

[Wolfgang Ernst: SCRIPTS ON TECHNICAL MEDIA]

TEXT BLOCK "TIME-VARYING SOUND SIGNALS (SONICITY)"

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So-called "audio-visual" media can be reformulated, from the technical view, as time-varying (part A) and space-varying (part B) signal processing. Within technological signal transduction and data processing, there is no "sound", neither "image"; abandoning with such anthropocentric categories would be warranted in radical media archaeological analysis indeed. For technical ensembles like "radio" and "television", though, the bias of its techno-logical "individuations" (Simondon) can only be explained by their technical "intentionality" (Husserl) towards addressing the human auditory and visual sense perception. Techno-conceptual terms like phonicity, sonicity, and iconicity are therefore proposed to embrace both approaches, the media-phenomenological and the non-human, technological one.

SONIC "PRESENCING" AND TECHNOLOGICAL VOICING OF THE PAST

Analysis of the "sonic"

"But what is a historic present if not a present that can be successfully archived?"¹ What has not been recordable in alphabetic writing (even if symbolically intended but the explicit introduction of single letters representing vowels in the early Greek alphabet) is the physics of the

¹ Doane 2002: 105

voice which can be recorded only in the gramophonic signal. "What defies literary memory is approachable only by means of nonliterary media."²

While the present has been considered an inevitably ephemeral, uncapturable time momentum for the longest time, the human voice especially has embodied and allegorized this "fugit tempus" experience of presence. An early newspaper article announcing the invention of the gramophone disc by Emile Berliner starts with the remark that volatile speech has finally been "imprisoned" by the new recording technology, making it not only repeatable for aesthetic or bureaucratic use, but accessible to scientific speech analysis on a micro-level of formation which - different from the human physiological options of memorizing delayed presence - only measuring media can capture, register and thus keep for time axis manipulations. On the darker side of this widening of research topics for humans, with this option goes the traumatic experience that the voice can be preserved as a "dis-embodied" event. Thus it has got into the focus of communication engineering, psychoanalytic and historiographical analysis, particularly in its capacity to engender a sense of heightened presence (as compared with written records).

Audio signal archives emanate from chrono-technical recordings; their specific feature is the power of "re-presencing" (Vivian Sobchack) the sonic event.³ Sonicity affects and irritates human time consciousness.

Husserlean and Aristotelean time: Sonic "rhythmograms" vs. discrete clocking

Sound being understood as time signal event opens access to a plurality of nonnarrative temporalities which even subverts the apparent cultural-historical context of sound perception, production and consumption.

An early advertising for the Bulova Accutron Space View watch announced "The Tick vs. the HUM". But even if "the hum" sound is smoothly "analogue", and thereby coincides with human world experience and the notion of the "flow of time", the mechanical "tick" is (as remarked by Fourier) just an extreme discretisation of the very same vibrant event.

While it has been electronic tools that enabled the investigation of the memory function in the human brain, such as functional Magnetic Resonance Imaging (fMRI) which monitors brain areal activity of

² Pinchevski 2012: 156

³ For a discussion of Janet Cardiff's audio walk *Her Long Black Hair* (2004) as aural re-presencing, see Barker 2012: 20

experimental subjects⁴, an alternative to neuro*imaging* is the sonification approach, by parameter mapping, since the sonic access, based on time signals, is closer to the dynamical unfolding and re-assembling of "memories" which do not have a fixed locus in the human brain. The rhythms which structure perception in the human brain cannot immediately be consciously perceived.⁵ Therefore a direct sonification of alpha waves in the brain is required. Subjective time sensation occurs apart from the "clocked" time of the Newtonian universe (for classical physics) and "breaking news" (in broadcasting media). Media archaeology as method couples Husserl's diagnosis *tightly* with technological and archival knowledge. "Data Retention" in fact is a term precisely known from static storage within the computer to ensure that the data in an elementary cell will not be altered. The Static Random Access Memory (SRAM) must be supplied by a power supply that will not fluctuate beyond plus or minus five to ten percent, in order not to disturb the elementary cell and to ensure that it will correctly keep the data. "In that case, the SRAM is set to a retention mode when the power supply is lowered, and the part is not longer accessible."⁶

The central terms in the Husserlean phenomenology of the "inner" time sense, retention and protention, is subjective in an objective way: both neurologically, technologically and epistemologically. Predictive calculation has been the central temporal figure which gave birth to what was soon to become popular under the name of "cybernetics" which, as the eponymous Norbert Wiener frankly admitted in the introduction to his seminal *Cybernetics* of 1948, originated in the necessity of World War II anti-aircraft artillery to anticipate the immediate future moves of enemy planes for computing the point in space and time where both the anti-aircraft gunshots and the enemy aircraft meet: "[...] that missile and target may come together in space at some time in the future."⁷ This mathematics becomes media technology with the necessary implementation of pre-emptive calculation into a servo-mechanism which performs negative feedback correction of its on-going positioning of the artillery gun in *real-time*. Wiener describes the "mechanico-electrical system which was designed to usurp a specifically human function - [...] the execution of a complicated pattern of computation [...] the forecasting of the future".⁸ This "window of the present" is time-critical in

⁴ See Sebastian Klotz, Das BOLD-Signal im MRT. Eine medienarchäologische Diagnose, in: Moritz Hiller / Stefan Höltingen (eds.), Archäographien. Aspekte einer Radikalen Medienarchäologie, Berlin (Schwabe Verlag) 2019, 63-77

⁵ "[...] nehmen wir diese messbaren Signale mit keinem unserer Sinne wahr": Hinterberger 2005: 284

⁶ Integrated Circuit Engineering Corporation, chap. 8 (SRAM Technology), 8-4. Smithsonian - The Chip Collection, <http://smithsonianchips.si.edu>, accessed May 2014

⁷ Norbert Wiener, *Cybernetics, or: Control and Communication in the Animal and the Machine*, Paris (Hermann) et al. 1948, 11

⁸ Wiener 1948: 13

its most deadly sense and thereby does not that much refer to "live" transmission of radio signals but rather to "life" in its limited time span in combat. Together with Julian Bigelow, Wiener was involved in the "investigation of the theory of predicitons and of the construction of apparatus to embody these theories"⁹.

There is a specific "sonic" temporal quality of the present which is always already instantaneously transforming *passing* (French *passer*) into *past* (French: *passé*). Only with phonographic recording, such a presence becomes repeatable, thus an experience of enduring presence. The age of storability of voice and sound has already created its very retro-action: Sergiu Celibidache as concert director was radically opposed to phonographic "conservation" of music; he favoured the "now".¹⁰

The alternative to acoustic communication in terms of periodic propagation of continuous waves, is the "digital", discretizing approach in reverse: addressing the signal components in their frequency value, which makes wave forms countable. Such an analysis re-invents the Aristotelean definition of "time" in book IV of his *Physics* (219b 1-2): *touto gar estin ho chronos, arithmos kineseos kata to proteron kai hysteron*.

Frequency *versus* oscillation recalls "duration" in Bergson's sense.¹¹ There is a remarkable "timelessness" (the Nietzschean "eternal return of the same") in periodic processes which can be addressed as frequencies, as demonstrated with one's perception of the movement of a pendulum clock. When visually following the dial of a clock, nothing is left of the past positions.

A tuning fork, coupled to an electro-magnetic coil (as developed by Hermann von Helmholtz in reverse functionality as electro-mechanic device to measure the micro-temporal run time of nerve impulses¹²), provides the time base in the Bulova *Acutron* watch. The stroboscopic microscope is able to visualize the movements of a tuning fork-based clock developed by the Bulova company.¹³

⁹ Norbert Wiener, *Cybernetics. Or control and communication in the animal and the machine*, Paris (Hermann) et al. 1948: 13; see Rainer C. Becker, *Black Box Computer. Zur Wissensgeschichte einer universellen kybernetischen Maschine*, Bielefeld (transcript) 2012, 226

¹⁰ Thilo Hinterberger, *Kommunikation mit Signalen aus dem Gehirn*, in: Barbara Könches / Peter Weibel (eds.), *unSichtbares. Algorithmen als Schnittstellen zwischen Kunst und Wissenschaft*, Bern (Benteli) 2005, 262-285 (284)

¹¹ The concept of "rhythm" as interlacing of both discrete (digital) and continuous (analogue) temporality is discussed in Ikoniadou 2014, 7 f.

¹² See Helmholtz 1863

¹³ See <http://www.richardkunze.de> ("Faszination Stimmgabeluhren")

"The kind [sc. of clocks] that tick work on balance wheels, hairsprings and wachtworks. And that's what can make them work wrong. The Accutron timepiece [...] hums. (Musically, between E and F but above Middle C). Accutron operates on the precise vibrations of an electronic-powered tuning fork. Each vibration splits the seconds into 360 equal parts and Bulova can guarantee accuracy to within one minute a month. That's an average of 2 seconds a day."

In digital computing, this is matched by the Japanese *Parametron* based on resonant circuits. A sine tone here serves as time-giving media event - not for acoustical or even musical sake, but in implicit sonicity: the tempor(e)ality of sound which is shared by processual technologies. The second-indicator does not visibly move abruptly like in the escapement-driven mechanical clock, but almost moves continuously - just like above the hearing threshold of ca. 20 Hz the human mind can not discriminate between discrete acoustic impulses any more but perceives a continuous tone, even if this tone still consists of oscillating waves (sine / cosine, discretely passing the "Nullpunkt"). Here, two kinds of realities overlap: the media-archaeological and the phenomenological one.

Electronic media tempor(e)ality: "acoustic space" (McLuhan)

The wall painting *Pied Pipers All* (1969), created by René Cera for McLuhan's seminar room at the university campus in Toronto¹⁴, in an almost psychedelic manner unveils the television image as an implicitly sonic event. On the figurative level, the line-wise unfolding of an electronic TV (half-)frame is linear in the phonographic sense (John Logie Baird's "Phonovision", Bill Viola's "Sound of One-Line Scanning"), while in terms of the sublime ground (broadcasting by electro-magnetic waves), whatever becomes apparent as visual content on the TV tube, the tempo-real message of electronic media is "acoustic" in McLuhan's sense of a simultaneous chronosphere.¹⁵

[According to McLuhan, different from "typographic man", in electronic communication there is "acoustic space". For the age of electricity, McLuhan identifies a return of the primordial (oral language-based) "tacility" in terms of the temporal moment with its decisive criterium

¹⁴ For a colour reproduction see fig. 3 in: Peter Bexte, xxx, in: Derrick de Kerckhove / Martina Leeker / Kerstin Schmidt (eds.), *McLuhan neu lesen*, Bielefeld (transcript) 2008, 323-xxx (331); <http://www.greatpast.utoronto.ca/GalleryOfImages/VirtualMuseumArtifacts/PiedPipers.asp>, accessed September 2nd, 2014

¹⁵ See Erik Davis, *Acoustic Cyberspace*. Talk delivered at the Xchange conference, Riga, November 1997; *online* <http://www.techgnosis.com/aco>. Published in: Rasa A mite / Raitis A mits (eds.), *Acoustic Space - net*. audio issue, Riga (E-LAB) 1998

being its (almost) instantaneous speed of transmission.^{16]}

The sonic is understood here not in its manifest acoustic sense, but as processual ground, thereby akin to electro-magnetic oscillations. Acoustic space is simultaneous and superimposed instead of time-linear, and above all, it resonates: "Resonance is the mode of acoustic space."¹⁷ Through resonance in a physical - not symbolically coded - system, micro-events can cause distant objects to communicate - close to time-tunneling and Tesla-like energy transfer.

Sound is not just mechanical attacks, vibrations to the ear or aesthetic pleasure for the brain but addressing the human (pseudo-)sense of temporality. The true message of sound as event is processual time. There is no actual organ for the "sense" of time in humans but only substitutes and equivalents like the hearing organ which is most sensitive to micro-temporal changes of pattern and rhythm. The sublime temporal infrastructure of electronic culture (with its de-materialisation and instant signal transmission) has triggered the reentry of the category of "sonic" as vibrational event. Even if it is not accessible as acoustic content in human perception, its essential message (its simplicit sonicity) is its temporal form.

The remarkable affinity between sonic temporality and frequency-based technical media time is rooted in time-critical moments: First on the level of sonic performance and technological operativity, and second in the a-historic *momentum* of experiencing time in listening and in experiencing presence-generating devices (chrono-phenomenological *aisthesis*).¹⁸ Sound is transient. German *verklingen* expresses the dying-out of sonic events ("unsounding"). Musical articulation always had to take place in time, as a temporal unfolding; even John Cage's composition for piano *4'33* minutes of silence is chronologically defined (with its first public performance with David Tudor at the piano counting time without playing any tone).¹⁹ In a McLuhanite sense, the acoustical channel itself thus becomes the message.

