space that is in mind, communicated through sound. It also gives a supportive definition of sound as a technological medium, emphasizing the characteristics of the media. Sound reproduction and playback machine are fused into a phantasmagorical perception: the image of the ghost operated between the presence and the absence of the real stressing the technical reproduction of memory.

### Amplifying landscapes:

Soundscapes are capturing the phantom of the spectral sound wave in the landscape. One of the most recurrent practices in soundscapes is **field recording**. Artists who develop practices in this area are **Andrea Polli, Annea Lockwood, Antye Greie, Budhaditya Chattopadhyay, Christina Kubisch, Davide Tidoni, Felicity Ford, Francisco López, Hildegard Westerkamp, Hiroki Sasajima, Ian Rawes, Jana Winderen, Peter Cusack, Steven Feld, and Viv Corringham**.

Steve Feld's objective documentaries exemplify how acoustemology (acoustic epistemology) is a source for sound anthropology. Knowledge, aesthetic value, materials and recordings are linking listening practices with disciplines such ethnography, anthropology, sociology. Methods such participatory observation, informal interviewing, direct observation with data capture through sound media permits an information gathering in sonification and audification processes.

**Sonic Antarctica** by **Andrea Polli** uses natural and industrial field recording, sonification and audifications of scientific meteorological data. Adding interviews with scientist.

**Jana Winderen** based in biochemistry studies, ecology, marine biology and fine art, uses recorded sounds from sea animals, sounds of wind and glaciers. Avoiding her presence in the recordings recognizes her non-neutral representation, based on processing narratives and imaginary spaces.

**Annea Lockwood** works with recording rivers in documentaries like **a soundmap of Hudson River**. Using equalizers show the experience and awareness of the environment.

**Francisco Lopez's** soundscapes are interacting rather than representing reality.

**Brian Eno** is a composer that also uses natural recordings in its inspiring software manipulation. The range of technologies he uses goes from **iphone** to **high-art generative music** making experiments in **technology**. **Eno** has opted for a distance to globalization and industry within exhibiting sound in museum, using different **media** and producing what has resulted in **generative music** or **ambient music**. Audioworks such **Music for Films** (1978), **Ambient 1: Music for Airports** (1978), **Ambient 2: The Plateaux of Mirror** (1980, with Harold Budd), **Possible Musics** (1980, with Jon Hassell) and **Ambient 4: On Land** (1982). In addition, his studio consists of two **Apple Mac G4** computers running logic, plus a selection of outboard including: the Digitech

studio vocalist used extensively on **another day on earth**; a lexicon jam man loop sampler; an eventide **h3000 harmonizer**; and **vocoders**. It also includes devices that allow Eno to exercise 'muscle skill' such **Alesis airfx** and **Korg Kaos pads**. Finally, Eno is famous for his mastery in using Yamaha's FM synth.

Another dimension in capturing soundscapes is using **iphones** technologies. Those enhance the possibilities of field recording. In this sense, there should be a **sound-psycho-geographic-practice** that pays attention to the establishment of security practices in public space consisting of the display of CCTV. Electronic technologies provide video surveillance devices such cameras or microphones in the open space. Cctv, wireless video and other monitoring system are imposed to reduce the crime. Sousveillance is a counter-movement that analyses recorded video material and audio captured and registered from iphone and microphones from mobile technologies. It is a historical novelty about public space sound recording and new journalism. Regarding the **data protection law 1998** it is not permitted to record sound in public space. However, the choice of letting the audible nature of these recordings provide an acoustic referential frame that

is at once technical, creative, and conceptual.

An example of an artist using soundscapes and field recordings is **Maria Papadomanolaki** incorporating to sound recording influences by **geospatial techniques** such **nasa giss** or other devices for measuring temperatures.

**Psychogeophysics** explain landscape and soundscape through the development of experiments in interaction with sound as a local spectral ecosystem. Reading the memory of the landscape, artists give a counterculture radical position of established artistic policies, industries and resources. Following the definition of psychogeography, psychogeophysics summit introduces to the study of the geographical environment, the consideration of emotions, behaviour and mental states of the citizens and passers-by. Including geophysics and studies of local spectral ecology, the term psychogeophysics was first used explicitly during a research group conducted as part of the Transmediale.10 festival, Berlin, February 2010, entitled topology of a future city. Psychogeophysics names a new direction in which many artists and researchers have explored recent history of sound. The first psychogeophysics summit took place in early august 2010 in London, assembling an international group

of artists, researchers and theorists to promote this novel discipline with a series of public oriented experimental workshops and seminars investigating various psychophysical fictions in east London. Psychogeophysics borrows techniques from **evp/itc (electronic voice phenomena and instrumental transcommunication), classical psychogeography, thoughtography, amateur radio astronomy, archaeological geophysics, tempest analysis and environmental steganography**. These techniques include **excitation, intervention and performance**, domains and frequencies (**earth or skin resistance or impedance measurement**), **low and high-frequency electromagnetic radiation detection** and all frequencies of **sound signal detection**. Apparatus and technologies that are used correspond to **VHS, tape recorder, television, magnetometers and spectrometers** and sometimes **electroencephalographs**.

Psychogeophysics also contributes aesthetically and technically to re-mapping, archaeological geophysics of urban locations, **data forensics, hidden emissions** and geomagnetic phenomena. There are psychogeophysics activities and projects such day collective exploration of **spectral phenomena**, investigations of **non-causality** and detection of **anomalies** within processes of measurement and

observation. So, psychogeophysics authors follow to describe a non-scientific knowledge based on research and experience. Its constant influence of landscape, memory and drift, besides **electromagnetic techniques** and factors such **indeterminacy, uncertainty**, refer to our hearing as a response and transposition of the sensible metaphor of metaphysics.

#### Satellites' technologies:

According to **NASA**, our planet is a natural source of **radio emissions**, which surround us all the time. **Radio waves** propagate in the earth's atmosphere, ionosphere and magnetosphere, and cannot be heard by humans since they are electromagnetic waves. When we convert them to sound waves, they can be detected by our ears. The way these waves sound, when played through an audio system, defines their name: **sferics, tweeks, whistlers, chorus, and hiss**. The **University of Iowa** has developed the **polar plasma wave** an instrument to capture sound of the magnetosphere. The **Department of Physics and Astronomy**, at the University of Iowa, developed the **Plasma Wave Instrument (PWI)** to measure the plasma waves in earth polar regions in between frequencies of 01 Hz to 800 Hz. Although

most of the sounds are in the acoustic frequency range, they are not audible to the human ear. These sounds are produced by processing the original wave data, in the same way, that radio stations process signals. The **Polar Plasma Waves** detected different range of sounds and was powered on 1997. The **Plasma Wave Instrument (PWI)** contains various **antennas: orthogonal electric dipole antennas, magnetic loop antenna, triaxial magnetic search coil antenna; five receivers: a high-time resolution multichannel analyser (MCA), a narrowband sweep frequency receiver (SFR), a high-frequency waveform receiver (HFWR), a low-frequency waveform receiver (LFWR), and a wideband receiver (WBR)**. The data processing is done through the multi-channel analyzer and the **signal processing** by the five receivers system. **Static electric field and magnetometers** are used, too. **Receivers and antennas** are used to design the plasma waves, altogether with a **software. Microprocessors** are part of the electronic circuit and help the constant signal being strength. The input signals with the use of a **compressor** are transformed into data values, processed logarithmically. There are also noise filters and noise generators that work together with the Sinewave's output and the wave's amplitude captured. Memory storage is used

to keep data. Sensors and signals are also part of the PWI. Previous **plasma wave phenomenon** were **detected in 1933** by **Burton and Boardman**. Using a telegraph line and a telephone receiver as a simple receiving system, **Burton and Boardman** discovered that bursts of very-low-frequency (VLF) radio "static" were sometimes correlated with flashes of aurora light. These observations were confirmed in later studies by **Ellis, 1957 and Dowden, 1959**, using ground-based VLF radio receivers.

Following, software logarithmic calculations of the variation of time between spectral frequencies in herz give different sounds: **whistlers, saucer, chorus, "aurora hiss" emissions, aurora kilometric radiation (akr). Whistlers** were first detected during the World War First. They are audio frequency electromagnetic waves produced by lighting. These waves travel along closed magnetic field lines from one hemisphere to the other. The resulting sound depends on the length and refraction of the wave. **Saucer** emissions are found near the low-latitude boundary of the auroras' precipitation region. Saucers are electromagnetic whistler-mode emissions. Saucers are upward-propagating emissions that usually last only seconds. On the audio tape, the saucers have distinct falling and rising tones. **Chorus**

emissions are electromagnetic emissions, and they are among the most intense plasma waves in the outer magnetosphere. The spectral characteristic which gives these emissions their name is the succession of predominantly rising tones which sound like a chorus of chirping birds. These rising tones are very short in duration, typically only 0.1-1.0 seconds. **"Auroral hiss" emissions** are broad, intense electromagnetic emissions which occur over a wide frequency range from a few hundred Hz to several tens of kHz. The resulting tones on the audio tape are strongly modulated hiss-like tones. **Aurora Kilometric Radiation (AKR)** is an intense radio emission escaping outward from the earth auroras regions at frequencies above the local electron plasma frequency. AKR usually consists of a very intense band of radiation in the frequency range of about 50-500 kHz.

More information regarding the exploration of sound in the **outer landscape** is provided by **STEM Science Engineering Technology and Mathematics** network that facilitates approach to studying and explores very low frequency natural radio. **The Inspire Project** is another example that does research on sound in outer-space. Presented by NASA, Inspire Project presents **physics ionosphere radio experiments with VLF signals receivers' devices**.