Martin Heidegger's use of terms from the sonosphere does not refer to explicit acoustics (as physical sound event), but rather to the implicit, epistemological meaning. He made use of sonic vocabulary as a

¹⁶Till A. Heilmann, Digitalität als Taktilität. McLuhan, der Computer und die Taste, in: Zeitschrift für Medienwissenschaft 3, no. 2 (2010), 125-134 (128)

¹⁷ Marshall McLuhan / Bruce Powers, The Global Village. Transformations in World Life and Media in the 21st Century, Oxford et al. (Oxford University Press) 1989, paperback edition 1992, 6

¹⁸ On "the ontology of vibrational force" and "microsonic turbulence": Steve Goodman, Sonic Warfare. Sound, Affect and the Ecology of Fear, Cambridge, Mass. (MIT Press) 2010, 81-84

¹⁹ John M. Cage, Silence. Lectures and Writings, xxx (Weleyan University Press) 1961, 8

substitutional way of expressing the microtemporal structure of the "event" of being.²⁰ The "tuning of the world" (as expressed by Murray Schafer in 1977) is a *timing* of the world as well. What looks physically acoustic is temporal in its subliminal affect. If the "sonic environment" is extended to so-called Hertzian waves as well, electromagnetism turns out as sublime temporality in all ways.

While visual presence is based on "radio"-like electro-magnetic wave signal transmission, acoustic sensation is based on comparatively slow signal run-time in mechanical matter. That is why, in contrast to the immediacy of optical signals which are perceived as pure presence, the acoustic, which can be recognized, even by humans, as time signals, has been associated with a different temporality. The unfolding of "acoustic space" is not linear, but reverberating. McLuhan once called it "echo land" - which is micro-temporal folding. When taking the metaphor literally, acoustic echo implies delay. The temporal signal run-time induced by the medium of air as channel for acoustic signal transfer actually triggered Aristotle, in his treatise *Peri psyches*, to discover, (media-)philosophically, the "between" (*to metaxy*). By turning the adverb into a noun, after its translation by medieval scholasticism this became *medium*. Therefore the very term media stems from sonic analysis.

Notwithstanding his confusing electricity and electronics, McLuhan thereby made a crucial discovery about the intrinsically "acoustic" structure of electronic mediascapes which are rather defined by temporal relations to each other than by spatial ones.

The affective immediacy of electricity is the reason for traumatic subliminal effects in human perception; this makes the time-critical difference to the world of traditional print culture which, as McLuhan analyzed in his days already, "[...] is threatened, not by any single factors such as television or radio, but by the electric speed of information movement in general. Electric speed is approximately the speed of light, and this constitutes an information environment that has basically an acoustic structure."²¹

Acoustic signal presence (wave form) differs from the present digital instant (impulse coded as bit). If signals come simultaneous from all directions this corresponds with the structure in the act of *hearing*. But very media-archaeologically, McLuhan's identification of the essence of

²⁰ Rainer Bayreuther, "Phänomenologische Grundlegung" einer Disziplin, in: Heidegger-Handbuch: Leben - Werk - Wirkung, ed. Dieter Thomä, Katrin Meyer, Hans Bernhard Schmid, chapter 2.2 "Auf dem Weg zu einer Akustik des Seyns": 'Stimmung', 'Schwingung', und 'Harmonie' nach Sein und Zeit", Stuttgart / Weimar (Metzler) 2013, 509-512

²¹ Marshall McLuhan, letter to Barbara Ward, 9 February, 1973, published in: McLuhan 1987: 466

electronic media as "acoustic structure" evidently refers to an epistemological ground, not to the acoustic figure of what ears can hear. This ground-breaking took place with the collapse of Euclidian space into Riemann spaces and culminates around 1900 with quantum physical notions (the para-sonic wave/particle dualism, up to the "superstring" theory of today) on the one side, and Henri Bergson's dynamic idea of matter as image in the sense of vibrating waves and frequencies on the other side.²² McLuhan's "acoustic space" is oscillating time and implicitly re-returns in Gilles Deleuze's Leibniz-inspired "interval" philosophy. Less philosophically, it actually happens within algo-rhythmic media.

Therefore the message of the sonic is not limited to the audible at all, but a mode of revealing modalities of temporal processuality - which requires media-archaeological auscultation like with an epistemological stethoscope.

But the digitally modulated (PCM) electrosphere of today differs from this radiosonic (AM) metaphor; its musicality consists of rhythmic impulses rather than continuous waves. With digital numbers, central characteristics of what McLuhan diagnosed as the Gutenberg Galaxy of print culture²³ have returned, thus bracketing the age of analog electronic (mass) media as a interplay of modernity. In a dialectic synthesis, mobile digital telecommunication is now combined with the characteristics of "acoustic space" which is the instant. According to Marshall McLuhan's *Media Log*, "[s]imultaneity is related to telegraph, as the telegraph to math and physics."²⁴ But this discrete simultaneity is of a different kind. The Internet consists of techno-mathematical topologies rather than electromagnetic waves (even if the electromagnetic sphere survives as channel of wireless data transmission). "Now, Internet 'radio' isn't radio; it does not exploit the spectrum, and that is a big difference"²⁵ - just like the difference between recording in vinyl grooves and its Compact Disc inscription where its close analysis reveals bit streams which allow for information theory, thereby: mathematical intelligence to control the event of signal storage and transmission. This happens in sublime manipulation on the micro-temporal level. Even if according to the Nyquist / Shannon Sampling Theorem human perception might not even notice the difference between a high definition analog television image and its digital equivalent, ontologically this image has transformed into a different time-object once the critical perspective of the "receiver" is not humans but technologies themselves. But digital data processing which absorbs time to calculate always lags behind live transmission

²² Henri Bergson, *Matter and Memory*, London (George Allen & Unwin) 1950, 276

²³ Marshall McLuhan, *The Gutenberg Galaxy*, Toronto (University of Toronto Press) 1962

²⁴ Marshall McLuhan, *Counterblast*. 1954 Edition, published by transmediale.11 Berlin (in cooperation with Gingko Press) in 2011

²⁵ Davis 1997

which allows for a different presence.

„Presence“ in audio technology

By software-based motion tracking it can be micro-analyzed that the performative motion anticipates the actually unfolding tone sequence which corresponds to Husserl's notion of the "time window" of melodic presence in neuronal pro- and retention.²⁶

Different from the originality of a work of art in photographic reproduction (as described by Walter Benjamin), the *aura* of physical sound can remain intact in its essential feature which is temporal integrity even if converted into the digital code. If by physical modelling matter can be algorithmically reproduced, but movement and sonicity - thus not losing its temporal quality.

"Presence" in sound engineering is the term for the degree of clarity in instrumental and vocal sound, which can be increased by use of the Equalizer within the frequency ranges of around 18 Hertz to 16 kHz. "In an amplifier, a presence control controls 'presence'. A presence control boosts the upper mid-range frequencies. Thus by increasing the presence with the presence control, the sounds of voices and such instruments seem more 'present'."²⁷ Remarkably, the audio-technical term *presence* is attached to the voice (or instrument) here. The voice is perceived as indexical testimony of presence on the one hand, and its irritation (subverting testimony) on the other when re-played from phonographic recording.²⁸

"On television production studio's sound desk, there can be several presence controls, for several different, switchable, frequencies. [...] If the degree of mis-match between microphones is great, simply increasing presence is not enough, and instead a sound engineer will use a graphic equalizer, sometimes several, each connected to an individual sound channel"²⁹ - an operative diagram.

„Presence controls can also be found on electric guitar amplifiers. The first presence control on a Fender amplifier [...] appeared in 1954 on the Twin. [...] The original Fender presence control acted upon the amplifier's negative-feedback loop" (ibid.).

²⁶ See Rolf Inge Godøy, Marc Leman (eds.), *Musical Gestures. Sound, Movement, and Meaning*, London / New York (Routledge) 2010

²⁷ http://en.wikipedia.org/wiki/Presence_%28amplification%29; accessed September 3, 2013. See Rudolf F. Graf, entry "presence control", in: *Modern Dictionary of Electronics*, Newnes 1999, 586

²⁸ See Doris Kolesch / Sybille Krämer, *Stimmen im Konzert der Disziplinen*, in: same authors (eds.) 2006: 7-15 (7)

²⁹ Wikipedia op. cit.

Signal run-time as acoustic media archaeology

There is a privileged affinity between "the larger gestalts of auditory temporality"³⁰ on the phenomenological level and the processual being of technical media. Here, time-critical moments parallel the most frequency-sensitive ("rhythmic") sense organ within the human which is hearing.

If a movie camera or projector is driven manually like in the vera early days, it turns out the visual perception is much more tolerant to slight temporal deviations. This is different with auditory signal replay. Let me illustrate this by a short audio-visual argument produced by the Media Archaeological Fund at Humboldt University:

A symbolic order such as the musical composition, being a conceptual diagram, is ideally invariant towards shifts on the time axis, while the historicity of sounds depend on its material embodiment. "Is the sound of an existing Roman era bell dating from the third century a more ancient sound?", the artistic media archaeologist Paul DeMarinis asks. "For this to be the case we would have to think of the bell itself as an encoding of some 'sound'; that sound, in turn, would have to include the splashing of the molten brass, the beating by smiths' hammers etc. But the sound the bell produces in its current use is far from being a recording of these sounds" - rather co-originary sonic production.³¹

Phonographic "engraving" on the contrary is sound in latency. The ontological status of recorded sound is waiting to be activated (German "in-Vollzug-Setzung"), that is: to become medium. This corresponds with the Heideggerean "being-in-time". "Heidegger does not mean by essence (*Wesen*) *what* something is, but how it comes to presence (*wesen*, a verb)."³²

This can be correlated with the temporal "window of present" of sonic experience which itself corresponds with micro-temporal actions within both primary physics and derived technologies.³³ The conflict between the physically impossible ideal sinus wave in Fourier Analysis and its

³⁰ Don Ihde, *Listening and Voice. Phenomenologies of Sound* [*1976], Albany, NY (State University of New York) 2007, 87

³¹ Paul DeMarinis, *According to Scripture* [2002], in: Ingrid Beirer / Carsten Seiffarth / Sabine Himmelsbach (eds), *Paul deMarinis. Buried in Noise*, Heidelberg (Kehrer) 2010, 247-252 (247)

³² Kathleen Wright, *The place of the work of Art in the Age of Technology*, in: Martin Heidegger. *Critical Reassessments*, ed. Christopher Macann, vol. IV: *Reverberations*, London / New York (Routledge) 1992, 247-266 (264, note 2)

³³ See Joachim Klose, *Die Struktur der Zeit in der Philosophie Alfred North Whiteheads*, Freiburg i. Br. / München (Alber) 2002, 358 ff.

transient *momentum* as an actually physically performed tone epistemologically resonates.

While traditionally acoustic elements have been symbolically ordered in time ("music"), on the micro-temporal level Fourier analysis identified sound as an event of superimposed (sine) tones itself with its individual frequencies . "Die Trennung 'akustischer Vorordnungen' *im* Material und 'musikalischer Ordnungen' *mit* diesem Material müßte dann aufgehoben werden."³⁴

The Temporal Message of Sound: Active Sonar

The implicit sonicity of temporal delay comes into play with the active sonar in submarine communication. It creates a sonic pulse called a "ping", and then waits for its reply from reflections. The time from emission of a pulse to the reception of its echo is measured by hydrophones or other sensors to calculate the distance; "space" thereby becomes a signal function of the temporal interval. It has been the temporal delay manifest in echo acoustics which once induced Aristotle to focus on *to metaxy*, the channel as resistant "*the* between" in signal transmission (be it water, or air, or a hypothetical medium called "ether"). This channel has been translated as *medium* in medieval scholastic reading of Aristotle. Any media theory is therefore inherently treating "time" as operational, oscillating between the "analog" and the "digital", replacing cognitive notions of the "flow" vs. the "ticking" of "time".

The sonic present

In electronic epistemology, what looks like a particle is in fact a high frequency motion, mathematically expressed by the wave equation. The concept of *micro-tones* corresponds with micro-temporalities in the media-archaeological sense. In fact, "tones" are in the frequency realm what is the reverse of a time function (the sonic wave).³⁵

Discrete Cosine-Transformation encodes complex, time- or space-variant signals into a series of discrete frequency components. "They can be added together to reconstitute the original signal during decoding. Nearly all video codecs transform spatially extended images into sets of simple frequencies"³⁶ - a form of implicit "sonification", and thereby time-critical: "This allows them to isolate those components of an image that are most

³⁴ Karlheinz Stockhausen, Die Einheit der musikalischen Zeit, in: Dieter Schnebel (ed.), Karlheinz Stockhausen. Texte zur elektronischen und instrumentalen Musik, Bd. 1, Köln (DuMont) 1963, 211-221 (214)

³⁵ See Curtis Roads, Microsound, Cambridge, Mass. 2004

³⁶ Mackenzie 2008: 51

perceptually salient to human eyes" (ibid.). At first glance this "sonification" appears counter-intuitive: "In what way can a video frame be seen as a waveform?" (ibid.). A notion of implicit sonicity emerges: the emancipation of sound as temporal form from physical acoustics.

"Sound is not static, it is first and foremost vibrations, and secondly it is friction that causes sound to be heard"³⁷ - the friction between different physical elements. This is *actually embodied* in the piezo-electric effect, when a voltage is applied to a crystalline surface and induces a shock wave.

In McLuhan's sense, "acoustic space" - beyond the age of printed knowledge - is characterized by its non-fixity - "[v]ersatile and vibrating thoughts that do not rest to stay [...]." High-technological media share with sound its mode of existence-in-time: they exist only in sonorous performance respectively technical operativity. Therefore media analysis non-metaphorically applies sonic terms such as echo, resonance, vibrato, reverberation.

Another form of sonicist investigation is "to examine the pauses, the rests, and the silence". Different from cultural poetics and aesthetics (John Cage), technological silence signals a differential articulation. Speaking a silence, or letting silence speak, is practice in communication engineering since telegraphy and type-writing (and printing) with the empty "space" key. In the binary alphabet, the "off" counts as much for information as the "on". Thus speaks media-archaeology.

Micro-archiving sonic presence with technologies

Technical recording of sound is a process of storage. "The breaking of the time constraint has profoundly changed the nature of acoustic communication."³⁸ The temporality (and volatile being-to-death) of sonic articulation which hitherto could only be recorded symbolically by mnemonic notation is transformed into space and visualization by the very act of recording, making it available for analysis "outside of time" (ibid.). The temporal essence of sound is thereby turned into a reified, objectified time object, from evanescence to the ob-scene.

The traditional sound record - like the textual record - can be included within an institutional archival frame. With digital sound, though, literally every bit of sonic articulation becomes part of a generalized "archival presence", since a) every digital signal processing involved ultra-short quasi-archival intermediary storage and b) every sound "bit" becomes

³⁷ Tisha Mukarji, *Auscultation* (2009);

<http://www.sonicthinking.org/auscultation.html>; accessed February 16, 2010

³⁸ Barry Truax, *Acoustic Communication*, Norwood, N. J. (Ablex) 1984, 117

numerically addressable and thereby accessible to mathematical, algorithmic manipulation. The archival frame is deconstructed and returns from within the digital archival records themselves. From analog to digital "archiving" sonic presence, "the manner of storage determines the kind of control that can be exercised over it" - from manipulation to distortion.³⁹ At the same time, the analog-to-digital conversion results in a transsubstantiation of the audio signal: from the primary physical event to information which is essentially neither energy nor matter. Thereby the signal loses its indexical trace; transitive transduction is therefore to be set into quotation marks: "[...] the digital 'transduction' process includes the digitalization of the analog signal by the ADC, its <micro->storage and / or manipulation in binary number format, and its reconstruction as an analog signal by the DAC"⁴⁰ - which is the conversion of an electronic representation (embodiment?) of a number stored in the computer memory to discrete voltage steps at fixed time intervals (Dt). The physically continuous original waves are thus transformed into square waves; in fact every binary computational act is an abrupt form of oscillation between zero and one in a time-sequential form. Only by smoothing the square wave by filters the wave becomes continuous again.

Sonic Media Tempor(e)alities: From Analog to Digital

The primal scene (Freudian *Urszene*) of affective irritation of "presence" has been the moment when the human voice which has represented the most transient articulation of presence for ages (since Plato's criticism of writing until the deconstruction of occidental logo-centrism by Jacques Derrida) phonographically could be stored and re-played even beyond the death of the voice-bearer. The working assumption of the Berlin Team research is that Edison's invention of 1877 which allowed for not just symbolical (phonetic writing in vocal alphabet) but physical (the acoustic signal) recording of the dis-embodied individual voice has been a cultural shock which - although it soon became part of everyday sound culture - has still not been digested within the cultural unconscious. What seems natural to an animal (the notorious dog Nipper listening to "His Master's Voice" at the gramophone tube) for humans leads to a traumatic dissonance between cognitive knowledge (the historicity of the recording) and neuro-physiological affect which perceived the gramophonic voice as pure presence (Dolar).

When in Paris Pierre Schaeffer defined the acousmatic⁴¹ for *musique concrète*, he re-used a term once coined to describe the teaching method of Pythagoras who concentrated ("heated up", in McLuhan's

³⁹ Truax 1984: 119

⁴⁰ Truax 1984: 139

⁴¹ Pierre Schaeffer, *Traité des objets musicaux*, Paris (Seuil) 1966, 91

terms) on the human audio channel of communication by hiding behind a veil (or in a cave) while speaking. This acoustic purism is truly archaic in the media-archaeological sense: letting the pure, disembodied voice emanate while the sound-generating human or machine is hidden. For the listener it is undecidable whether there is human presence, radio transmission or a gramophone record behind the veil. Thereby the visual absence of the sound source does not only refer to space but to temporal irritation as well. An ongoing (even apparently accommodated) paradigmatic shock took place since the invention of the phonograph (and the answering machine), when all of the sudden the voices of the dead could be heard again in re-play: acousmatics in (flat, close to the present, or deep, "historically" distant) time. In addition, there is an additional micro-temporal dimension of acousmatics. Irritation of acoustic perception takes place even when a corresponding visual source can be noticed but is not synchronized with the acoustic event (well known from problems in lip synchronisation in sound film).

The voices and sounds emanating from such a black box are radically bodyless, resulting in a different timing than the symbolical historiographical time. This split between an original sound and its electroacoustical recording results in what R. Murray Schafer called "schizophonia" - a dissonance between the affective and the cognitive awareness of sound-based time consciousness.

A special emphasis is put on the analysis of the digitization of "sonic" media archives in its wider sense - with "sonicity" here being used in a neo-logistic way as a category of time-related objects of knowledge, referring to the range of time-based media which are sonic in the sense that electro-mechanical and high-electronic operations share with acoustic events their radical temporal condition. While archives of visual evidence (photography, cinematographic frames) represent a static archive (endurance), the "acoustic space" (McLuhan) of recorded sound and electric circuits stands for processual temporalities. While on the level of user interfaces the digitization of sound sources from the analog archive is mostly unnoticed in the everyday media practice, it is of utmost importance to point out the deep rupture which sublimely takes place when qualities like analog "live" transmission is being replaced by "real time". Such calculations create ultra-short intermediary archives which look like presence in the narrow time window of what physiologically counts as presence. In addition, the authenticity of the indexical signal is challenged once it gets processed digitally. Acoustic experience within that context serves as a privileged field for analysis. Ironically, by analog-to-digital conversion ("sampling") the symbolical code (previously represented by the textual alphabet, or musical notation) returns in mathematical forms (alphanumeric algorithms), asking for a refreshed grammatology of the theory and practice of "archiving presence".

Digital sampling troubles the human ears by making it a player in the sonic *imitation game*: "Drum or keyboard sounds stored on a digital music computer can be triggered by analogue recordings. [...] a 'real' drummer, playing with human imperfections, can be made to sound like a machine. [...] this technique has been consolidated into a piece of hardware called *The Human Clock* - a triggering device that enables a drummer to drive machines in synch, according to a varying human tempo."⁴²

This results in irritations "between human and automated rhythm", culminating in a metaphysics of the analogue: "This sense that analogue is warmer and more natural than digital also extends to its visual signification, [...] signified via the words we use to describe these patterns - *waves* as opposed to *numbers*"⁴³ - or pulses.

While mechanical sound recording directly corresponds with (and to) the mechanical vibrations of the Gusle string and the Guslari voice, magnetic recording requires the intervenience or a literally technical "medium" which is the apparatus of electro-magnetic induction. The wire recorder, by its very recording medium (a steel wire), directly corresponds with the telephone line - thus allowing for a kind of direct transmission of recorded songs from storage to presence: "re-storing presence".

The sonic time sense in humans clearly observes what Roland Barthes has analysed for lightning-like momentum (*punctum*) of a photography from the past which (notwithstanding its intellectual cognitive *studium* which refers to its contextualisation in history) rather indexially (the chemical fixation of light traces) than metonymically (rhetorical narrative) links the past to the present spectator: "ça a été", the affect of a presence in absence, a kind of negative ontology of presence, resulting in "affective consciousness" when viewing a photography.⁴⁴

Sound pulses human / inhuman: heart beats

Media-based figures of time define life as a function of pulsating rhythms. Not the technical frequencies are being evoked (that would be electro-magnetic radar pulses) but human presence as represented by heart beats - imprisoned in many senses. The human heart turns out to be an archetypal case of the acousmatic dispositive; while it can be heard it can not be naturally seen. The chest has to remain closed in order to constitute a space of resonance for the heart beats.⁴⁵ In a dissimulative disguise of sonic technologies, non-invasive real-time ultrasound imaging

⁴² Andrew Goodwin, *Sample And Hold. Pop Music in the Digital Age of Reproduction*, In: Simon Frith / same author (eds.), *On Record. Rock, Pop and the Written Word*, London (Routledge) 1990, 258-274 (264)

⁴³ Goodwin 1990: 265

⁴⁴ Roland Barthes, *Camera Lucida*, London (Vintage) 1993, 55

in the medical context renders the phantasmagoric impression of actually "seeing" inside the body, while its visuality is a techno-mathematical transformation of ultra-sonic impulse responses. Appropriately, one of the earliest applications of sonic signal transduction into visual representation has been called *Hyperfonografie* in 1942 by the neurologist Karl Dussik.

What literally "counts" here is neither the sonic event nor its imaging procedure, but the run-time of the signal from which shapes of reflecting matter is computationally derived. The mythic nymph Echo becomes media-archaeologically grounded in echokardiography which is based on the impulse-echo-procedure.

The sono-traumatic affect

Presence is no ontological state but an affect of *différance* (Derrida). "Viola's deconstruction of presence leads [...] to the unconscious discovery and experience of time - an essentially traumatic event. [...] This sense of trauma is articulated through the primordial scream that recurs through Viola's work [...]." ⁴⁶

Jonathan Sterne writes on the idea of the resonant (phonography-based) tomb, embalming et al. as the discursive condition which gave rise to sound recording technologies: "Phonographic time was the outgrowth of a culture that had learned to can, to embalm, in order / to 'protect' itself from seemingly inevitable decay."⁴⁷ It might be added: this was the epoque of studies in thermodynamic entropy as well. This is the discourse-analytic approach, as expressed in the subtitle of Sterne's monography *The Audible Past: Cultural Origins of Sound Reproduction*. Under this perspective, recorded voices did not result in a schock but resonated with an already established discursive condition. But even if sound recording apparently results from a discursive setting within a socio-historical context, the probability does not explain the qualitative rupture which resulted from the being-there of phonography. Contrary to discursive phantasmogoria, *phonautography* arose from the epistemological desire to analyse acoustic wave forms (Young, Léon-Scott et al.).

⁴⁵ See Walter Filz, Herzarchiv. Oder: die Poesie der Dokumente, in: Verein für Medieninformation und Mediendokumentation (ed.), Fokus Medienarchive. Reden - Realitäten - Visionen 1999 bis 2009, Berlin (LIT) 2010, 159-167

⁴⁶ Donald Kuspit, Bill Viola: Deconstructing Presence, in: Barbara London et al. (Hg.), Bill Viola: Installations and Video Tapes, New York (The Museum of Modern Art) 1987, 73-80 (78)

⁴⁷ Jonathan Sterne, Preserving Sound in Northern America [extract of Sterne 2003], in: Mark M. Smith (ed.), Hearing History. A Reader, Athens (University of Georgia Press) 2004, 295-318 (308 f.)

Different from hermeneutic understanding (German *Verstehen* resonates with its acoustic hearing) Joseph Carl Robnett Licklider researched to which extent speech can be distorted and still remain intelligible: "Distortion is most easily thought of as a deformation of a function of time or of frequency"⁴⁸ on the rather microscopic level.

Only with its implementation in physical vibrations, sound as cognitive or symbolically notated "musical" concept starts to haptically affect the human sense of temporal presence. From this material implementation emanates the power of phonographic sound recording media to "represence" (Vivian Sobchack) past performances. Whereas the cinematic format and TV image is always perceived as framed and thus contained (as a kind of distancing quotation mark of reality), the acoustic signal cuts directly, even aggressively into the ear. The radio voice is not perceived as *representation* of the "real" (physically present) but as identical with the human voice itself.

ASYMMETRIES BETWEEN SONIC SIGNALS AND MUSICAL MEANING

It has been a "first order" cybernetic premise that capacities of the human "mind" (less emphatically than its German equivalent *Geist*) can be modelled by logical circuitry (McCulloch / Pitts) and by "learning" automata, as has been demonstrated with the "Perceptron" for visual pattern recognition.⁴⁹ This has been developed further into musical information aesthetics, admitting the problem of machine "creation of valuable, meaningful artificial texts, the aptitude to master a general semantics"⁵⁰, based on the "functionalist" hypothesis that non-biological processing of sensory objects are chrono-structurally equivalent (isomorphous) to what is declared "meaningful" by humans, as expressed, e. g., in Turing's paper "Computing Machinery and Intelligence", or in Gotthard Günther's definition of the "trans-classical machine" consciousness⁵¹. If mental states are analogous to computational states, they are multiply analyzable and synthesizable, even "in electronic states of robots"⁵². The question of machine meaning has to be preceded by a definition of what is understood as "meaning" -

⁴⁸ J. C. R. Licklider, The manner in which and extent to which speech can be distorted and remain intelligible, in: *Cybernetics / Kybernetik. The Macy-Conferences 1946-1953, vol. 1: Transactions / Protokolle*, ed. Claus Pias, Zurich / Berlin (diaphanes) 2003, 203-247 (203)

⁴⁹ See Karl Steinbuch, *Automat und Mensch*, 4th (revised) ed. Berlin / Heidelberg / New York (Springer) 1971, 130 f.