Another supporting practice and regarding **aero-spatial practices** is **Laboral Orbiting Satellites**. These sound practices should be included in **new media theories**, as well as in sound studies. Apart, the dimension of its production enriches the field of **new media curating** adding to the exhibition space, **museum and institution** the figure of the **collaborative lab**. Live participation, practitioners, artists and audiences are reunited. Moreover, that kind of collaborative practices approach the theory, asking and demanding researchers to add theoretical conclusion to the final result. **Orbiting satellites** was a **workshop and an exhibition** conducted by sound artists, engineers, hackers and musicians; the workshop used **geophysics methodologies** and typologies for a quantitative observation of the earth, the sun and lava flows altogether with its correspondent physical properties. **Orbiting Satellites** was part of **plataforma0** and took part in **Laboral Gijon**. It showed some of the results of the investigation process begun by **Plataforma0** in May 2011 with the meeting of a group of artists, investigators and amateurs dedicated to listening, watching, thinking and imagining satellites. The aim was to approach and improve the observation and listening to **satellites** and its **technology**. The outer space

features and their poetics were used to analyse data captured from satellites and transcript it into sound and images. Among the participants were **Alejandro Duque, Joanna Griffin, David Pello, Reni Hofmueller, Luca Carrubba Husk, Lord Epsilon, Xiu Cueva, Bruno Vianna, Cinthia Mendonça, Laura Plana, Pedro Soler, Gonzalo Garcia, Pablo Gallo, Victor Mazón, Raquel mp19, una\_fremen, Ana Arboleya, Nuria Rodriguez, Cristina Ferrández, Lorena Lozano, Josian Llorente, Aritz Zabaleta**. The manual **Orbiting Satellites [OS]** presents text by text and one by one all of the authors. It is said that since 1990s, the arrival and growth of the **internet** facilitated the exchange of information among natural **radio hobbyists** and eventually made real-time **solar and geomagnetic** information available to everyone. During the workshop, the participants developed and learned from different tools, **software and hardware** to manage and listen to the satellites that are already orbiting the earth. A list of the devices used includes: **gpredict**, a real-time satellite tracking program based on John Magliacane's tracking engine and written by Alexandru Csete, also known as oz9aec, a physicist at the University of Aarhus, working in the European Space Industry, holder of a cept cat.1 amateur radio since 1991. **Pure data,**

written by Miller Puckette and the PD community, used by Husk, connected via OSC to gpredict in the audio track of the exhibition called Dreaming Satellites. **Gnu radio**, developed toolkit that provides the signal processing runtime and processing blocks to implement software radios using readily available, low-cost external RF hardware. **Sattrack3d**, written by Makoto Kamada, japan. **Fun cube dongle** that connects the antenna reception to gnu radio via USB by amsat-uk as part of the funcube satellite project. **Openrotor**, built by David Pello, is an ionic satellite fountain model based in one constructed by Bruno Vianna. **Osc module for gpredict** envisioned as a useful bridge to allow experimental uses of data in sound installations. All this techniques and different range of tools, allow artists to capture sounds, intercept communications and provide more information about the outer space. All was an exercise in the imperceptible realm of the waves of radio-electric frequencies to spot and listen to both geosynchronous and low elevation orbiters. To locate and observe, like the ornithologist, guided by sound and spectral analysis technologies of the Victorian age, and given as a result soundscape captured with a VLF (very low frequency) receiver to allow the listening of satellites.

**Sonic landscapes** contribute to media ecology with audioworks offering an ethical composition and an aesthetical resolution for the preservation of the space, the urban space, or the outer space where waves have been captured and reshaped into sound. Protection laws should develop an active policy to facilitate the research for audio work in the conservation of sound as (eco) system. It has to be said that within the last examples, orbiting satellites or psychogeophysics summit; all these practices are using spectrophotometers, spectrographs or spectroscopes to measure the unit of light in the electromagnetic spectrum. Magnetometers are frequently used, too. It is primordial to use and understand these devices and tools in the creation of audio work to define the nature of the sonic landscape. In addition, radio waves detectors, wavelength in airplanes with autopilot for geoscientific exploration and remote sensing apparatus.

#### Streaming networks:

**Streaming technologies** are part of the sonic landscape too. Streaming is a new technology developed through the extensive of personal and collective use of **internet**. **Streaming media** uses **multimedia devices** in a regularly

received communication by and presented to an end-user while being delivered by a provider. Its verb form "to stream" refers to the process of providing media in this manner; the term refers to the delivery method of the medium rather than the medium itself. The first band to **perform live on the internet** was on June 24, 1993 while scientists were discussing **new technology** (the mbone) for **broadcasting on the internet** using multicasting. As a proof of their technology, the band was transmitted and could be seen live in Australia and elsewhere. Most parts of the streaming developers encounter support within the **Real-Time Streaming Protocol (RTSP)** which was specifically designed to **stream media over networks**. Rtp runs over a variety of transport protocols. Some examples of streaming channels are **VideoLAN**, an open source media player and streaming server. Another one, **Giss TV**. The open source movement streaming channels were created to supply the needs and requirements for the most part of visual artists and media artists working in a **performative time based art**. Such devices have the optimal conditions to control distributed communications online in real time and also to gain the features of internet, being **worldwide broadcasted**. It is the origin of **stream art**.

Another fact that contributes to understanding the meanings of stream art as a new media art is the creation of **Streaming Museum**, New York. Directed by Nina Colosi, Streaming Museum presents contemporary-themed exhibitions of international fine arts, pop culture and cross-disciplinary perspectives to the global audience through an expanding network of screens in public spaces on seven continents. All are partnering cultural centers in collaboration with [streamingmuseum.org](http://streamingmuseum.org). Since 2008, millions of people have viewed streaming museum's exhibitions in over 65 locations around the world. Streaming museum is part of the inspiration-and-information-with-social-value economy. So, it is believed that the arts and technology are challenging inspiration and knowledge to make the world a better place.

A more particularly example using streaming networks for the **development and storage of sound creative practices** is the one developed by **Brad Brace**. The net-art based artists have created an online channel and archive to **live stream sound**. All, mono recordings, using mics and a tiny \$7 radio broadcast, includes five-hour recordings from Canadian arctic, recent compilations of radio programming, field recordings from lake brule, over

13 hours of fresh mp3 monaural rips, radio-drifts and forgotten film-soundtracks. **Brad Brace sound project** is named the **global islands project**, including strange, compelling recordings from the car radio under high-frequency transmission, ongoing series of multi-media pdf books and a pastoral, pictorial and phonic elicitation of island parameters. Its server status is currently updated and public. The stream is up at 128 kbps with 1 of 6 listeners. This example is considered a **stream genre in field recording and wild sound**.

Here it is mentioned different supporting examples to illustrate the idea of **streaming networks** as a solution for communicating and storing sound online. **Live streaming** includes practice with **microphones and field recording**, as well as **servers, protocols, domains and generally, internet**.

One of the most advanced systems of streaming is the networked platform **Locus Sonus**, a Pure Data tool for **microphones** and **soundscapes** that collaboratively creates a **network of connected profiles worldwide** established. **Locus Sonus** is a **live open microphone network online**. The project locus songs are a global open microphone network based in southern and central France. Locus Sonus is engaged at all levels,

from hosting a network to develop streaming hardware and promoting research. All these different ways to produce audio works or artworks offer a new possibility to understand and interpret reality of sonic landscapes.



Sound as (eco) system:

The **Japanese group-oriented society confronts the Heisenberg theory based on the particle modulation and wave modulation in western quantum** society. Mechanistic science and its culture show an increased dissatisfaction. From Hegel, Webern, Jung until Sartre, **science** has been opposed to altered perceptions. A new science raises an opportunity for **technoscience and bio-science**, based in a more human and intuiti-

tive science. Although physics has socially displaced spiritually, there is a high growth in the human mind conscious, producing **intermedia** projects connecting biology, politics, philosophy or literature. **Physics** is a language that provides testable vision of reality, and it is indeed a universal language. Founding father of **quantum physics, Werner Heisenberg** stated that modern physics is a very characteristic part of a general historical process that tends towards the

unification and widening of our present world. Our world becomes a quantum transformation, based on Newton specifications where the world is not static. So, the mechanical systems are determined and predictable. Meanwhile, the **chaotic systems** proceed through **excitation**, defined as **indeterminate** and astoundingly complex. **Indeterminacy** and multiplicity are the principles defining the quantum realm. Packets of energy fill the **quantum theory**, developed by the **physicist Max Planck**, where the energy is a tiny lumpy unit. **Niels Bohr** defined the atom's electrons as energy in a state of orbit, moving into a discontinuous quantum of energy. **Indeterminacy** is present in the solar system, and nucleus of particles and electron energy give form to atomic theory for the solar system. Energy patterns are deluding self-organizing system, between order and disorder. In these states, too much disturbance applied causes the system turns into pieces. Contrary, too much law used and the system dissipates. A **self-organizing system** that relaxes falls out of the dialogue with its environment. It is understood that natural physical systems organize **spontaneously**, between order and chaos. Those are critically organized. It has been a recent case of study how system became **sensitive to stimuli** like in **brain dynamics**. **Unstable media**, child-

ren, artists, psychotics are **spontaneously organized**. In physics, the quantum vacuum could not yet be perceived or measured. It is considered void, seems empty, and it is called vacuum, similar to a black background universe filled with particles and waves conforming a quantum reality. In quantum dynamics, wave-particle shows dualism. High energies and impermanence are principles for quantum field theory. It represents a new model in contemporary science where waves and particles based in Einstein relativity theory are proving that ether does not exist. Any substance fills the Universe. It is a pervasive potential principle. It is unseen, and vacuum replaces the ether. It is evanescent, not empty. Where there is not something, not anything, a vacuum state of energy, a flux, a stream, a force that moves, a wind emptying the air, reaching no air, fluctuations between the poles, electromagnetic orbits, oceans, seas and waves of electromagnetic forces and nuclear energy. All those can be studied through **processes of condensation** in superconductors and the Boson field phenomena.