⁵⁰ Abraham A. Moles, *Cybernetics and the Work of Art* [FO 1965], in: Rosen (ed.) 2011, 217-225 (218)

⁵¹ Gotthard Günther, *Das Bewußtsein der Maschinen. Eine Metaphysik der Kybernetik*, Krefeld / Baden-Baden (Agis) 2nd ed. 1963, supplement IV "Die 'zweite' Maschine" 179-203

⁵² <http://www.scholarpedia.org/article/Teleofunctionalism>, accessed 5 April, 2018

accompanied by the media-archaeological perspective of how the machine looks at human meaning, in reverse simulating artistic creation such as by Markov approximation (Max Bense's radio play *Der Monolog der Terry Jo*). In the age of Turing tests, there is a persistent, uncanny (if not "traumatic") uncertainty whether the musical meaning arising in human derives from human or technological composition.

Hermann von Helmholtz' differentiation between physiological acoustic perception ("Wahrnehmung") and musical sensation ("Empfindung") as well as the neuro-aesthetic focus of Systematic Musical Science on musical cognition, remains overtly anthropocentric. Technology-focused Sound Studies, on the contrary, listen to the sonic signal and from there define music as a cultural technique of "organized sound" (Edgar Varèse). With the media-epistemic concept of implicit sonicity as temporal, time-critical form, the notion of "music" does not only make sense for human receivers, but equally refers to the "algorhythm" (Miyazaki) of programmed computation.⁵³ There is musical understanding (if not "meaning") within technological systems themselves; radical media archaeology here separates from phenomenology in favor of a techno-processual ontology.

Against the phenomenological anthropocentrism of discussing musical "meaning"

Music, as a cognitive concept, can occur without sound, and rather with implicit sonicity. A most prominent case in point concerning "inaudible" music is the Pythagorean notion of *musica mundana*, according to which the spheres of celestial bodies have "Sirenic" singing (Platon) but cannot be perceived by human ears.⁵⁴

Steve Goodman proposes an "ontology of the vibrational force"⁵⁵. There is implicit "hearing": "Sonic events – e.g. noises, sounds, music – are not perceived by the ear alone; with other bodily or material sensors, they trigger both physiological and physical reactions. In research of such phenomena, measuring devices, augmented by software intelligence, are the first listeners, first of all; only such technologies provide the means "to better understand and explore these and other affects."⁵⁶ The loss of "musical" control of sound by electronic variations is compensated by

⁵³ For such a blending of mathematical algorithm with musical rhythm, see Shintaro Miyazaki, *Algorithmics. Understanding Micro-Temporality in Computational Cultures*, *online* in: *Computational Culture*, Issue 2 / 2012, <http://computationalculture.net>

⁵⁴ *Sonic Things: knowledge formation in flux*, special issue of: *Sound Studies*, 6:2 (2020), DOI: 10.1080/20551940.2020.1794651; Viktoria Tkaczyk / Leendert van der Miesen, Introduction, 105-113 (abstract)

⁵⁵ Goodman 2010: 82

algorithmic control again. Media archaeological understanding leads to an "epochal" (Husserl), at least temporary disempowerment of the perceiver's position as the listening subject; human "musical meaning" becomes open to non-hierarchical connections between sonic phenomena. There is the acoustic physical signal, which is perceived as "sonic" within humans by cultural prefiguration, and the musical sensation being semantically charged and temporally ordered. But once "rhythm is wrested from the established notion of measure in music, a perplexing diversity of terms, instruments and practices unfolds, situating it between a manner of flowing (rhythmos) and an order of movement, proportioned figure (metron) [...]."⁵⁷ Rhythmic semantic can be derived from automatism already, like the non-auditory planetary "spheric" music, diagrammatically defined by Platon. Aesthetic experience does not come to existence in human perception only.]

In an advertising prospectus from 1905, the Freiburg Welte company differentiated between "mechanical music" from its personalized recording technique for reproduction piano "mit allen Feinheiten des rhythmischen und dynamischen Vortrags mit völligem Erfassen der persönlichen Note"⁵⁸. Against the human pianist re-enacting "historic" scores, the reverse question arises: Does machinic "interpretation" preserve a different machinic meaning, arising in the dynamics of the machine body? Welte-Mignon reproduction pianos "read" punched information from rolls, pneumatically triggering piano keys. Is the human musicologist or piano player, when reading or playing a score, him / herself in such a machine state, in the sense of the *turingmachine* with its tape "reader"? Charles Babbage once derived the mechanics for programming his digital Analytical Engine (around 1830) from the Jacquard loom, from textile machines based on "digital", punched card notation. But different from a musical score, such "operative coding of a textile structure", when implemented mechanically, allowed for an instrument to algebraically generate not only repeated but new patterns⁵⁹ - implicitly "musical" algorithms in Ada Lovelaces sense .

Is the cultural phenomenology of "musical meaning" *incommensurable* with technical, that is: non-discursive embodiments of sound as

⁵⁶ The Berlin Club Transmediale (CTM) 2015 festival theme *Un Tune* draft; <http://www.ctm-festival.de/festival-2015/theme>

⁵⁷ Online draft for the *Rhythm-Expression* discussion of the Berlin festival MaerzMusik, hosted by Bojana Cvejić, Tom Engels and P.A.R.T.S. Research Studios group, with Bernhard Lang. Haus der Berliner Festspiele, 14 March, 2016, within the "Thinking Together" discourse program

⁵⁸ Gerhard Dangel (ed.), *Aus Freiburg in die Welt. 100 Jahre Welte-Mignon: automatische Musikinstrumente*, exhibition catalogue, Stadt Freiburg, Augustinermuseum, Freiburg i. Br. 2005, "Vorwort", 7-9 (8)

⁵⁹ See Birgit Schneider, *Programmierte Bilder. Notationssysteme der Weberei aus dem 17. und 18. Jahrhundert*, in: Horst Bredekamp et al. (eds.), *Das technische Bild*, 2008, 182-190 (189)

articulation of specific tempor(e)alities? There is an asymmetrical relation between "sound" as signal event and "music" as cultural code - unless, in a technical recursion of the ancient European link between music and mathematics, "digital" media are understood as the truly techno-logical mathematization of sonic matter - and thereby a re-entry of the "musical" structure which is numerical ratios (harmony) and rhythms respectively "algorithmics"⁶⁰.

Time-Critical Analytics of Human Musical Expression

The technological capturing of human "musical" performance (both physiology and cognition) enables not only its machine reproduction and synthesis, but scientific analysis as well. Media archaeologically, the recording apparatus, as has been developed by Welte company in Freiburg for *recording* the dynamics of piano play for replay, correlates with technical devices developed for scientific *measuring* of micro-temporal piano key movements.⁶¹ As has been experimented by Boris Yankovsky in his Syntonfilm Laboratory in Moscow, once sound has been spectrographically analyzed, it can be re-synthesized, resulting in synthetic acoustics without human source at all, like the Vo(co)der. Such graphical sound extends to manipulations like time-stretching and pitch transposition.⁶² Nikolay Bernstein's "chronocyclography" has been a parallel effort for techno-analytically catching the musical "gesture".⁶³ Graphical analysis results in a spatialisation of the sonic time axis. Such a geometrisation of the sonic event deprives it of its essential message which is time, ultimately *logifying* the wave signal into a mathematical, "musical" ratio (*lógos*) instead of its processual acoustic (matter) event.⁶⁴ But when coupled to a machine reading, graphical inscription becomes a musical time-event again. A Chopin score "is not a transcription of a performance; it prescribes how certain performances [...] should be [...]. In this respect, it is more like the circuit diagram an engineer produces

⁶⁰ In Shintaro Miyazaki's sense: xxx

⁶¹ Such as the graphical registration developed by Alfred Binet and Jules Courtier, *Recherches graphiques sur la musique*, in: *L'Année Psychologique* vol. 2, Paris 1986, 201-222. See Wolfgang Auhagen, "In Search of Beauty in Music". *Zur Geschichte der musikpsychologischen Interpretationsforschung*, in: Loesch / Weinzierl (eds.) 2011: 15-26. For a case study, see Hermann Gottschewski, *Die Interpretation als Kunstwerk. Musikalische Zeitgestaltung und ihre Analyse am Beispiel von Welte-Mignon-Klavieraufnahmen aus dem Jahre 1905*, Laaber (Laaber) 1996

⁶² See Smirnov 2013: 209-226

⁶³ See Julia Kursell, *Moscow Eye and Ear-Control. Über die neurophysiologischen Arbeiten von Nikolaj Bernstein zum Klavierspiel*, in: Sabine Flach / Margarete Vöhringer (eds.), *Ultravision. Zum Wissenschaftsverständnis der Avantgarde*, Munich (Fink) 2010, 83-105

⁶⁴ Hermann Gottschewski, *Graphic Analysis of Recorded Interpretation*, in: *Computing in Musicology* vol. 8, 1992, 93-96

for a new electrical component [...]."⁶⁵ But in electro-diagrammatic reasoning, it is matter itself which interprets the (musico)logical score. In contrast to machine reproduction, human piano play from a historic score is hermeneutising the notation, just like in early nineteenth century, lithographic engraving of historical paintings endured as "critical" form of human reproduction, rivalling the recent visual reproduction medium of photography.⁶⁶

Oral epic poetry, once fixed on phonographic media like the master recording of a Jazz improvisation, has almost immediately been transcribed for philological (scholars like Milmar Parry and Albert Lord) and musical interpretation into a score for research by Béla Bartók in its time. But from its parallel storage on aluminium disc, wire spool or sound film as signal memory, it can now be techno-mathematically "transcribed" into a score of a different kind, serving Digital (or better: algorithmicised) Humanities, as well as "artistic", research.

The dynamically faithful Welte recording of artistic piano play corresponds with microtiming in the recomposition of past performance practice. Richard Beaudoin, since 2009, composes new, notated, acoustic works based on millisecond-faithful transcriptions of recorded piano performances, applying most refined methods of acoustic microscopy and microtiming.⁶⁷ Interpretation as sonic hermeneutics and as scientific measuring the acoustic event, all of the sudden, are no contradictions any more.⁶⁸

"Western musical notation has been developed to represent [...] works that require performative interpretation."⁶⁹ The micro-temporal analysis of an actual interpretation of a score by the piano performer has replaced the "philological" interpretation of the written score as *oeuvre* in Western music. By technical inscription for signal measuring, the investigative *lógos* approaches what at first sight seems to escape analysis: the ephemeral sonic articulation. A spectrogram, e. g. of the first 21 seconds of Chopin's *opus* 28/4 in Martha Argerich's 1975 interpretation, created with the Lucerne Audio Recording Analyzer (LARA)⁷⁰, may be considered a sonoanalytic "photograph" of the performance: "A spectrograph represents *sounds*, or vibrations in the air, but not *music*, which requires

⁶⁵ Beaudoin / Kania: 124

⁶⁶ See leMan 1994

⁶⁷ See Richard Beaudoin, *The Principles of Microtiming and Musical Photorealism*, manuscript <http://nrs.harvard.edu/urn-3:HUL.InstRepos:3415685>

⁶⁸ See Heinz von Loesch / Stefan Weinzierl (eds.), *Gemessene Interpretation. Computergestützte Aufführungsanalyse im Kreuzverhör der Disziplinen*, Mainz et al. (Schott) 2011

⁶⁹ Beaudoin / Kania: 123

⁷⁰ See Beaudoin / Kania: 122, Fig. 4: output from the Luzern Audio Recording Analyzer (LARA), showing the millisecond-faithful measurement of four bars of Chopin Op. 28/4 in the recording of Martha Argerich from October 1975

perception of a uniquely human sort [...] just as we see three-dimensional objects *in* certain two-dimensional arrangements of pigment."⁷¹ Beaudoin therefore manually transferred the spectrographic information back into a symbolic score (*Latticed Window*), as a reentry of musical *lógos* into sonic matter. The technological question, here, is equivalent to the sonic machine.

Sub-semantic listening vs. musical code

It has been in linguistic research that effective algorithms for recognition have first been developed - as transformation of physically measurable wave forms of speech signals into electric impulses; such operations are based first on electronic transduction and then the transformation of the time-signal to its frequency number.⁷² Sonicity can not be reduced to the dynamics of waveforms, but encompasses mathematical operations and subsequently their machinic computing as well. Once a series of digits can represent waveforms, sound is liberated from its acoustic phenomenology. The statistic tools from corpus-based linguistics have been adopted for music analysis: "While the basic elements and features (or tokens) over which statistics are computed naturally differ between linguistics and musicology, the statistical concepts that allow us to infer regularities within the specific domain are quite similar or nearly identical. Among the chief statistical concepts that can be derived from frequency counts of tokens / features, and that are employed in both fields, are Markov models, entropy and mutual information, association measures, unsupervised clustering techniques, and supervised classifiers such as decision trees."⁷³

The agenda of emancipating sound from music is media-epistemological indeed: It has been signal recording technologies and media theories (*avant la lettre*) which heightened awareness of the physicality of sound as vibrational event (both mechanical and electro-magnetic). In terms of ontological unrevealing, it is techno-logical analysis (such as spectrography and Fast Fourier Analysis) as well counts as a better "understanding" of sound than in human hearing itself.

⁷¹ Richard Beaudoin and Andrew Kania, A Musical Photograph?, in: *The Journal of Aesthetics and Art Criticism*, 115-127 (121)

⁷² H. Schnelle, Automatische Sprachlauterkennung, in: *Kybernetische Maschinen. Prinzip und Anwendung der automatischen Nachrichtenverarbeitung*, Frankfurt/M. (S. Fischer) 1964, 208-219 (211)

⁷³ Daniel Müllensiefen / Geraint Wiggins / David Lewis, High-level feature descriptors and corpus-based musicology: Techniques for modelling music cognition, in: *Systematic and Comparative Musicology: Concepts, Methods, Findings*, hg. v. Albrecht Schneider, Frankfurt am Main u. a. (Peter Lang) 2008, 133-153 (140)

For the media-archaeological understanding, the musical structure does not already unfold in a silent decoding of the score (as claimed by Theodor Adorno), but only as actual enactment, in its operative implementation in structurable matter - be it machine listening, or human cognition.

Is "musical meaning" dependent on sound as event in matter? In the symbolic order of score notation, "structural listening can take place in the mind through intelligent score-reading, without the physical presence of an external sound source"⁷⁴, as diagrammatical unfolding of music. As conceived by Theodor W. Adorno, "the silent, imaginative reading of music could render actual playing as superfluous as speaking is made by reading of written material"⁷⁵.

Musical events (from noise to music) are not perceived by the human ear alone. Technological analysis not only provided the means with which to better understand bodily and neuronal affects; they have a musical understanding themselves.

When sound recording changed from technical signal recording (such as analog phonography) to calculation (in digital computing), this was not just another version of its materialities, but a conceptual change.

"Music" as cultural art form, in Western tradition, does not belong to the sonic realm, since it is primarily conceptual; from there stems its affinity to early programmed computer music such as Lejaren Hiller's Illiac Suite composition. In 1984, IBM Germany edited a combined book (Heinz Josef Herbolt) and LP record called *Computer-Musik*, with the appropriate subtitle "Vertonung im Zeitalter der Prozeßrechner".

Logocentrism becomes (algo)ryhtmic. Vilém Flusser, in Lecture 16 at Sao Paolo, defines music as "any set of sounds purposely composed by the human intellect", while at the same time clearly separating between music as epistemic structure and its physical implementation as audible sound. In the 1980s, Vilém Flusser lectured on the musical code as both concrete and abstract at the same time. Music, like mathematics, is an abstract code, triggering an intellectual process which Flusser termed "pure music"; even "visual codes become spontaneously 'musical'" once they no longer mean the outside world, "but inner, mental processes"; the media artist "transposes the processes of his brain onto [the] apparatus".⁷⁶ Flusser's enthusiastic correlation of music with

⁷⁴ Rose Rosengard Subotnik, *Deconstructive Variations. Music and Reason in Western Society*, Minneapolis (Univ. of Minnesota Press) 1996, chap. 3 ("Toward a Deconstruction of Structural Listening. A Critique of Schoenberg, Adorno, and Stravinsky"), 148-176 (161)

⁷⁵ Subotnik 1996: 161 f.

⁷⁶ Flusser, Letter to the editor of *Leonardo Magazine* in review of an article, 1987 (information by Rodrigo Maltez Novaes, Research Fellow Vilém Flusser

mathematics looks at "pure music" as freed from discursive (aesthetic or cultural, even phenomenal or neurobiological) restraints. This situates human "musical meaning" in a non-historicist tempor(e)ality in itself - a truly structural, archaeological concept. Under this perspective, computer music is not simply a creation of the 20th century, but a recursion of the oldest concept of occidental music as such. All of the sudden, *lógos* becomes musical again - in a deeper sense of *epistemé mousiké*.

Leibniz' modelled musical understanding within humans to be "a recondite arithmetical exercise" by the soul "which is unaware that it is counting". Such subliminal calculations actually happen in computations which are fast enough to complete a given task in real-time; time-bound model of musical reasoning. There is "musical meaning" even in the "transition time from straight to curved flight" of aeroplanes, as calculated by the Bell Labs in 1943; its ca. 3 secs⁷⁷ corresponds with the human "time-window" of the present. Anti-aircraft artillery literally counts with such anticipatory timing and describes it in musical terms: "There is a silent music to it."⁷⁸

In anti-aircraft prediction, the pre-calculated lists based on statistics become part of the actual present itself, its register, *online* as condition of data processing in real-time.⁷⁹

When discovering sub-semantic poetic respectively musical articulation, interpretation results from measuring. Separating "music" from "noise", Norbert Wiener, with his method of *harmonic analysis* (borrowed from musical terminology) was interested in responses of a linear resonator to random impulses.

["This is physically realized by the well-known 'shot-effect' in vacuum tube circuits. In such a circuit, the current is carried across the vacuum by individual electrons, and, since these are indivisible, is subject to fluctuations which are independent for non-overlapping intervals of time, and have a constant mean square average."⁸⁰ An impulse signal - be it an enemy aircraft, or electrons - can then be separated as fluctuating ones.⁸¹]

Archive, University of the Arts, Berlin)

⁷⁷ NA-227-D7-GP, Box 12, Folder Project 11, "Diary of DJS Conference at NACA v. 9. März 1943, here quoted after: Roch 2009: 74

⁷⁸ Robert Silverberg, as quoted by Claude Shannon; here: Roch 2009: 188

⁷⁹ Roch 2009: 162

⁸⁰ Norbert Wiener, On Linear Prediction [1941], 1 (NA-227-D7-GP, Box 4, Folder: Project 6), quoted after: Roch 2009: 57

⁸¹ Roch 2009: 58

"[M]usical time is the organization or the set of forms 'imprinted' [...] on sonorous matter, on sound."⁸² Therefore sound is material, and music conceptual. If music is sounding matter shaped in symbolically ordered time, it is *drama*, while coded writing of music is symbolical time. "Real" time only takes places in analog signal recording or digital signal processing. Philip Glass, in 1974, remarked on Repetitive respectively Minimal Music: "So bleibt zu hoffen, daß man dann in der Lage sein wird, das „Jetzt“ der Musik wahrzunehmen, frei von jeder dramatischen Struktur, als ein reines Medium des Klangs"⁸³ - which subtracts the very term "music" itself.

Only when a musical score is decoded and *incorporated* into human performers or *implemented* into signal processing machines, it can be articulated as sound. "Music" is the semantic content of "organized sound"; the "sonic" message of a vibrational medium is the experience of time, just as in technological operations: "Media mediate change and are therefore the material form of time."⁸⁴

Sound moves inbetween musical meaning in what it attempts to portray, and communication engineering⁸⁵ which measures and calculates the effects sound and frequencies have upon humans. "Musical meaning", at first glance, is excluded by communication engineering; Claude Shannon defines artificial languages abstractly, as "a stochastic process which generates a sequence of symbols"⁸⁶. Warren Weaver, though, suggested to add the semantic dimension to Shannon's seminal diagram: "One can imagine, as an addition to the diagram, another box labeled 'Semantic Receiver' interposed between the engineering receiver (which changes signals to messages) and the destination. This semantic receiver subjects the message to a second decoding, the demand on this one being that it must match the statistical semantic characteristics of the message to the statistical semantic capacities of the totality of receivers, or of that subset of receivers which constitute the audience one wishes to affect."⁸⁷

"Semantic" listening concentrates on *musical objects* like a melody. Whereby a melody is basically a contour kept and recognized in memory "over time" (in both senses), the time-critical approach of media

⁸² Jean-François Lyotard, God and the Puppet, in: ders., The Inhuman. Reflections on Time [*L'Inhuman: Causeries sur le temps, Paris 1988], Stanford, Cal. (Stanford University Press) 1991, 153-164 (153)

⁸³ Quoted after program brochure of the performance (Berliner Kammeroper) *In the Penal Colony*, music: Philip Glass, Hebbel-Theater Berlin, November 2002, 7

⁸⁴ Sean Cubitt, The Practice of Light, Cambridge, MA (The MIT Press) 2014, 257, as quoted in the introduction to Timothy Barker, Television In and Out of Time, in: Andrew Hoskins (ed.), Digital Memory Studies. Remembering through digital and social media, London / New York (Routledge)

⁸⁵ Barry Truax, Acoustic Communication, Norwood, N. J. (Ablex) 1984

⁸⁶ Claude Shannon, Collected Papers, Piscataway (IEEE Press) 1993, 5

⁸⁷ Weaver, in: Shannon / Weaver 1963: 26

archaeology rather concentrates on non-harmonic micro-figurations of temporality within the sonic event. Effective algorithms are capable to identify "musical" qualities such as dynamic time warping⁸⁸, and to extract "the repetitive structure of an audio recording"⁸⁹.

"Objects of music cognition like melodies, rhythms, and harmonies [...] seem to be mentally represented in a form comparable with symbolic encoding formats."⁹⁰

Computational "Deep Learning" conceptually aims at "musical cognition" previously limited to human brain capacities - a reentry of the archetypal cybernetic hypothesis that "musical" aesthetics in principle (*en arché*) is re-definable algorithmically, mechanizable as a Turing machine.

Cognitive processes like memory encoding, retrieval and similarity perception are obviously influenced by the familiarity of the musical material that is to be processed.⁹¹

Technological understanding differs from sense-making in human hearing. Claude Shannon, in his notorious diagram of communication engineering, makes a difference between the technical reception and the final "understanding" of a received message. The ear becomes an electronic receiver. Zwicker called the ear a "Nachrichtenempfänger", with the brain being the final destination. Does media-archaeological analysis arrive at its limits when it comes to explaining "musical meaning"? A bridge, though, are the measuring instruments and modeling algorithms (software) for brain research. To what degree is the identification of "musical meaning" itself an effect of such an apparatus?

The research group Music, Mind, Motion, Machines⁹² works on music cognition, by application of sensor technologies, motion tracking cameras, and machine learning which is an actualization of the cybernetic premise. Motiongrams and sonograms made from recordings of oral poetry or musical performances allow to identify the correlation of musical meaning and gesture, just like articulated speech in its rhythmic pattern when expressed on a typewriter. Just as Nicolai Bernstein analyzed piano play by chrono-cyclograms in post-revolutionary Russia⁹³, motion capture of musical gestures nowadays includes computer vision techniques, infrared, electromagnetic, ultrasound, mechanical and

⁸⁸ See Müller 2007: 69

⁸⁹ Meinard Müller, *Information Retrieval for Music and Motion*, Berlin / Heidelberg / New York (Springer) 2007, 165

⁹⁰ Müllensiefen et al., 133

⁹¹ Müllensiefen et al., 136

⁹² See Rolf Inge Godøy / Marc Leman (eds.), *Musical Gestures Sound, Movement, and Meaning*, New York / London 2010 (Routledge); <http://www.uio.no/english/research/groups/fourms>

⁹³ See Julia Kursell, "Moscow eye" xxx

inertial motion capture systems. Successful *synthetic* production of semantically "meaningful" music sensations are the proof that "musical meaning" can be reduced to second-order syntax by techno-mathematical *analysis*.

Symbolic Musical Score vs. Technical Sound Recording

After sound has been frozen in merely symbolical "musical" score notation of for thousands of years, only with so-called analogue technical media such as the phonograph, sound could be registered not only as symbolic signs of time, but as time signals themselves. Grooves in a record maintain not just a symbolical relationship to macro-time (such as historiography); they inscribe and reproduce functions of micro-time themselves.

But in a remarkable trick (*mechané*) of technological reason, with the digital computer, the symbolic "musical" regime *dialectically* re-turns: this time in a genuinely dynamic mode (which differentiates implementation of software from the traditional Gutenberg galaxy): algorithmic time, operative diagrams.

Archiving Music / Recording Sound

Notions of the 'analog' and the 'digital' sound and music relate to aspects of (analogue) embodiment and (digital) disembodiment.

"Music" refers to the scripture ("score") of sound in the "archive" which relates to the symbolic time order, while "sound" as the acoustically real - or sonically implicit physical wave - is an actual "time signal" event. If - independent from the musical "message" (with McLuhan) - the actual *message* of sound its its nature as time signal, it epistemically corresponds with the essence of technologies which become *media* only when in being (in operation). Therefore, there can be no "sound *archive*", just an archive of sound records. But in an ironic turn of techno*lógos*, the kymographic record becomes symbolical itself with its digitization, again. Algorithmic computation is a re-"musicalization" of sound, whereas conventional electroacoustics rather equals "analogue computing where values are typically represented in a (basically) continuous form as voltages or currents and not as sequences of bits. Analogue computing is "inherently interactive [...] one of the key advantages when it comes to the study of dynamic systems in general and chaotic systems in special, where a researcher can easily change some parameters and "see" the effect in realtime on some output device such as an oscilloscope."⁹⁴ In

⁹⁴ Bernd Ulmann, Exploring chaos with analog computers, in: Links 2021 [special issue "Unconventional Computing", edited by Andrew

that point of view, the classic electro-acoustic synthesizer is an analogue computer, where the ear is allowed not only to listen to implicit computation, but to "real time" itself.

LISTENING TO SONIC EXPRESSIONS WITH MEDIA-ARCHAEOLOGICAL EARS

Media-archaeological argumentation turns the notion of sound upside down in order to reveal, below its apparent auditory phenomena, its epistemological essence which is an enunciation of specific *tempor(e)alities*. The notion of "implicit sonicity" reveals the hidden chrono-epistemological implications of sound itself. While sound as acoustic vibration is a physically material event, in its temporal form ("implicit sonicity") which affects the human sense of time it is volatile and immaterial. How does sound as matter relate to its immaterial timing?