Condensation processes and **changes in matter** are tested in **brain excitation** through the hearing sense's input into the thought. Superconductors used in sound leads to second sound phenomena. Second sound is a quantum

mechanical phenomenon in which heat transfer occurs by wave-like motion. It is known as "second sound" because the wave action of heat is similar to the propagation of sound in air. Ordinary sound waves are fluctuations in the density of molecules in a substance; second sound waves are fluctuations in the density of phonons. In any system in which most phonon-phonon collisions momentum happen, the second sound can be observed. It occurs in superfluid and also in some dielectric crystals applied to sound practices.

In addition, **Media Art** is mostly based on **theories of communication**, epistemological experience, semiotic process of lecture and interpretation, like hermeneutic, symbolism or phenomenology. The **cybernetics** or the **science of communication** is part of the **Media Art studies** influenced by **theory of computation, systems' failures and errors**, relativism and non-defined processes. Moreover, **noise theory** is based in **non-predictable systems, dynamical processes**, such those **high sensitive to initial conditions** rendering long-term prediction and **affected by time**. Some can appear in **chaotic electrical circuits**. Noise theory also refers to **uncertainty principles and chaos disorder**. Most of the dynamical systems are **sensitive to**

**initial conditions**. So, **sensitivity to initial conditions** is a feature of chaotic systems affected by arbitrarily, small changes and perturbation. In 1972, **Edward Lorenz** made the firsts approaches to **Chaos Theory**. **Chaos Theory** includes  $k$  systems and ergodic theory and is based on strange attractors such Lorenz attractor (the first chaotic system diagram with an intricate pattern). Complex patterns are studied in **fractals structures** and are operated in fractal dimensions or minimum complexity in a chaotic system. There are studies regarding **synchronization in chaotic systems** like coupled oscillation of Christian Huygens, neurons, resonance phenomena, ergodic physics and some radio engineering. **Linear theory** or **systems theory** cannot explain logistic maps doing measurements on **imprecision and noise**. Contrary, **chaos theory** refers to electronic computer repetition of simple mathematical formulas and calculations. Following, **Benoit Mandelbrot**, based in information theory, deducted that **noise** appeared in free periods of errors. These intervals were inevitable and produced discontinuous changes. Mandelbrot insisted in the fractal geometry of nature where **fractional dimension of infinitesimally small scales were irregularly constant**. So, **non-linear systems theories** were de-

ducted from **chaos theory** and received influences from **information theory**. According the studies, there are different **non-linear systems**. System with no time series could form pure signals types of corrupting noise. For example, in **stochastic systems** where could be found an error under differential time conditions. The **stochastic systems** have randomly distributed errors. **Deterministic systems** have a mistake that remains stable and regular. Investigating the failure in between two states is deduced that randomness increases dimension of the wave. In **non-linear deterministic systems**, external fluctuations produce severe permanent distortions. Noise amplified has non-linear dynamic properties. **Non-linear feedback systems** are produced by interactions between nonlinear deterministic and noise. **Stochastic systems** could be found in computer sciences such cryptography and encryption, sometimes leading to confusion. Others examples are DNA, computing, quantum physics and electrical engineering. Finally, there are complex adaptive systems, fundamentals to understand the natural **nonlinear structures** based on the interval of external forces. **Feedback noise is used** as a media language in responsive systems. Concluding, these processes are revealing factors such the **meta-communication, intentionality** and **non-**

**determination in systems** of information.

### **Cyber-sound:**

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The reduction of unwanted noise by engineers in **cybernetics and computing** is used to connect sound with art, science and technology. **Cybernetic studies** regarding sound are experimenting with stochastic processes. In this direction, research in the plasma gas has concluded to the development of devices such as plasma loudspeakers. Composition of audio works is a complete construction offering meaning and answer to the space that surrounds us. This idea is defended in **cybernetic theories** developed by **Norbert Wiener**. The author offers an analytical response to understand the sound as a non-linear system. Through an approximation to noise as an effect in the computational process, the sound is known as a **chaotic and non-determinate responsive process**. When sound collapses is considered noise. Moreover, Norbert Wiener cites the **Copernican system and the Ptolemaic system** as philosophical examples to study the geocentric system of the universe. Those ancient traditions are based on the trigonometric analysis. However, in a **complex system (such as electronics, computing or physics)**, **random and indeterminacy** are

main features of **non-linear processes**, making the systems become more complex and sometimes subjective. Noise is understood as a **random system**. It creates an approximate definition of the creative processes in the universe. In **Norbert Wiener**, all these considerations regarding **complex system** lead to open a new direction for contemporary **science**. It represents the development of new models of **technoscience** based in **electronics and biology**. The new model of science is dedicated to the study of "alive" system and processes in life as **complex, dynamic and randomness**. Finally, to understand sound like an (eco) system.

**Cybernetics** is a confluence of biology and electronics and in some part of its studies uses sound or noise to analyse complex systems. Indeed, the **cybernetics** theories support the idea of **cyber-biology, technoscience and cyberfeminism**. This new science considers the **sound as an eco-system of spectral frequencies**. Cybernetics studies of frequencies and spectrums and various ranges of amplitudes altogether too **homeostatic processes** or **condensation processes** lead to consider the reaction of gas and air in the spectrum of sound. The **experimental use of sound** in cybernetics connect art, science and technology and resolve the idea of **noise** as a fundamental

part on cybernetics theories. **Cybernetic noise** considers and connects with disciplines such as computing, engineering, cardiology, mathematics and neuroscience, a part of sound and vision.

**Cyber-physical systems (CPS)** are becoming a promising research field to integrate the **computing** components, the **physical** processes and the communication **networks**. The primary challenge in designing **CPS** is to understand the effect of physical factors on the **communication**. It is proposed a mathematical model to present the relations between the performance or the **controller area network (CAN)** and some **physical** factors, such as the temperature, the impedance value and the **electromagnetic interference**. The first two factors are not considered in previous studies. **CPS** systems are based on the probabilistic density function of the voltage generated by **noise**. It can be obtained insight into the **bit-error** rate a function of these **physical** factors. It gives an approach to fundamental insights into the **impact of the physical factors on communication**. **Cyber-physical systems** are in charge of the **control of physical processes** characterized by **dynamics or movement**. This control must comply with timing constraints to capture changes in the system. **CPS** system cases of studies are **generative**

**software, interactive installations and neural signal systems.**

### **Neuro-noise:**

Studies and experiments with **brain waves** give more information about **biological process and brain functions**. Sounds coming into the mind provide us with a physical response to the surrounding environment. Another supporting idea is **Music of Changes** by **John Cage**. In John Cage, **Indeterminacy** is the central feature to create music. **Nonlinear systems, uncertainty, fractal, indeterminacy, randomness, chaos** are the main characteristics of music according **oriental system of thought**. John Cage opened the possibility of the **indeterminacy**, a prophetic style in art and music that developed the cutting edge scene of the vanguard culture. It took some references from cut up projects. In its study of **language** as a **multi-layered content** in the **brain**, John Cage described the use of different **registers of voices**, especially those what allow to the personality and to the human being to develop **memory and to communicate**. These records are studied by artists belonging to beatnik generation: **William Burroughs** and **Brion Gysin**. In their poetics and aesthetics, the beatnik generation, the Fluxus movement and the conceptual

artists followed orientalism and zen attitude. All producing audio works resembling **inner landscapes, states of the soul, transcendent and immanent inner visions**, explaining **"spacing out" phenomena**. **Bronac Ferran**, the author of *Mind over Media*, contributes to this theory with her participation at '*Make your own Dream Machine*', an exhibition that was launched at FACT Media Centre, in December 2013.

Nowadays, the artists have a better scientific approach resolving the problem of the senses, using methodologies based on atomic physics or **neuroscience**. Electronic interactions altogether to life sciences, **psychology, psychiatry, neurology, physiology, technology for arts, music, tv, film, radio** or **Kinect art** have led to a major understanding of what the **cerebral cortex** is. In **1929**, **Hans Berger** discovered the alpha rhythm, a fundamental rhythmic brain signal that could be used as a **mental remote control**, through **electroencephalographic (EGG) data operated through open source software**. In this field of research, the functional cortical areas are determining **control behavior** and physical actions. Spontaneous electrical signals have also been found in the cortical origins. Signals generated by cerebral cortex in the brain are translated to data or digital information, then used as a source for sound genera-

tion, producing, for example, feedback loops. The result is **electroencephalo-music**, a sort of **spontaneous music**, created by cortical signals producing sounds. Factors such as attention and distraction determine the outcome. In a **feedback loop circuit**, bits of cortical material are processed into sound. Sound can be produced immediately or stored in sound sequences as signal data. Between the behavior and the recorded, remains a relative state.

In neurosciences studies, **neural signals receivers** are commonly using **CMOS** technology.

Low-noise biopotential recording circuit are a CMOS micro system that provides an excellent method for the reduction of noise in a **low-frequency signal processing**. The simple circuit structure can be a widespread application for **neural signal recording**. The circuit consists of a close-loop bio-amplifier circuit. As demonstrated by simulation results, the circuit significantly suppresses low-frequency noise and focuses in the **bio-potential signal**, in a range from 10 Hz to 10 kHz.