In a fundamental sense, sound *matters* as time-critical articulation. The concept of "sonicity" as epistemological approach is rather related to media-archaeology than to the acoustic. Sonicity happens as non-material oscillations even without being heard as acoustic "sound" any more. "When we see rhythm preserved in a radio aerial, we cannot stop the image of a reciprocal action between the geometric and the temporal from intruding into our thought. It is therefore on our best interests to regard things as truly the products of stationary waves. Periods are spatio-temporal function. They are the temporal face of material things. As it vibrates, a thing reveals both a temporal and a material structure."⁹⁵

The almost immaterial sonicity of electro-magnetic waves, far beyond simply a phenomenon in acoustic culture, make "sound matters" a fundamental event of being-in-the-world. There is sound in the machines themselves, in symbolic representation (data) and non-symbolic occurrence (signals).

According to Norbert Wiener's seminal cybernetic definition, information - measured in *bits* - is "neither energy nor matter". Is the current interest in sound therefore a "post-digital" nostalgia for vibrational matter? Sonic auscultation is an attempt to capture the volatility of sound and reveal its temporal message in a concrete manner through the algorithmic stethoscope, which is software for sound analysis.

Spectral analysis of sound transforms the signal from the time domain into the frequency domain. The analytic science has become aesthetic practice in "spectralism" as compositional technique in contemporary

Adamatzky], 21-24 (21)

⁹⁵ Gaston Bachelard, *The Dialectic of Duration* [FO 1950], Manchester (Clinamen) 2000, 78

music⁹⁶, where the experimentation of micro-times is being replaced by mathematical patterns.

Sound art matters: Implicit "sonicity"

In discussing the essence of the *tone*, G. W. F. Hegel defines it in its temporal essence: "Ein Verschwinden des Daseins, indem es ist"⁹⁷. - a disappearance of being, while it exists. The commonality of sound, vibration, light, and technical image lies in their equal condition that by analytic measuring media they can be identified as time-critical frequencies. The existence of sound *in* and *as* time signal is twofold: its explicit tempor(e)alities in human perception and its implicit dynamics as epistemic object.

Most media studies have originated either from literary studies, or from theater, film and television studies, with a neglect of the auditory channel of communication. The alliance between sound studies and media archaeology results from a focus on implicit "sonicity", understood as time-based signal processing, as its structural link.

The privileged alliance between technological events and musical sound is based on their common denominator which is its temporal processuality. This is evident in a central electro-technical device: the resonant circuit, otherwise significantly called "tuned" circuit. Such an electric circuit consists of an inductor and a capacitor in mutual connection. "The circuit can act as an electrical resonator, an electrical analogue of a tuning fork, storing energy oscillating at the circuit's resonant frequency."⁹⁸ Resonant circuits are used either as sender (for generating signals), or as receiver (for picking out a signal at a particular frequency from a band of carrier signals), particularly in radio technology, up to the mobile media in digital wireless communication.

In an experiment from 1889, David Lodge placed two resonant circuits next to each other, each consisting of a Leyden jar connected to an adjustable one-turn coil with a spark gap. When a high voltage from an induction coil was applied to one tuned circuit, creating oscillating currents, electric sparks were excited in the other tuned circuit only when the circuits were adjusted to resonance. Not by coincidence engineers borrowed the terms to describe the micro-temporal event of oscillatory electro-magnetic discharge from musical science. "Lodge and some English scientists preferred the term 'syntony' for this effect, but the term "resonance" eventually stuck" (ibid.).

⁹⁶ See Hugues Dufourt, *Musique spectrale: pour une pratique des formes de l'énergie*, in: *Bicéphale* no.3 (1981), 85–89

⁹⁷G. W. F. Hegel, *Enzyklopädie* (1830), § 459: *Werke*, Frankfurt / M. 1970, vol. 10, 271

⁹⁸ http://en.wikipedia.org/wiki/LC_circuit, accessed 23rd January, 2015

What McLuhan once daringly termed "acoustic space", is more fundamental than what the human ear can hear, indeed. As the radio producer Tony Schwartz wrote in his book *The responsive chord* in 1974: "In discussing electronically based communication processes, it is very helpful to use auditory terms [...] like *feedback ... reverberation ... tuning* [...]." ⁹⁹

"Sonicity" between vibrational force and electro-magnetic waves

In *The Audible Past*, Jonathan Sterne differentiates sound as perceptual quality from mechanical vibration as physical event: „As a part of a larger physical phenomenon of vibration, sound is a product of the human senses and not a thing in the world apart from humans. Sound is a little piece of the vibrating world“ ¹⁰⁰ and „somewhat human-centered“ ¹⁰¹. But some conditions must be given "for something to become recognized, labeled and valorized as audible in the first place" ¹⁰².

Vibration encompasses both a „dissolution of matter“ as well as „sensory experiences of things which vibrate“ ¹⁰³. Vibration (such as in high frequency radio) operates even before being translated into sense-data called sound, light, heat - against „purely audiological conceptions of sound“ ¹⁰⁴ which limit the frequency range. Against a „naive physicalism“ and a „phenomenological anthropocentrism“, Steve Goodman defines the "ontology of the vibrational force" as an "in-between of oscillation, the vibration of vibration, the virtuality of the tremble. Vibrations always exceed the actual entities that emit them. Vibrating entities are always entities out of phase with themselves." ¹⁰⁵

The theoretical conceptualization of vibration carries itself a temporal index: In late 18th and 19th century, "new technologies and scientific theories heightened awareness of the physicality of sound as vibration" ¹⁰⁶, while at the same time generating non-mechanical vibrations like the electro-magnetic oscillation, technologies of telephony and radio. ¹⁰⁷ Tactility is the mode in which sound can be experienced by humans as vibration - different from the electro-magnetic field ("light") which does not mechanically enact pressure.

⁹⁹ Garden City, New York (Anchor books), 23

¹⁰⁰ Sterne 2003: 11

¹⁰¹ Sterne 2012: 7

¹⁰² Veit Erlmann 2010: 18

¹⁰³ Shelley Trower 2012: 7

¹⁰⁴ Friedner / Helmreich 2012: 76, as quoted by Papenburg

¹⁰⁵ Goodman 2010: 82

¹⁰⁶ Trower 2012: 2

¹⁰⁷ Trower 2008: 134

The English noun "sound", in German, splits into two different notions: a) *Schall* which is the physical acoustic air pressure which can be perceived by the human ear and hearing; b) *Klang* which names the periodic, harmonic sonic events.

Taken at face value, sound is "mechanical disturbance from a state of equilibrium that propagates through an elastic material medium"¹⁰⁸. But German language differentiates between *Schall*, *Klang*, *Ton*. In English, the semantics of "sound" embraces all this trinity.

Sound excludes noise by definition - but noise is integral to communication theory. Sound therefore is too limited in its epistemological scope. The notion of "sonicity" includes noise as the stochastic alternative to music in Iannis Xenakis' sense and in terms of electronic music: subtractive sound synthesis creates "order from noise", filtering frequency bands, an all-encompassing "drone" ambience which is continually present throughout and from which sound can be extracted - different from the traditional Occidental additive notion of sound from single harmonic proportions or sine waves. Additive music builds sonic events up synthetically, with its base being silence, whereas the subtractive musical concept actually begins from sound. Here, all the notes and possible notes to be played are present before the musicians even start playing.¹⁰⁹

[The implicit sonicity, which is dormant in vintage computer sound chips, is well known from another analog electro-acoustic device: the synthesizer. All Programmable Sound Generator chips "generate white noise, which can be used to design sound effects, as rhythm instruments, or to be mixed in with other sounds in order to manipulate their tone color. Generating a noise signal adds an alien feature to digital computers since white noise is a sound that consists of all possible sounds spread equally across the frequency band; it is made to sound random" (Höltgen 2018, section 4.2). And "noise", beyond its acoustic semantics, is used, in computing, to derive symbolic (pseudo-) random numbers from the thermic real.]

Sonicity refers to the specific temporal knowledge which is implicit within sonic instruments of analysis and synthesis¹¹⁰ on the one hand; in that sense, "sonic revelations" of the vibrational qualities of the human eardrum arose from Hermann von Helmholtz' artefactual resonators. Another kind of insight into sonic temporality arises from graphically or mathematically derived sound. This even extends to the concept of non-struck sound like the theoretical fiction of vibrational forces called

¹⁰⁸ Encyclopaedia Britannica, 2003

¹⁰⁹ Bill Viola, *The Sound of One-Line Scanning*, in: xxx 1990, 44

¹¹⁰ John Durham Peters, *Helmholtz, Edison, and Sound History*, in: Lauren Rabinovitz / Abraham Geil (eds.), *Memory Bytes. History, Technology, and Digital Culture*, Durham / London (Duke University Press) 2004, 177-298 (185)

"ether".

At that point, the semantic associations of "sonicity" might start to get misleading. In 19th century discussions on the nature of electro-magnetic phenomena, acoustic terms have been borrowed, e. g. Maxwell's notion of the "electrotonic state"¹¹¹. It had been Christiaan Huyghens' "undulation theory" which equalled light to acoustic waves, resulting in the literally "media"-theoretical fiction of an ether.¹¹² But the equation of electro-magnetic "waves" with elastic mechanical vibrations is just a heuristic model to gain metaphorical evidence (*Anschaulichkeit*) of an otherwise directly imperceptible event.¹¹³ Maxwell cautions on the (otherwise useful) analogy between light and the vibrations of an elastic medium.¹¹⁴

From bodily sound ... to the all-embracing sonic?

"Sound matters. It mediates between the real and the virtual, connects the physical reality of acoustics with the mental reality of the muses."¹¹⁵ But even if the affective potential of sound is clearly a focal point, "yet it constitutes only one aspect of an investigation into the distribution, modulation, and perception of frequencies"¹¹⁶. Therefore sonicity might be liberated from sound. With the traditional distinctions between noise, sound, and music being increasingly blurred in artistic practice, "the concept of 'the sonic' [...] as an overall category [...] transgresses the limits of the musical and the acoustic" (ibid.) and opens into "the spectrum between bio-acoustical field recordings, brainwave entrainment, binaural beats, biofeedback, psychoacoustics, noise, and sub-bass vibrations" (ibid.). Such vibrations are delicately moved matter.

¹¹¹"Elektrotonischer Zustand", in: James Clerk Maxwell, Ueber physikalische Kraftlinien [Ostwalds Klassiker vol. 69], 5

¹¹² Criticized by Albert Einstein, Äther und Relativitätstheorie, Berlin (Julius Springer) 1920, esp. 9f

¹¹³ Josef Maria Eder, Photochemie (die chemischen Wirkungen des Lichts), Hallen (Wilhelm Knapp) 1906, 11

¹¹⁴ "[...] so müssen wir doch dessen eingedenk bleiben, dass sie nur auf einer formalen Aehnlichkeit zwischen den Gesetzen der Lichterscheinungen und denen der elastischen Schwingungen beruht": James Clerk Maxwell, Ueber Faraday's Kraftlinien, ed. L. Boltzmann, Leipzig (Akadem. Verl.-Ges.) 1898, 5 [Reprint 1995]

¹¹⁵ Martin Carlé / Anastasia Georgaki, Re-configuring Ancient Greek Music Theory through Technology. An adaptive electronic tuning system on a reconstructed ancient Greek barbiton, in: Michèle Castellengo / Hugues Genevois (ed.), La musique et ses instruments / Music and its instruments, Sampzon (Éditions Delatour France) 2013, 333-380 (335)

¹¹⁶ CTM 2015 theme

Material sound *versus* electro-magnetic sonicity

Even if sound is - to human perception - the most immaterial matter, still it is different from the electro-magnetic waves which touch the human eye as really immaterial "light". Sergei Eisenstein was wrong when he asked "to remove the barriers between sight and sound"¹¹⁷. In terms of harmonic relationships there might be a symmetry between the visual and the auditive, but in terms of (electro-)physics there is an epistemological asymmetry between mechanical, violent vibrations and electro-magnetic "waves". Optophonic "listening" to the "sound" of visual patterns by sonification rather obscures this fundamental difference.

(Ultra-)Sonic imaging

The electronic image, different from traditional painting, with its 650 successive lines every 25th / second, only exists when succeeding within a time-critical window of synchronized presence. Video artist Bill Viola actually listens to "The Sound of One Line Scanning"¹¹⁸. Marshall McLuhan actually termed electronically mediated communication "acoustic space".¹¹⁹

Ultrasound imaging, known from medical diagnosis, itself is images based on sound, where the (comparative to EM waves) slowness of acoustic waves (echo delay) are used to create electronic signals which can computationally be transformed into two-dimensional visual data. Such sound phenomenally is not experienced directly (binaurally) but indirectly seen, as image.

Ultrasound, by definition, transcends (above 20 kHz) the realm of acoustic signals which can at least be recognized within the audible range of the human ear.

Different from visualised "light sound" from celluloid in cinema, in sonography the inaudible sound is visually revealed. The age of sound film is linked to the functional (Fournier d'Albe) or aesthetic (Raoul Hausmann) "optophone".

Visualising sonic similarity

Many algorithms for audio content analysis already bear resemblance to visual retrieval techniques, such the Query by Image Content (QBIC) system. The Audacity software tool allows for sonic frequency analysis

¹¹⁷ Sergei Eisenstein, *The Film Sense*, New York 1969, 87

¹¹⁸ In: xxx Lexier (ed.), *Sound by Artists*, xxx

¹¹⁹ See Tony Schwartz, *The Responsive Chord*, New York 1974

via the optical channel itself, by means of waveform display, spectrograms and sonagrams, displaying how the energy distribution changes in the frequency band over time. In sonagraphy, the final graph of the sound event three-dimensionally plots frequency vs. amplitude vs. time. Audio content identification occurs in two ways, one phenomenal (for human perception), and one media archaeological (for machine listening) - from auditive sensation into a visual display, and into numerical computation.

Current audio analysis software predominantly displays visual interfaces, as indicated by the very name of Sonic Visualiser, representing time, frequency and energy of the sonic event. The software package literally allows for the visual comparison of different recordings of the same musical piece and to navigate across a number of such recordings, e. g., "how Rubinstein played Op. 6 No. 1 in his 1939, 1952, and 1966 recordings"¹²⁰, while further allows for detailed analysis of performance timing.

Audio signals radically (and essentially) unfold on the time axis, against which the visual regime serves to abbreviate temporal extension, with the image as compressed information on sound. Waveform and spectral displays turn knowledge from the attentive ear into the analytic eye. The visual displays of an n -dimensional search space becomes appropriate for browsing large sound databases where human acoustic memory would fail - while the machine simply calculates. Even what appears just similar to human perception, is exact in techno-mathematical terms. The algorithmic ear, in that respect, is relentless.

The sonified *Wunderkammer*

The electro-sphere, appropriately defined for analog broadcast media as synchronous "acoustic space" by Marshall McLuhan (and currently transformed into asynchronous "rhythmic space" in pulse-modulated digital mobile communication), separates the new Wunderkammer from its visually oriented historic version. All is different when the Wunderkammer objects become sonic and methods of "digital archaeology" as operative image analysis are applied to *sonify* the image-memory, resulting in a continuously evolving composition. This is no deliberate, but an algorithm-based, rule-based, in strictly Foucauldian

¹²⁰ Nicholas Cook / David Leech-Wilkinson, A musicologist's guide to Sonic Visualiser, http://www.charm.rhul.ac.uk/analysing/p9_1.html, accessed June 4, 2019

terms *archival* transformation¹²¹, giving a voice to the Wunderkammer, sonifying the artefactual collection.

Beyond the notorious Vocoder (the electronic device for speech synthesis resulting from spectrographic speech analysis for efficient voice transmission), the natural itself can be given a "voice" by un-natural means. In Ryan McGee's, Joshua Dickinson's and George Legrady's multimedia installation *Voice of Sisyphus*, a black & white photographic image from the 1970s displaying a hotel scene "At the Bar" is filtered by a computer program which then reads the segments and produces sounds out of them.¹²² From a digitally scanned image of a Baroque Wunderkammer as well, several regions and items can be automatically identified and then repositioned over time, therefore allowing for the subsequent sonification of the items. "Unlike the spectrograph approach used by most graphical synthesis programs, such an image-to-sound technique is derived from raster scanning of pixel data. By adding frequency domain filters, polyphony within a single image can be achieved.¹²³ Sound spatialization filters and segmentation algorithms thereby try to "make sense" of a *Wunderkammer* from a signal processing point of view. What human visual perception recognized as shapes and *Gestalt* does not sound melodic when audified: "Non-acoustical data is inherently noisy when audified since it is not a time series of pressure data obeying the wave equation" (McGee et al.).

Digital scans of Wunderkammer paintings can be converted into its sonic equivalents as MP3 files, based on defaults of the sonification software Photosounder - which, as a re-entry of the *Wunderkammer* as its diagrammatic image, can be in return visualized in its wave forms and frequency domain.¹²⁴

On the y-axis of such a digitized image, each line of pixels, by means of parameter mapping, is related to a defined frequency generated by an oscillator (sine tone generator). Line by line a spectrogram is being produced in which periodicities or non-periodicities can be detected and thereby can be sonified. By sonifying the otherwise spatial configuration of the *Wunderkammer*, its temporalization unfolds: no more museum, but music. From that results a really (electro-)acoustic Wunderkammer, or a huge archive of sound items from techno-mathematical culture.

¹²¹Ryan McGee (image analysis, audio and spatialization software), Joshua Dickinson (assisted with the audio composition software), George Legrady, VOICE OF SISYPHUS: An Image Sonification Multimedia Installation, presented at: The 18th International Conference on Auditory Display (ICAD-2012), June 18-22, 2012, Atlanta, USA

¹²²See <http://vimeo.com/30238729>

¹²³McGee / Dickinson / Legrady 2012, "abstract"

¹²⁴ <http://photosounder.com>, Demo version

Sound & matter *versus* the electronic audio signal

All kind of "waves" are a form of energy transfer without physical transport. Still there is a radical difference between mechanical and electro-magnetic waves. Acoustic vibrations are among the most immaterial articulations of materiality. Not only can physical matter can be forced to vibrate, but - as pointed out by Henri Bergson - matter itself consists of vibrations, that is: implicit sound.¹²⁵ Matter thus resolves "into numberless vibrations, all linked together in uninterrupted continuity, all bound up with each other, and travelling in every direction like shivers through an immense body"¹²⁶.

But "sound" relates to "matter" only in the acoustic sense of mechanical vibrations. The oscillations of the electro-magnetic field are a different kind of sound. Let us therefore undo the tight sound/matter coupling, in favor of a more processual, time-critical notion of sound as signal event.

When propagated in a physical medium like air or water, sound is the most ephemeral form of matter; itself it has no solid materiality but is matter unfolding in time. Matter here becomes a temporeality, like an analog electronic image which the video artist Bill Viola once described as "The Sound of one-line Scanning". "Phonovision" was the name given to gramophone records as storage medium of the earliest electro-mechanical Baird-Television picture series.

When mechanically propagated sound is being technically transduced, this is not simply a linear translation, but it changes its essence from acoustic to electric signal. Within a telephone line, or when stored as magnetic charges on tape, a media-epistemological "transsubstantiation"¹²⁷ of sound has happened, since as such the audio event becomes accessible to signal processing.

The so-called audio signal, beyond its possible origin in the physical world, may come into existence by electronic generation exclusively - in electro-technical *autopoiesis*.

The real essence of sound such as in Electronic Dance Music or Drum and Base is not primarily bodies but electrons in periodic motion. As (still) human composition or mix or mastering, it is still *musical*, while the *sound* itself has been de-corporalized completely, neither be connected to a human performer or voice nor to a mechanical instrument any longer. What started with the electronic live recording and studio editing,

¹²⁵ As emphasized in the Mauricio Lazzarato, Video Philosophie, Berlin (b-books) 2xxx

¹²⁶ Henri Bergson, Matter and Memory, London (George Allen & Unwin) 1950, 276

¹²⁷ See Wikipedia: <https://en.wikipedia.org/w/index.php?title=Transsubstantiation&oldid=696228320>; accessed December 21, 2015

now has become the message of the electronic and algorithmic (that is, techno-logical) medium itself.

Beyond the physical world of mechanical vibrations, the sonic articulation, on the electronic level, exists as signal only. In reverse, electrons - the essential elements of electronic media - are themselves accompanied by waves. Erwin Schrödinger intuitively recalled the oscillating monochord and thereby defined implicit sonicity: "Suppose the electron in the hydrogen atom is analogous to a string - tied at both ends - in a musical instrument. Such a string emits a very definite tone together with its overtones, but not the wavelenghts in between. With this idea in mind, Schrödinger [...] set up a wave equation for the electron"¹²⁸ - which is the only true "radio", as radiation.

The electro-acoustic "lab": Cologne *versus* Paris

Memory manipulation on and by tape has been common practice in the heroic age of magnetophone-based audio engineering. This actually reminds of the different techno-aesthetics of the Paris electronic music studio run by Pierre Schaeffer with its conceptual *musique concrète*. Stockhausen has criticised the Paris studio for its aleatory concept of "found sound" (passive magnetophone recording and then active manipulation) rather than generating electronic sound genuinely from non-environmental electronics.¹²⁹

Only in electronics, the almost pure sine wave as elementary unit exists (which fascinated young Stockhausen). In its physically impossible form, the *ideal* sine wave has a technological existence indeed: within the digital computer as mathematical function expressed in executable code.

A primary difference between the Paris studio of *musique concrète* (Pierre Schaeffer) and the Cologne WDR radio of Electronic Music (created by Herbert von Einem) is not simply an aesthetic but a media-epistemological one: Recording and manipulation of originally physical sound *versus* electronic sound generated by tone oscillators from the beginning, in pure sonicity. There is electro-mechanical kinetics and tactility on the one side, and circuitry-operative electronics on the other.

In artistic practice the active co-agency of the magnetophone has been recognized by pianist Glenn Gould.¹³⁰ Many of such compositions enhance the live performance by human musicians in communication

¹²⁸ Steve J. Heims, John von Neumann and Norbert Wiener. From Mathematics to the Technologies of Life and Death, Cambridge, Mass. / London (MIT) 1980, 103

¹²⁹ Tilman Baumgärtel, Schleifen. Geschichte und Ästhetik des Loops, Berlin (Kulturverlag Kadmos) 2015, 100

¹³⁰ See the "Glossary" explaining practices of audio tape recording and cutting, in: Glenn Gould, Vom Konzertsaal zum Tonstudio, Munich / Mainz 1992, 173

with pre-recorded sound. It has been against this tape-based sampling that, in contrast, the computational paradigm of real-time human-machine-interface developed, such as Roland Pfrengle's piece *Klaviermusik* (1984).

Very experimentally, Karlheinz Stockhausen in the Cologne Westdeutscher Rundfunk radio station "Studio für elektronische Musik" generated sine waves genuinely from within electronic oscillators. Notably his piece *Kontakte* (created contemporary to KLT, 1958-1960), in its first version, is not primarily about communicational "contacts" between human instrumentalists and sound machines any more but about the coupling inbetween electronics in its radically *non*-discursive *autopoiesis*. While for instrumental parts there is a conventional score, the electronic parts are in graphic representation.

[While sound film recording of musical articulation remains external to the instrument-player (machine-body) system, the photo-electric generation of sound from light waves from within an instrument (such as the Welte organ) is truly media music.¹³¹]

De-materialization? Digitized "sound"

When acoustic sound becomes transduced into an electric signal, it can thereby modulate a radio high frequency carrier band. Electro-magnetic waves do not mechanically touch the human ear. All the sound is there but unhearable - the implicit sonicity of electromagnetic vibrations, close to what humans perceive as light (especially in Ultra Short Wave radio transmission). The electro-magnetic event is not material any more but an epistemological challenge to re-think sound-as-matter. It can only be phenomenologically observed by its effects or needs mathematically to be diagrammaticized (Maxwell's equations).

Once the analog audio signal becomes digitized, the term "signal processing" becomes fully justified in terms of computing. Coded in binary values, the signal within computing devices shall not be called "audio" any more, even if it can - by digital-to-analog conversion - be emitted via loud-speaker for human ears as sound again. What phenomenologically appears like sound has inbetween (in the technological media channel) gone through a complete substantiation. In digital media, we have lost "sound".

The gap between the material recording of a sonic event and informational ephemerality principally started with the first coded

¹³¹ On the opto-acoustic ("optophononic") discs in Welte organs, see Peter Donhauser, *Elektrische Klangmaschinen*, Vienna - Cologne - Weimar (Böhlau) 2007

inscription already: the alphabet. The binary code is the smallest possible of such alphabets, and its advantage stems from its distinctive signal-to-noise ratio in signal transmission and signal storage, as it has been defined as the "Philosophy of PCM"¹³².

Friedrich Kittler, in his writings on the entanglement of music & mathematics, reminds that one and the same alphabet has been used to notate verbal language, music and mathematics - a "unicode" which unexpectedly returned as alphanumeric notation with the digital computer. This recursion can not be described in terms of cultural history any more but calls for a different diagram of cultural timing.

Digitized signals at first sight resemble the tradition of music notation (the score), but in addition, they are endowed with operational activity: they are algorithmically executable. Symbolic archival permanence is almost time-invariant, sublated from change with time, leading to ahistorical immediacy in the moment of re-play. We are not tuning into the past any more in sonic temporality.