Another example, ultra-low-power neural recording microsystem for implantable brain-machine interface, is an implantable CMOS microsystem for the detection of **neural spike signals** from complex brain neural potentials which achieves the characteristics of

ultra-low-power and high-precision. The neural recording microsystem consists of a low-noise **bio-amplifier**, a **neural spike detector** based on nonlinear energy operator and a precision hysteresis comparator. It is introduced into the bio-amplifier a new active feedback configuration, the algorithm is implemented by simple analogue circuits operating in sub-threshold region and the hysteresis comparator is added to determine the location of neural spike. The proposed system precisely detects neural spike signals from extracellular recording.

**Neuro-noise and neuro-feedback** are used in neuroscience system altogether with hearing, psychology, physics or engineering and are articulating sounds that response to stimulus or signals sends to the brain. These **electrical signals** are transmitted to **auditory nerves**. They are called **brain alteration techniques**. Artists to be mentioned and developing studies in art and neuroscience are: **Roy Ascott, moist media and mediated mind; Jonathan Kemp, experimental communication system; Ryan Jordan, Hylozoistic neural computation; Mick Grierson, real-time interaction activity research on cognition and perception.** Wendy Hasenkamp uses **MRI scanners** capturing attention/distraction phenomena. Following, in the Max

Planck Institute of Physics, **Thomas Fritz** develops the research on **human cognitive** and **brain sciences**. Based in Leipzig, Germany, defines how music activates the **brain stimulus**. In some occasions, excites and releases dopamine. Fritz is interested in the mind as a chemical messenger through the nervous system. **Peter Weibel** is one of the recognized artists that defends the neuroscience as a discipline to be connected to sound, art, science and technology. Following to Abraham **Moles** in the **Information Theory and Aesthetic Perception**, it is understood how conditioned communications systems are. **Neuro-aesthetics** are developed following this field of research. Attention receptors in systematic experiments are underlying the a-perceptual limits of neurosciences. Aesthetic or psychological tests conclude how the reception determined by psychophysiological laws or social-cultural background could modify electronic music, in living theatre, multimedia environments or bioart.

### **Biomusic:**

*"Korg have their Kaos pads, which are a way of taking sounds*

*into the domain of muscular control. If you have a few kaoss pads in line, like I do, you can start playing with sound itself, with the physical character of the sound. The pads are very intuitive; anyone can learn to use them in a second. It is immediately obvious what you do, and it immediately takes you to a whole different place. Because when working with computers, you do not use your muscles in that way. You are focused on your head, and the three million years of evolution that resulted in incredible muscular skill does not get a look-in. I would say that, funnily enough, the muscular part is more likely to bring out our collective, shared part while the brain region is more likely to be an individual, separate part. I feel that when I am in the muscle world, I am getting out of this little thing I call Brian Eno, and I feel more connected to a bigger community."* Brian Eno.

Sound studies have amplified its field of research to the use of feedbacks or biopotentials. Skin detectors or complex dynamical systems operate integrating the response or the interaction with the subject. Biomusic focuses its studies in sensory stimulation systems. Biopotentials use skin sensors in information processing. Electrical signals generated are detected as an information source. Psycho-galvanic skin reflex and

skin resistance sensors are biopotentials. Signals generated by involuntary muscular contraction are captured and processed. Biopotentials are using these particular sensors to create bio-music. Biopotentials are electronic systems with biological potential detectors that create real-time feedback loop. **ORCUS** research started developing biopotentials in 1960. Through the control of the physiological state of the performer and within a biological real-time monitoring system, the electronic generation of visual, aural and electrical stimulation is applied to the organism. A biofeedback is generated stimulating the organism. Biopotentials work capturing motion through biofeedback in order to produce biological feedback stimulation. The biological feedback sensory stimulation amplifies electrical signals. Biopotentials attached to the body or in its proximity convert these responsive signals into aural, visual or electrical phenomena. Biopotentials feedback respond to voluntary and involuntary movements or emotions, to control them again in order to generate feedback. Muscle stimulation, sensory deprivation, and sensory bombardment will be incorporated into bio-music. It can use electric shock in low intensity or real-time biological feedbacks controlling physio-psychic expe-

rience. Biopotentials are also informational systems for biomusic techniques. Biopotentials are applied to art, science, technology, psychology, neurology, pharmacology or psychoacoustics, too. Some examples are tracking eye movement with a pair of electrodes attached.

Another example is the **Bio-metric Sound Engine (BSE)**, 2001. It uses biometric identification systems like iris scanning. Personal data like the colour of the human iris is not used only for surveillance or identification purposes but for emphasizing the beauty and inimitability of the individual. The *BSE* is a piece of software that generates soundscapes out of the colours and structures of the iris' picture. The underlying algorithm produces parameters out of the global and local pixel information and moves them to a synthesizer to form sound structures as complex as the individual.

Marco Donnarumma; sound artist and live media performance developer use biophysical media in the *Xth sense (XS)*, a biophysical musical instrument. Developed in 2011, it consists of a microphone picking subcutaneous mechanical vibrations. This work explores the territory in between bioscience, music technology and performance art. Marco Donnarumma was awarded the first prize in the Guthman musical instrument competition

(Georgia tech, us) for the Xth sense, a biophysical technology described as the "world's most innovative new musical instrument".

Usually, **biopotential sensors** are used to detect the human body's **nervous system**, which functions through EBB and flow of ions to communicate. This ionic transport within and along the nerve's fibres can be measured on the surface of the skin using a particular type of **electrochemical sensor**, commonly referred to the surface recording **electrode** (sometimes just called the electrode). An excellent reference to understand the operation of the electrode can be found in the medical instrument by **Webster, 1992**. The purpose of the electrode is to act as a **transducer** between the ionic transport of the **nerve and the electron flow** in copper wire. **Myoelectric signals** are necessary for a variety of medical applications, the game industry and art. A central feature of **myoelectric signals** that is essential to further developments is its amplitude. The amplitude of a myoelectric signal is thought to represent the contraction force of the respective **muscle**. Some myoelectric signals are used in control of the hand prosthesis, and its **sonifications** are a possible application. Some phenomena can affect the **transduction**, such radical **interference** in informa-

tion transmission, **unintelligible rendered sound**, completely disavowed sound or misled sound by incorrect data.

**Incorrect data transmission** is supporting awareness theory in **media ecology and media archaeology** studies that declare the fatal technique's embrace. Random decisions or combinatorial rules differentiate among control societies governed by prediction systems and unpredicted systems developing other uses of technology and devices.

#### **Intermedia interactive immersive environments:**

Answering about what is **interaction**, it comes that the **communication** is an interactive process. **Media** are interactive, too. Once media and **digital technology** become more accessible to the masses, the interest in interactivity increases and becomes a cultural trend especially in the arts. The **human-computer interaction** and the **human-human communication** are typologies of **interactive communication**. Human to human interactivity is also interaction. However, human-computer interactivity is essential in new media communication. Human-computer interaction is an experimental field based on cybernetics and communication. According **Rada Roy**, "the human-computer interac-

*tion model might consist of 4 main components which consist of human, computer, task environment and machine environment". Interaction consists of people performing with computers or models of human-computer interfaces. The human to human interaction considers **responses to physical movement, body language** and explanation to **mental states**. However, others types of interaction are considered too: **haptic interaction**, used in electronic art as an evolution of the optic interfaces to the haptic interfaces. Haptic mode of interactivity is any form of **non-verbal communication** involving **touch** (from Greek ἅπτω = 'I touch'). **Interactive art** includes computers, sensors (movement, meteorological data), internet, virtual reality, electronic art or performance. It started in 1990's. It includes audiences' participation, responses and interpretation. **Frank Popper** has written: "*Ascott was among the first artists to develop an idea about communication science that is human, but understanding the methodology of technology that resembles human behaviour and natural patterns. Aside from the "political" view, it was also current wisdom that interaction and engagement had a positive part to play in the creative process*". **Interactive systems** are developed in **sonic interaction design (sid)**. **Consisting in** proposing artefacts*

that offer a functional and representational quality of the sonic. Some apply the signalling role of sound. The interdisciplinary field of Sonic Interaction Design (SID) challenges approaches to consider sound as the active medium that enables novel sensory and social experiences through interactive technologies. Other uses of SID are **mobile music, sensorimotor learning**, rehabilitation, gaming, situating **interactive sound** as a **multisensory experience**.

Moreover, interactive sound environment is **installations** that the result it is not an object neither an image. These environments focus on **sound responses** and the interpretation through sound of metaphysic knowledge. The **non-verbal signals** of sound in **media communication** will be used to compose different range of sound installations that typically are directed by **interactive response** and **immersion** into the environment. Here could be found **interactive installations where sound responds to light, or installations where sound responds to the movement**. It will also study **transducers** such **accelerometers** and others **sensors**.

Besides, **interactive installation** where sound **responses to light** could use **sensors, solar cells, lasers harps, flashing lights, lamps, strobe lights** or any light source with luminous flows **modifications**. Light sensors transmit

the bright impulses and variations to a data-processing program. In return, a hidden computer analyses data and plays the sounds generated with the movements of the lights. It produces **complex acoustic environments**. So, sound comes from light intensity. Another technical recourse is using **wireless photoelectric sensors** distributed throughout the performance space measuring the changes of light in the environment. Part of **responsive sound installations** to luminous conditions has a natural - technological implication, but its interest is in media ecology. In immersive environment, sound is produced by light sources without the interpretation of data analytics or software, creating an electronic circuit with sensors and generators.

An **interactive installation which sounds response to movement** is **dark matter** by the pioneer **David Rokeby**. The darkened gallery space is dominated by an invisible sculpture of silent sound. The body probes the area listening to the spatial form to be expressed through the sounds of the contact with its immaterial presence. **Infrared sensitive video cameras** survey the darkened gallery from 4 angles. These **cameras** carve up the space into thousands of 3-dimensional zones. The selection of the areas has been attributed to sound behaviours. Together, these **interactive areas** define a

**complex physical** but invisible form in the gallery space. A computer cross references from the cameras. It works out which regions are experiencing the greatest physical activity at any given moment. Then, it plays the sounds linked to those zones through an 8-channel sound system, distributing the sounds through the space in relation to the locations of the physical stimuli. The sounds are all very physical: breaking ice and breaking glass, creaking metal, falling rocks, bursts of flame. Starting with an empty space, the work can be described as an **interactive sculpture of sound**.

Following the same aesthetic, artist **David Rokeby** produced another artwork in the same direction. *Measure* is using an extremely simple and regular **sound source**, a ticking clock. A **virtual acoustic space** is presented through which the sound resonates. **Movements** transform the acoustic behaviour of this virtual space. This **virtual space** shifts, collapses and explodes relative to the gestures of the people in the area around the clock. The actual installation involves a ticking clock suspended in the middle of the installation space and an interactive acoustic processing system triggered and controlled by movements around the clock. The clock's ticking is amplified and fed into an acoustic processor

whose parameters are modified by the dynamics of gestures made by the gallery visitors in the proximity of the clock. Initially, with no movement, the straight sound of the clock is heard. Small, initial changes cause slight disturbances in the rate of flow of time, as represented by the ticking. Slightly higher levels of movement bring the ticking into self-syncopation, and beyond. Significant circulation in the presence of the clock causes radical mutations of the ticking sound. At its extreme, the measured pace of the ticking falls apart into a chaos out of which a resonant tone emerges. After the visitor(s) have left, the clock settles back into its steady ticking.

**Noise responsive environments** can be produced through **actor's movements**, too. An example is the **motion tracking experiments** conducted at the castle of Montalbano, Elicona, during the residency of **Trasformatorio, 2013**, the laboratory context based on the development of innovative site-specific performances and theatre installations. Federica Dauri is in charge of movement improvisation. Antoni Rijekoff and Jestern a.k.a. Alberto Novello is in charge of the **motion tracking and sound design**. It consists in the modified space perception using **sensors**. It is a dance with physical improvisation and sound

improvisation. The work is influenced by shamans, morphic field theory, Popper, Jung, and Bergson. It is also based on holistic systems and permaculture as well as networked communities and the sustainable development, ride by principles such as efficiency of energy, affordability and connectivity. The work is set in Montalbano Elicona, north-east Sicily. Supported by the University of Messina, the project is developed with the use of **sensors from STEIM (Studio for Electro-instrumental Music)**. The dancer controls the sound using **motion tracking software** activated through a **sensor tracker device**. Jestern is using **motion tracking studies**, connected to **sound and mapping the movements** of the performers. Sound and movement are interconnected. Above, it uses: **pan::ik (an asus infrared, Kinect model camera)** and the **steim sensors** called **minibeas** that communicate with the **computer wirelessly**. **Minibeas** are just **acceleration sensors**, but jester has included a **flex sensor** for the performer. The **software is sophisticated: vvvv, max/msp and supercollider** for the sound synthesis. The **sense/stage minibeas** is a **small, battery-powered Arduino-based wireless node** that can be worn on the wrist, sewn into clothing or embedded in bodies. Each node is equipped with a built-in **accelerometer** (ideal for

capturing motion), but also has analogue/digital input possibilities for adding more sensors. It can communicate using osc. The performer can have as many or as few of these nodes as needed. It uses data sharing software to translate into sound.

**Accelerometers** such the **minibee** are considered **transducers**. A **transducer** is a device that **converts a signal** to one form of energy to another form of energy. Energy-types include **electrical, mechanical, electromagnetic** (including light), chemical, acoustic and thermal energy. While the term *transducer* commonly implies the use of a **sensor/detector**, any device that converts energy can be considered a **transducer**. **Antennas, piezoelectrical crystal, hydrophone, light emitting diodes, cathode ray tube (CRT)**, receivers and transmitters are used in **noise responsive systems** and **interactive installation** as well as sensors, actuators and interfaces that are configured for a personal computer. Using midi, Bluetooth or the universal serial bus (USB) as the

basis for all communication, the complexity is managed behind a variety of software tools which allow applications to be developed in macosx, Linux and windows operating systems.

Usage is primarily focused on enabling exploration and construction of alternative physical computer interaction systems, but have most notably been adopted by music enthusiasts, as greatly simplifies musical instrument mods and creation of novel electronic musical instruments. Another development that is very useful for **intermedia interactive immersive environments** is the creation of simple and affordable electronic circuits, that do not necessary require a software data translation, such electronic sound generators as they greatly simplify interactive installation and environments (most of them presented at NIME, Ars Electronica or Siggraph). These circuits are extensively used for teaching. They allow the construction of complex interactive systems out of simpler components.

## software-based art

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**Karlheinz Stockhausen** composed his first electronic piece influenced by **Meyer-Eppler** (Stockhausen was one of his students), based on **information theory**. **Meyer-Eppler** developed studies in phonetics and programming through computer. He extended studies in communication machines, such coders, vocoders and speech synthesizers. Communication processes introduce the term **aleatory** in the phonology research. He was the author of fundamental principles and applications of communication theory and worked on devices for the synthetic language production.

Following, new composition techniques for sound incorporate **software** to interpret data or create it. **Software** is used as a source to create sound processes. **Software** composition is influenced by **information theory** and **aesthetic perception**, by **Abraham Moles**. **Software** is used in creative processes where sound connected to network nodes. The result is called **generative art** and includes practices such **granular synthesis** or **live coding**. These correspond to **Shannon's communication theory**, guided by features such: **indeterminacy**, **unpredictability** and

unstable media. Claude Shannon's paper *A Mathematical Theory of Communication*, which founded the field of information theory, was published as two-part article in July and October at the **Bell System Technical Journal**, 1948. **Communication Theory** analyses noise disturbance in the communicational channel. The schematic diagram of general communication systems based on **semiotic and computing machine** shows different parts: **information** (message or sequences of messages); **transmitter** (changes the signals into a signal, for example, sound into electrical voltage); **a channel** (issued to transmit the signal from the transmitter to the receiver); **the receiver** (which informs the inverse operation of the transmitter, reconstructing the message from the signal). **Encoding and encryption** techniques are used in transmission. Vocoders, TV and frequency modulation use transmitters, too. **Communication systems** are an essential part of communication theory and computing machines. In this processes, deduction resulted is conditioned to **unexpected, stochastic and randomness**. Even there are a finite number of possible states in the system; there is a set of transition probabilities. It brings to study **ergodic processes** in communication theory. These are **complex dynamic systems**, formed by indefinite components,

which make them uncertain. The result deducted will be reasonably probable or also called **relative entropy**. There are reduction methods or extremes of redundancy used to approach better results. **James Joyce's** book *Finnegans Wake* deduces how the multiplicity phenomena is compared to complex languages, stating the constraints of an imposed language against **non-verbal communication. Encoding and decoding** processes are part of communications theories, and they do not exclude errors caused by **noise**. Some distributed system through correction channels, **filters** or using decreasing functions will help to improve communication processes. However, the **signals** or messages will be continuously **variable**, and this makes communication system having to be measured under **randomness relative assumed standards**. **White noise** is the maximum possible **entropy** to which **Wiener** offered numerable solutions like filtering and prediction.

The first calculating machine appeared in **1833**, and it was an engine developed by **Babbage**. It was a computer analytical engine. At the same time, first **punch-cards for storage** made apparition. The first program-controlled computer was **Z3K**, by Zuse developed in 1945, after the 1943 ENIAC computer. By the same dates, internal programme storage EDSAC started functioning followed by computer

Strela - Besk, IBM magnetic drum computer 650. Computer achieved to formulate the music as algorithm or algorithmic music according to Barbaud. All these innovations lead to composing programs and digital composition.

**Software creative processes** incorporate mathematical methods in computing. It is known that computer is the best technique for composition. Computer is a universal and composing instrument. Among its features and because of its nature, creative processes resulting from computer and **software composition** are subjected to **randomness and uncertainty** guided by **cybernetic theories**. Most of **computer software** are aware of this condition in new media. Its intentionality directs to experimental empiricism opting for instinct rather than dogmatism. Its approach is scientific and aesthetic. What it brings to research in software composition is the study of **sound in live communicational processes**. **Granular synthesis, pure data, supercollider or live coding** uses **real-time operations** in systems using sound as a source.

**Granular synthesis** was invented by **Dennis Gabor**, better known for its developments in **holography**. **Norbert Wiener** cites Gabor as an influent developer in **non-linear feedback systems** and other electronic inventions on their impact on civilization. Al-

though **Gabor** invented **granular synthesis** processes, the method is better known thanks to **Iannis Xenakis** studies. In 1954, Xenakis defined **stochastic music** as **polyphonic, irrational, contradictory and probable**. **Granular synthesis** is used by **audio-visual media artists** that strive to fuse video and sound into one medium where **video is sound** and vice versa. As an important part of this undertaking, artists develop **real-time** video software and customized computer configurations, enabling them play video as a musical instrument. Their performances and space within space installations in **granular synthesis** create emotions, surround and the immerse audience, overwhelm the human sensory apparatus by massive use of subsonic and penetrating frequencies, and will touch the visitors.

### Live coding

There are other practices regarding uses of software-based technologies. **Live coding** is formed by developers, code breakers, hackers and artists; **Goto 10** has published many texts about it. **Chun lee, Fabienne Balvedi, Florian Cramer, Sher Doruff, Nancy Mauro Flude, Olga Goriunova, Dave Griffiths, Ross Harley, Martin Howse, Shahee Ilyas, Ricardo**

Lafuente, Ivan Monroy Lopez, Thor Magnusson, Rob Myers, Alejandra Maria Perez Nuñez, Eleonora Oreggia, orx-qx, Julien Ottavi, Michael van Schaik, Femke Snelting, Pedro Soler, Hans-Christoph Steiner, Prodromos Tsiavos, Simon Yuill, Alex McLean contributed to the publication "ASCII, Floss plus Art". Live coders program in conversation with their machine, playing with instructions while the computer follows. Developing a software belong to an act of creation. There is no difference between software and sound. Live coding is a complex environment, vulnerable to control flows, crashes and breaks. The lively condition of live coding increases the possibilities of **real time** performances. It uses **algorithms** as part of the programming languages. It engages audiences and could be considered a performative art. **Improvisations** are commonly used and empty text editors to start building **rules** are part of live coding performance. High order **functions** form a language to direct live coding. Musical training and computer music is frequently required. Live coding is considered a **time-based art** because of its dynamical condition in running programs. Affections in output by changes in the structure of the code affect the result and in **real-time** live coding performance increase the risk, the **unpredictability** and the

crash of the system. **Live coding** uses different techniques of composition including delays, static core, reload, conversational programming or source code feedback. Some of the most important programming languages are **Haskell, Supercollider, Chuck, Fluxus**. Some of them use sound - image interaction, such **Pure Data**, able to live edit graphs. Other languages are **Perl, Python and Ruby**. Most of the live coding languages are **FLOSS Free / Libre / Open Source Software**. One of the first users in live coding was **Ron Kuivila, from STEIM, 1985**. Live coding is among of that, a community. It develops practices of **sharing synthesis units and libraries, generators, scripts, patches**. It is based on **collaboration. Participation** is an **informal sharing**. **Live coding** takes distance from the commercial product. It focuses in human activity reunion. Its linguistically performative **statements** transform the capacity of language from **saying to doing. Say is an action defying being**. **Rules** and language **instructions** are foundational system **laws**. As **Richard Stallman** reclaims, **the code is the law**. It leads to cryptography and encryption of vulnerable systems. Aware of own precarious social conditions, thus remain encrypted and non-commercial. Its consideration of **software distribution** remains connected to **culture hacking, free sharing licenses and open soft-**

**ware.** Meanwhile, software corporation business and iso quality design are still building predictable system favoured by commercialism and control society. **Floss** is still supporting free software practices by non-paying users. Live coding is a language where dynamic or conversational practices and command line languages control the system. Another feature of live coding is the **networked computers performances.** Live coding offers a new social dimension within its versatility to show reading code through a projection. That is a participatory engaging practice for media literacy.

Regarding live coding practices, **Shelly Knotts**, developer in network music festival and composer/performer/musician/improviser in **BILE (Birmingham Laptop Ensemble)**, in an experimental collaboration with **Alo Allik** at the **Zeppelin Festival in Barcelona** explores the nature of digital environments in the context of live coding from mutually augmented perspectives. She says: "*we attempt to create an audio-visual data feedback loop by writing code live on stage and exchanging information over the network*".

According to **Geoff Cox**, **Aarhus University**, software studies bring a profound innovation and knowledge to contemporary art.

From its point of view and supported by **critical theory**, live coding reforms the social structure of **control and predictable capitalism**, incorporating new ways of **dynamism and new labour conditions.** His interest in live coding relates to an ongoing general interest in performative aspects of software: how the practice of live coding seems to exemplify contemporary forms of **labour** that are linguistic and performative in character; live coding is a way to understand **broader cultural dynamics** and to suggest ways out of various others.

The relationship between art and technology is strengthened with the use of **open source software.** The use of "**free software**" has become a crucial material stimulating the digital age. The ideology of **pro-common networking** encourages the creation and development of tools such as **GNU/Linux, processing, pure data, open frameworks** and other open source software. Much of the developers operate establishing **networks of collaborative work**, facilitating emerging practices that allow access to the use of **free software and free code.** The distinction between **open source and closed source** responds to different conditions. Functions or intentions determine the use of a type of code, and it is transparent or opaque. Open source facilitates the **copy,** the

improvement and the **distribution** of the software. Open source is rooted in particular **ideological motivation**. Its birth was the **free software foundation**, founded by **Richard Stallman**, who created the **GNU/Linux** operating system in 1998. Following Stallman, **Lawrence Lessig** is a proponent of open source. According to **Lessig**, the code is a statement, annotation and works as an operating order. The code is also a structural part of the internet. It means that in its structural function, the **code** is treated as a **law**. The **code is the law**, a computer law and the **principles** which to build a **network**. Designing the **cyberspace**, a type of code will enable certain principles, for example, protection of creativity, communication, information, privacy or identity, trade and freedom. These principles are threatened by the regulation, control, security and cyber-surveillance powered by **Microsoft**, who develops tracking structures, laws that regulate the state's punishment. Apart from social and historical conditions, there are also formal and **ideological** relations between computer coding, contemporary narratives, digital creation, conceptual art and minimal art. Legislation is also functionally related to computer code. Code, ideology and science are also part of a social network where relations of production

mediate the society. Creative freedom and individual responsibility are foundational rights of the **social community** in the current digital age; the development of software engines is determined by the use of the code. Like ideology or science, the use of the code provides guidelines that will form the basis of individual values for the system.

**Thomas Dreher** (studies on software art, conceptual art, and art & language) is a reference for living coding because it operates using **instructions**. According **Inke Arns**, code is an executable text. It coincides with **Wittgenstein** definition of propositions in linguistic studies and, also with **Benjamin** methods of writing. Both authors started abandoning conventional language, to be fragmented, reduced, minimalized, reaching paragraph instead of large text expressing ideas as a minimal unit of language. **Wittgenstein** was a professor of **philosophy** and **mathematics**. **Allan Turing** was among his student. **Wittgenstein's** philosophy is an example of the relation between studies in **language, philosophy, logic and maths**, which probably influenced **computer science**. **Live coding** performances are an **innovative** tool for change, implying movement and non-objecthood. Its practical development will be indispensable for **media literacy**, pedagogy of code or new learning methodologies. Subse-

quently, **Thomas Dreher** analysed the relationship between **art, science and computer code**. His study gives answers about how and why the conceptual art is a reference to code art. The texts in conceptual art, as in the programming language, are **liberated** from conventions regarding its medium. In programming language is done a textual relationship between the development and the action, a direct link. The use of **annotations, short texts, propositions and rules** are typical. The text is used as an **instruction for operations** and responds to observations and descriptions in accordance with thought processes. Here thought is understood through concepts. They are the foundational principles of the logic. The reduction of thought to concepts allows **permutation and combinatorial** law that confirm the rebuttal or truth, or in a more scientific approach, prediction, feedback or calculation. Here the thought (**Leibniz**), **logic (Wittgenstein)**, **mathematics and computer science (Norbert Weiner)** binds. This approach to the code as language is as exciting as the code becomes an operational tool. The code operates directly as a function. It means that all language functions are omitted and concentrated in the direction of action. Initially, the code as a

generator and ordination eliminates everything superfluous or unnecessary. **Inke Arns** described the programming code as a being characterized by the fact that **"say,"** matches with **"do"**. The code is an efficient act of speech, not a description or representation of something. Directly and it runs or gives life to the process. These considerations evaluate the code as something essential and determining in **computer processes and communication** sciences as well as other devices. The code in art is understood as an instruction for the creation, a tool for art. Instructions and textual annotations are also linguistic processes in conceptual art and electronic art. An **algorithm** can be considered as a detailed and systematically order to perform a task procedure. **Casey Reas** uses the programming language and the code as part of the process in the artwork entitled "software structures" . The creator of processing is interested, as **Thomas Dreher** is, in the ability of the language to a **code and as an order to execute**. The interest in processes that approach the **conceptual operation of language** is an elemental characteristic of these authors. Casey Reas made the first steps towards the development and problem-solving in programming. Then he used these concepts in different programming languages such as **processing, c++**

and flash mx, with the help of Jared Tarbell, Robert Hodgins and William Ngan.

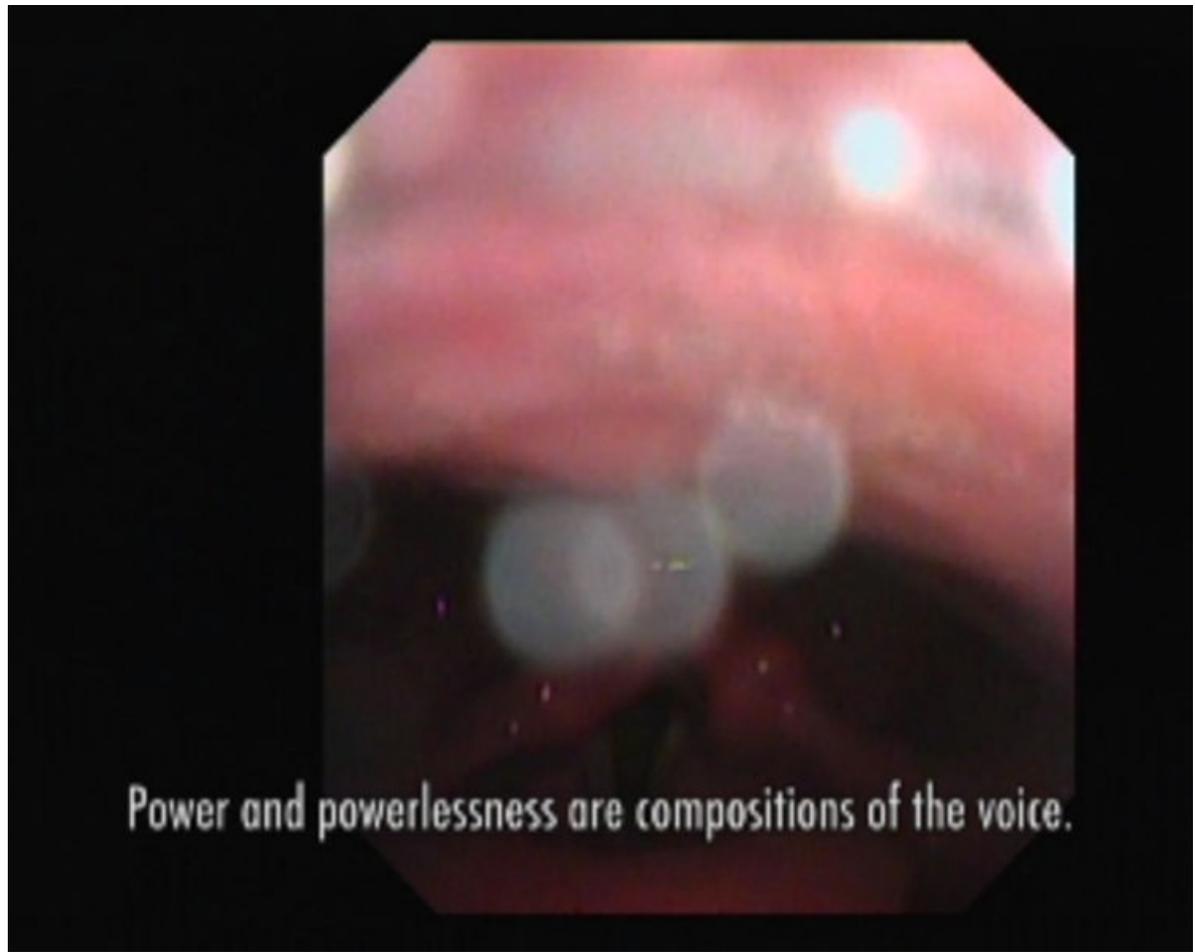
### Software based-audio

An analysis of **software-based audio** comprehends technical narratives, methods, purposes, uses and values and a technical description. Once investigating about **software-based sound** two central questions should be answered: how are **software-based audio** described and represented for the purposes of preservation, understanding and access? What does constitute a technical art history for software-based audio? The term '**software-based audio**' refers to **sound practices** that **software** is the primary artistic medium. As a **new medium** is questioned which is its place within the **art institution**. Formed by **complex systems, exhibiting possibilities** are still unexplored. A range of dependencies on **changing hardware, software, interfaces** or **technological environments** are influencing this process. **Software-based audio** include **coded** elements by artists or programmers, thought as **interactive environments**. **Software-based audio** raises major challenges for **digital preservation**, and there is neither consensus regarding conservation strategies nor established methodologies for

identifying the characteristics or significant properties to be preserved. **Digital archives** or **online platforms** such **runme.org** or **slub.org** provide **hosting and server** to live coding artists. Which are the appropriate strategies? How **museums servers'** or **hostings** will **preserve** this works? How a preservation software structure, safer and legally protected will allow sharing and openness? **Whitney museum** host numerous net.art project, avoiding forgiveness and lost, the **Whitney artpot**. How code will be preserved? The aspect to be considered once keeping **software-based audio** could follow emerging practices, museums practices, cataloguing, conservation or technical requirements. These should be renewed according technical conditions; that will also replace the catalogue entry creating new categories for **software-based audio** in **museums databases** and **collections** according **types of code**, artist's name or place of the performance. **Technical art history** is an evolving field that focuses on the material choices of the artist, how the work has been made, its meaning, the relationship with the history and context of production. The documentation of **software-based audio** may also be explored. In developing methodologies for technical descriptions of **software-based audio**, technical art history will draw on a number of fields, in-

cluding techniques for **computer science, digital preservation** and **digital forensics**. A detailed technical study of **software-based audio** will be used as a principle for analytical methods applied to the software, systems and media. The knowledge created will support conservation of museums'

collections of software-based audio and will contribute to the refinement of conservation methods for these artworks. It will also help to make an increasing interest in digital preservation, conservation, digital humanities, information theory, computer science or curatorial practice.



*Valie export: the voice as performance, act and body - 2007 - venice bienale*

## epilogue: women artists in the boundaries of sound

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*Why women represent this idea of the universal body?* Women based on sound practices play **sonic imaginary**, such **Annea Lockwood** did. She appeared in a publication by **v2**, about **unstable media**. **Janet Cardiff** audio works drifts into voices, speech, in a narrative dream, a journey through the existential body full of criticism and activism. **Feminism, art, science and technology, biotechnology, life science**, research into **biomaterials** all will bring a new experience of knowledge and universalism.

**Ada Lovelace**, Augusta Ada king, countess of Lovelace and daughter of Lord Byron, the writer, developed a deep interest in **mathematics**. She had a particular interest in **Charles Babbage's** work **analytical engine**. **Woman, mathematician, and code developer**, she is considered one of the first **software developers**, introducing some notes at the Charles Babbage paperwork. He was the inventor of the analytical engine, one of the first mechanical computers. **Lovelace** was fascinated by the creative and scientific **computer-generated music machines** such the analytical engine or the calculating machines. Both were developed through combinatorial

laws and systems (which in future will produce computer graphics and algorithmic composition). What **Ada Lovelace** did adding to the analytical engine' paper notes, was the beginning of the **software** as a language. In **Documenta (13)**, **Ada Lovelace** was honoured by **Joasia Krysa**, curator, academic and independent agent. The homage included a full reproduction of **Ada Lovelace** famous "**Note G**," one of the several notes that supplemented her translation of the text by Babbage's research. **Note G** contains an **algorithm** that functions as software to enable Babbage's engine to perform computing processes, and is regarded as the **first computer program**. While **Note G** expresses the author's doubt about a computer's capability to develop what we would call "artificial intelligence," in other places she foresees that computers could go beyond pure calculation. In her thinking, **Lovelace** "*managed to combine scientific rationalism with subjective imagination.*" Additionally to **Note G**, the homage in **Documenta13** contains selected transcripts and reproductions of letters exchanged between **Ada Lovelace** and **Babbage**, as well as her sonnet "*The Rainbow.*" **Ada Lovelace** (1815-1852) was an English writer.

During the 70's, conceptual art developed practices in **perfor-**

**mance art, experimental film and installation** allowing the birth of **feminist critique**. Feminist interpretations of women artists emphasis on sexuality and eroticism as a defiant criticism of patriarchal social and cultural norms. Women's **identity** is opposed to the tradition. Fascinated by the sensuality and the potential of human sexuality, breaking with the social conventions and supporting the social revolution of the **new ubiquitous technologies, video, sound, internet...** Examples are **Valie Export, Natalia Ll, Charlotte Moorman, Laurie Anderson, Sanja Ivekovic, Lygia Clark, Yoko Ono.**

**Valie Export** in "**The voice as performance, act and body**", 2007, **Venice Biennale**, represents the voice as a suture. She says: the voice is seam, the voice is cut, the voice is tears, the voice is my identity, it is not body or spirit, it is not language or image, it is sign, it is a sign of the pictures, it is a sign of sensuality. It is a sign of symbols; it is the boundary. It speaks the "split body," it is hidden in the clothing of the body, is it always somewhere else.

**Gender art net** considers the relations between **feminism and internet**, creating the **gender(ed) cultures** working with the "web", text, image, sound, video, animation, interactive works, and

other forms of art with **technology**. Guest editor **Jennifer Chan** says "the imbalanced history of representational structures upheld by museum and academic art institutions run up against the optimistic intentions on the **internet**. The majority of Wikipedia editors are males. Ideals of **masculinity and femininity** are still dominant in online communities."

**Phantasmata** by **Eleonora Oreggia** present the embodied technologies of the self, images of the soul, mental images, something existing in perception only. As in mental imagery, varieties of which are sometimes colloquially referred to as visualizing, seeing in the mind's eye, hearing in the head, imagining the feelings. It is a quasi-perceptual experience; it resembles perceptual experience, but occurs in the absence of the appropriate external stimuli. It uses empiric noise-at-a-distance, electronic circuits, pulsating lights and instructions. It is not about aesthetics or techniques, but it is a non-material experience, the definition of universalism and creation. If the result of the work is the most optimal, the more nearly is the audience to receive an answer. According **body - sound -gender**, the lack of representation of woman artist in **live-coding**, in art, culture, and generally, in

society, is because the models of production, the creation and the development have put them behind the **masculinity**. Contrary, understanding creation and universalism, practices of **body and technology** change the mentality and allow a new path of evolution. **Pedro Soler** writes: *the artist work to change our perception of the world. She digs into the medium and techniques, experimenting and developing.* ... This change in designation and terminology links gender with technology, and supports the **post-critique** based in new **linguistics**. Answering questions about **body - sound- gender**, artists must bet for **media ecology** practices. **Post-media culture** and **cinematic era**, with its origins in **19th century**, is based on symbolic code of representation based on **images**, because the picture is immediately preceding the object. It has its roots in the **iconographic culture**, based on the consumption of **relics and objects**. These are analysed by **Foucault** and **Adorno** as the symptomatic pathologies of capitalism: purpose and image reproduction. Contrary **ecologies of sound**, are demanding for **immateriality**, for the **body without organs**, as in Musil, for **androgyny models** and **incorporeal ecology of media**. This **body is a reproductive space**, an organ. It is an **immaterial system** that resembles **sound spectra** and is

represented by **mathematics and codes**. **Body is mathematics, language, code, and a universal form of creation.**

**Oxa** is a band not made out of people, but objects and patches, snippets of **codes** that bleep and blinks and are added and modified in the online repository, where it all began. As the repository grew, **Oxa** evolves with it. **Aymeric Mansoux, Chun Lee and Olivier Laruelle** are the current active contributors. They have performed **Oxa** across Europe, North America and Asia in places like galleries, clubs and festivals. **Expr~** is the first music release of **Oxa**, consists of **retro sounding tracks** made almost entirely with the [expr~] object in **Pure Data**.

According **Evgeny Morozov**, the digital network and the connections in between terminals could be considered as a **virtual belly** to rent; a **digital utopia**, where total emotion, summa democracy, **flowing** into an universal network of citizens, fighting against oppressive governments and the figure of **father** (abuse, power, colonialism, rationalism, tekhné). At this point, **sound is an unbound, immaterial and universal experience**. It is a medium for distributed communication.

Artist such **Iris Garrelfs** produces to express the oppressed voices published in **muse ruole**, a

platform for women in **experimental music**.

It is known how practices consisting in embodiment and creation are using body synthesizers to give a response to their body. Most of them are **activist** against mainstream, and their performances are shockingly shaking the audiences.

**The ghost taco** is a piss-take on experimental music and performance art being "self-indulgent". It is a Dadaist feedback loop: the sound of Tristan Tzara rolling in his grave. The serendipitous evolution of Carolee Schneeman's interior scroll, the ghost taco gives feminine semiotic presence of a sonic vagina dentata. It is done in the spirit of Annie Sprinkle's masturbation ritual and the work of Augusto Boal. It is about the suspension of disbelief—the trust game implicit informing an audience of any size and the risks taken when we engage stereotypes or try to move past them. It is a call to arms to cut the bullshit. It is cloyingly sincere and caustic slapstick improv with tits. Devon Michigan is an intermedia skid from the coast territories of western Canada, currently living in Montreal. Her background is in underground venue management, collective/grassroots anti-oppressive organizing, witchcraft, and dada/surrealism. She performs

as the ghost taco and dirty wizard, does vocals for the doom band xothogua and organizes weird shows with the wizard sound system.

Following this aesthetic, **body universe** is a reaction against the perception of the **system machine**; the century of **industrialism** influenced the modern vision of space. **Industrialism, serialism** and **computer systems** considered **tekhné** as superior in the creativity. It has been criticised for **Adorno, Lacan and Foucault**. **Technoscience** confronts the technological way of creation, offering an **image of space as a body, a lively organism**, a body of reproduction and creation. This picture is connected to **technoscience**, where masculine models of modern **tekhné** (like logic rationalism) are surpassed by other categories: the myth of **androgyny, biology, female body experience, and mutants**.

Diana McCarty wrote, "**Mapping feminism**" a conference on the occasion of **ISEA 2009**, about the role of the women in the evolution and development of **new media art**. She is contrasting the **biological-ethical discourse** against the military colonialism produced by the paternalist society under capitalism and **neoliberalism**. The feminine role in the creation is directly linked to poetics of origin, practices of carrying life, discovering the original

place or the space of the original production. **Colonialism and euro-centrism** are opposed to "**terra incognita**": the land of the **post-colonial freedom** and the **social revolution**. "**Mater naturans**" is understood as the origin and definition of creativity, **memory and sign** in the space. So then, art has developed practices that are capable of **bringing back the heterotopia to life, death into life**.

Regarding **techno-science, technology, feminisms** and the participation of **women in technology**, there is a part of **gender art** practices based in **queer or pornoterrorism**. Convulsing beauty and bodies of decay, their option **is trans-gender**; they cross boundaries and practice experience as a lively methodology. Most of the artists and central figures are developers of devices, using **electronic do it yourself circuit bending, open source and free culture**.

"Dpi feminist journal of art and digital culture", the magazine about technology and feminism, represents all the varieties of art and digital culture, presented in **htmlles - feminist festival of media arts + digital culture** that gives to new technologies a feminist perspective. It answers socio-political questions about boundaries of artistic and feminist practices. It is also a feminist artist-run-centre for

technological exploration, creation and critique. Is based on women's web art presentation, Trans and gender non-conforming artists' and independent media artworks. It presents the idea of zero as de-territorialism, zero as noise. It is the future against neoliberalism, "post ideology" of class, race and gender. It is against the desert of semiocapitalist desires and the noise of the overproduction of commodities and intellectual property. It detects biosurveillance as a security war on the net. Is against the implementation of financial insecurity and declares the afrofuturism, the cyberfeminism and the queer futurity, and cyberpunk as the resolution. In a future in crisis, dystopia will not be oppressive, but a struggle to (re)build community and reunite technology, science and progress. Afrofuturism, chicanafuturism, feminist cyberpunk, utopian and dystopian cyberfeminism and the queer futurity will defend the self-identified women, trans and gender non-conforming artists, curators, activists, collectives, and organizations.

Data from **n.paradoxa** and **k.t.press** is stating about the volume of female artists. One of the most distinctive features of "contemporary art" in the last 20 years has been the rise of women artists from many different parts

of the world in international exhibitions in an unprecedented scale in the 20th and 21st century. Culture industry has declared women "originality" as worse "genius". Despite progress and freedom, the difficulty of women to advance in her career is very common. The presence of women in the art world is represented in these data:

- 13.5% of works by women in federal art collections
- 18% of female professors at art universities
- 22% of female directors at art museums
- 27% average of female percentage at exhibitions in art museums
- 32% of honorary prizes in the visual arts are won by women
- 42% of all freelance employees in the visual arts are women
- 55% of students in the visual arts are women
- 22% of female artists at documenta x (in 1990s: the 29% in documenta xi, 46% in Documenta xii, and back to 38% in Documenta xiii.)

More data about women in music industry from **BBC**: Mandy Parnell, mastering engineer for Bjork declares that there is not any women in mixing desk, it is thought women are not attracted to the technical side of music, because of electrical engineers implies lots of physics. They rather perform sound. The female participation in social industry

or music industry is affected by the evidence of a lack of models.

- PRS 13% of members are females
- Music producers' guild only 4% of members are women

Hannah Reid: *within record labels there are not many women. I find it weird; it is just so filled with men. I have never worked with a female.*

**Chloe Howl:** *I have never worked with a female producer. They are never in recording; most of them are all men.*

**Sinead Garvan,** from Newsbeat, music reporter, says among the best-selling artists are women, but the British music industry is following masculine patterns, is dominating the scene.

According in **A Portrait, by Barry Miles, William Burroughs** proposed that sexes should be separated, and all male children are raised by men and all female children raised by women. The less the two sexes had to do with each other, the better. " *I think love is a virus. I think love is a con put down by the female sex. I do not believe that it is a solution to anything.. I think they [women] were a fundamental mistake, and the whole dualistic universe evolved from this error.*" **Burroughs** later modified his feelings regarding women, but while he was working on the cut-up trilogy, they were seen very much as the enemy, possibly even as agents from another galaxy. **Burroughs'**

views on women were notorious and dated back to pre-war St. Louis society. Burroughs was often very influenced by his misogyny correspond to the times when he lived in proximity to other extreme misogynists: **Brion Gysin, Michael Portman and Ian Sommerville.** The kind of woman that **Burroughs** disliked was the woman still playing the traditional role: demanding security and protection, looking for her man for money, flattery and love, restricting his freedom, tying him down to house and family. It is a form of women hatred common in America and explains the popularity of writers, such as **Charles Bukowski,** in whose work women keep their place and men keep their freedom. However, as feminist ideas spread through American society in the 70s, **Burroughs** recognized that liberated women were no threat to him. In an interview in 1977, he said: "*they [the women's movement] are opposed to the matriarchal society. They do not want to be treated as women. I certainly have no objection to any of their objectives. They say they want job equality and to be treated the same way as men. The difference between the sexes is certainly more sociological than biological. Like the southern belle who was put on a pedestal*". Now it is seen that not all women wanted to be taken care of and began to befriend some of the most

independent women who entered his circle. In the 70's he was happy to spend time with **Patti Smith, Laurie Anderson, Kathy Acker, Debbie Harry** and others.

Regarding the pioneering role of women in media art, should be stressed, Alison Craighead, Donna Haraway, Sadie Plant, Vera Molnar, Steina Vasulka, Joan Jonas, Marisa Olson, Pauline Oliveros, Christiane Paul, Sarah Cook, Laurie Anderson, Josephine Bosma, Ada Lovelace, Judy Butler, Olia Lilliana, Natalie Jeremijenko, Coco Fusco, Ghislaine Boddington, Guerilla Girls, Ilze Black, Larisa Blazic, Daphne Dragona, Mia Makela, Sanja Ivekovic, Eva Mattes, Joasia Krysa, Valie Export, Charlotte Moorman, Lygia Clark, Yoko Ono, E.Valldosera, La Turbo Avedon, Fabi Borges, Alejandra Perez, Eleonora Oreggia, Simona Levy, Diana McCarty, Maria Llopis, Marloes de Valk, Shu Lea Chang, Chris Sugrue, Paula Graham (fossbox), Ruth Catlow (furtherfield). It is an essential failure. It is unacceptable in the context of electronic, new media, and within the frame of cyberfeminism. Women artists have contributed to the development of media art in a very deep and profound sense, changing structures and contributing to the social benefit of human behaviour.

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