MEDIA TEMPORALITIES AND THEIR SONIC UNDERSTANDING

Media Musicality: The Echo of the "Now"

E. R. Clay termed the "specious present" in 1882 for a recent past which is delusively given as perception of the now, different from the obvious past. Every electronic image is already the "halo" of an image (William James), "the dying echo of whence it came to us [and] the dawning sense of whither it is to lead". Such an image (like sound) is always already in transition.¹³³ New media phenomenology, by combining recent research in neuro science on brain temporalities¹³⁴ with the Husserlean definition of temporal experience (pro- and retention), couples technologies with the human experience of affective temporalities.¹³⁵ Already Marshall McLuhan's notorious theorem of the "acoustic space" opened the notion of electrified media. In media art like Bill Viola's works the "cinema-digital-video hybrid technique exposes the viewer to minute shifts in

¹³² Claude E. Shannon / John R. Pierce / B. M. Oliver, *The Philosophy of PCM* [*1948], in: N. Sloane / A. Wyner (eds.), *Claude Elwood Shannon. Collected Papers*, Piscataway (IEEE) 1993, 151-159

¹³³ As quoted in: Bill Viola. *Installations and Videotapes*, ed. Barbara London, New York (The Museum of Modern Art) 1987, 79

¹³⁴ On the neuro-processual time frame ("window of simultaneity") which counts as the human experience of "presence" see Francisco Varela, *The Specious Present. A Neurophenomenology of Time Consciousness*, in: Jean Petitot / Francisco J. Varela / Bernard Pachoud / Jean-Michel Roy (eds.), *Naturalizing Phenomenology. Issues in Contemporary Phenomenology and Cognitive Science*, Stanford, Cal. (Stanford UP) 1999, esp. 272f and 276f

¹³⁵ See esp. Hansen 2004, chap. 7 "Body Times", 235-268

affective tonality well beyond what is visible to natural perception"¹³⁶. If *tonality* is taken literally, there is implicit "sound" in electronic media, with the sonic not taken in its physical (acoustic, audible) but in its epistemological sense: being an expression of tempor(e)alities. Technological experimenting with media time (and its cognitive experience) lead to *sonicity* as epistemic media object in the dynamic chronosphere. The privileged relation between sound and technological media is grounded in their analogous time-basedness and chrono-poietical time-basing.¹³⁷ New media articulate themselves in symbolically ordered time, which is their media-dramatic musicality.

On *sonicity*: Sound as epistemic object of (media) analysis

In assuming the epistemological dimension of sonic memorization, the analysis goes far beyond to simply doing justice to *auditory memory* which indeed "has been largely neglected in memory studies in favour of visually-oriented arts of memorization [with their long tradition within rhetoric (*ars memorativa*)]"¹³⁸.

Electronic tuning allows to change a piano's tuning (its "temperament") with ease from universal "equal temperament" to time-specific ratios. "Modern pianos are tuned in "equal temperament," which divides each octave into twelve equal half-steps. The frequency of a note is adjusted up or down, sacrificing some harmony in all keys so none are too dissonant.

On the other hand, in many tunings that were popular in the Baroque period, intervals are extremely pure in some keys at the expense of others, increasing the dissonance in those keys.¹³⁹ Variable temperaments are essential tune into the earlier *Stimmung* of musical action. Techno-mathematical re-tuning of instruments (even in microtones) serves thereby as true media archaeology of the sonic past.

"Sing me, Muse, the deeds of a man called Odysseus", Homer's epic starts. What if the Muse is not only reduced to the narratives of "oral

¹³⁶ As paraphrased by Tim Lenoir, "Foreword" to Hansen 2004, xxvi

¹³⁷ See Bill Viola, *The Sound of One Line Scanning*, in: Dan Lander / Micah Lexier (eds.), *Sound by Artists*, Toronto / Banff (Art Metropole & Walter Phillips Gallery), 1990, 39-54. While entries like time, temporality and vision figure prominently in the "index" of Hansen's book, what is missing is the "acoustic", the "sonic", "sound media time".

¹³⁸ As defined in the call for papers to the workshop *Auditory Memory and Sound Archives from the Late-Nineteenth Century to the Present*, University of Amsterdam, 18 February 2013

¹³⁹ Katie Hafner, *Piano Tuners Have Built a Bridge To 18th Century*, in: *The New York Times*, published February 17, 2000, <http://www.nytimes.com/2000/02/17/technology/piano-tuners-have-built-a-bridge-to-18th-century.html?pagewanted=all&src=pm> (accessed July 11, 2013)

poetry" to be registered and displaced in writing symbols which replace (and "technologize"¹⁴⁰) the oral signal with all its rich overtones (tuning, pitch, timbre, rhythm), but phonographically remembered essentially sonic in itself?

Erkki Kurenniemi is "an unsung" pioneer of electronic art, the back cover (endorsement) of the DVD *The Dawn of Dimi* articulates¹⁴¹, quoting *The Wire* (January 2003): "Viewed from a historical perspective, Kurenniemi's music foretold digital directions in rhythm, noise and jumpcut editing, only back then no-one was listening." Is there a "historically" delayed listening? Yes and no: not historically (since this cognitive sphere is a function of historiography and the alphabetically recorded and organized archive), and yes: temporally delayed, reminding of the physically given evidence that every "presence" of aural listening already involves the delayed transfer of acoustic vibrations through air with a speed of around 330 meters/sec. - *medium* time in terms of Aristotle's "acoustic" definition of physical media.

Sonic eventuality is not only time-based, but in a more radical reading it leads humans to experience time at all. The neo-logism of "sonicity" aims at catching "sound" as an epistemological object of knowledge from a media-philosophical perspective. The audible section of the bandwidth of sonicity (acoustic sound) is just the deceptive top of the ice berg above the water level, or comparable (in less "layer" metaphors) to the visible part of the electromagnetic spectrum which animals perceive as "light". *Das Sonische*, a neo-logism in German language (different from *Klang* which is acoustic "sound") in this context refers to the inaudible vibrations ("analogue") and rhythms ("digital") within the electronic field (*Sonik*).

Sound as epistemological form of timing refers to continuous ("analog") vibrational and discrete ("digital") frequential dynamics of all kinds, ranging from the most precise (electro-)physical micro-moment over the human affect of temporal perfection up to repercussions of what traditionally (fixed by writing) used to be called history. But to understand the ways that media inscribe themselves on our bodies, we need a philosophy of time that recognizes the production of a different time-writing. "Before the phonograph, no sound had the option but to be fugitive. A historical rupture in the nature of sound arises that, in turn, rewrites its entire history."¹⁴² But maybe this irritation is more fundamental: not just a historical rupture, but a rupture of the privileged dominance of historical discourse over the phenomenology of emphatic time as such. The generation of vocal or otherwise sonic "presence" of

¹⁴⁰ In the sense of Walter Ong, *Orality and Literacy. The Technologizing of the Word*, London (Methuen) 1982

¹⁴¹ Published by Kinotar Oy and Museum of Contemporary Art Kiasma, Helsinki 2003; editor: Mika Taanila

¹⁴² Peters 2004: 193

cognitively known absence induced by the phonograph does not simply ask for a re-writing of media historiography, but requires different ways of writing temporal figurations as such - a kind of archaeography which the oscilloscope making visible sonic wave forms performs for long time already.

Sound allows for the co-experience of transient time and even time-invariant affects. It is this processual experience which the sonosphere shares with high-electronic media. Just like culture tries to save sound itself from its ephemeral temporality, signal recording media for the first time in cultural history mastered the time axis towards arbitrary manipulation.

The term "sonicity" does not refer to the apparent phenomenological quality of sound but rather to its essential temporal nature which is its subliminal message behind the apparent "musical" content.¹⁴³

Nicole Oresme's late medieval *Tractatus de configurationibus qualitatum et motuum* defines the "sonus" in its physical materiality as a function of the time axis¹⁴⁴ and thus comes close to the present definition of sonicity as epistemic articulation. The diffuse genealogy of the term *sonus* ranges from the concrete physical materiality of sound up to its epistemological definition¹⁴⁵ for which the neologism *sonicity* might be allowed. Sonicity refers to knowledge about implicit periodically varying functions of time.¹⁴⁶

Acoustic sound - in order to be communicated beyond its natural physical limits - must be technically transduced in order to fit to a technical channel such as the telephone line or electro-magnetic radio waves. While passing as transduced signal (voltage-controlled current), sound is in its implicit state.

¹⁴³ This argument refers both to Marshall McLuhan's central argument ("the medium is the message") in *Understanding Media* (1964, chap. 1) and to Martin Heidegger's epistemology of technology's essence, in: *The Question Concerning Technology and other Essays*, New York (Harper and Row) 1977

¹⁴⁴ "[...] aliam vero extensionem habet [sonus, et] motus, a tempore, que nunc vocetur longitudo ipsius soni": Nicole Oresme and the Medieval Geometry of Qualities and Motions, ed. by Marshall Clagett, Madison, Milwaukee / London (Univ. of Wisconsin Press) 1968, Book II, chap. 15 *De natura et difformitate sonorum*, 306

¹⁴⁵ See Frank Hentschel, entry "Sonus", www.sim.spk-berlin.de/static/hmt/HMT_SIM_Sonus.pdf (accessed July 2013)

¹⁴⁶ In that sense, John Durham Peters writes of "sonic revelations" of the vibrational qualities of the human eardrum by Hermann von Helmholtz' artefactual resonators (Resonatoren): Helmholtz, Edison, and Sound History, in: Lauren Rabinovitz / Abraham Geil (eds.), *Memory Bytes. History, Technology, and Digital Culture*, Durham / London (Duke University Press) 2004, 177-298 (185)

Volatile sound and speech must be converted implicit in order to pass the channel of cultural time and historical tradition: it must either be signal-recorded in phonography or symbolically coded by musical notation.¹⁴⁷ According to Marshall McLuhan, telephone, gramophone, and analogue radio were technologies of post-literate "acoustic space" which he declared on the climax of analogue electronic broadcast media culture. "Sonic" space is understood here as the epistemological existence of sound, somewhat opposite to the term in physics.

The term "sonic epistemologies" itself is awry; ancient Greek *epistemé* is already triggered by the visual bias of alphabetic writing (as defined by McLuhan 1962). *Sonic Epistemologies*¹⁴⁸ is sometimes called "acoustemic" already.

Marshall McLuhan made a crucial discovery about the intrinsically "acoustic" structure of electronic mediascapes. The immediacy of electricity is valued essential as the definite difference to the Gutenberg world of scriptural and printed storage of information: "Visual man is the most extreme case of abstractionism because he has separated his visual faculty from the other senses [...]. [...] today it is threatened, not by any single factors such as television or radio, but by the electric speed of information movement in general. Electric speed is approximately the speed of light, and this constitutes an information environment that has basically an acoustic structure."¹⁴⁹ Very media-archaeologically, McLuhan's terms "basic" and "acoustic structure" evidently refer to an epistemological ground, not to the acoustic figure in its phenomenological body-related sense.

In an epistemological sense, the sonic is not about (or limited to) the audible at all, but a mode of revealing modalities of temporal processuality, up to the "superstring" theory of today. Already Henri Bergson formulated his dynamic idea of matter in the sense of vibrating waves and frequencies.¹⁵⁰

"The *message* or effect of electric information is acoustic" (McLuhan) - even when it is perceived as an electronic "image" - as defined by the video artist Bill Viola in his essay "The Sound of One Line Scanning"¹⁵¹.

¹⁴⁷ Peters 2004: 188

¹⁴⁸ No. 4 (special issue) of the Journal for Sound Studies (JSS), xxx

¹⁴⁹ Letter to Barbara Ward, 9 February, 1973, in: McLuhan 1987: 466

¹⁵⁰ Henri Bergson, *Matière et Mémoire* [Paris 1898]; in English: *Matter and Memory*, xxx, 276

¹⁵¹ Bill Viola, *The Sound of One Line Scanning*, in: Dan Lander / Micah Lexier (Hg.), *Sound by Artists*, Toronto / Banff (Art Metropole & Walter Phillips Gallery), 1990, 39-54

McLuhan's "acoustic space" is oscillating time and implicitly re-returns in Gilles Deleuze's "interval" philosophy. But information in "online" worlds come a-simultaneous from topological directions which recalls a different structure of the act of *hearing*. "Sonic" tempor(e)alities unfold on the level of packet switching in the "social net": "Temporalities of flows, bursts, and various techniques and technologies of time management [...] is what characterises the specificity of reproducing existing worlds in network culture."¹⁵²

Listen to how "prosodic" communication in the World Wide Web sounds like on its basic media-archaeological level, its signal clocking in terms of *dactyles*: All of the sudden, one of the oldest figures of prosody in occidental poetic speech returns as implicit sound of digital telecommunication - true *technopoiesis*.

Sonic tempor(e)alities

In fact, the sonic ground of the electronic image is "hidden" in the media-archaeological and Heideggerean (*aletheia*) sense: "It is acoustic. It resonates. But this is a hidden ground, because superficially people think they're looking at a visual program. And they're not. They're not looking at all - they're absorbed, involved in a resonating experience."¹⁵³ So-called immersion is rather into a *sonic* than visual sphere.

There are two kinds of carrying sound through time: musical memory as symbolically notated in scores (the scripture-related archive), and sonic memory preserved in signal-based recording media (technical storage, starting with the Edison phonograph) which are endowed with "temporal indexicality" (Thomas Y. Levin). Media temporality refers both to the symbolical ("digital") and the physically real ("analogue") regime - like the clocking of computers and the "Time-To-Live" which in the Internet for data packets decides about the success of communication in virtual, that is: calculated space.

In the media culture which is experienced as the present an implosion of the despotic parameter "time" into a multiplicity of times and timings in the sense of chrono-poetics occurs. This time machine (not in the sense of time-travelling, but of time-generating mechanisms) is sonic by nature. The term "sonic" here refers to the two bodies of dynamic tempor(e)alities: the wave form and the digital, that is: mathematically

¹⁵² Abstract to Jurri Parikka, Of Queues and Traffic: Network Microtemporalities, lecture at the Glasgow Memory Group symposium *Digital / Social Media and Memory*, April 17th, 2013; publication: Andrew Hoskins (ed.), *Digital Memory Studies. Media Pasts in Transition*, New York (Routledge) 2017

¹⁵³ Marshall McLuhan, in: *Letters of Marshall McLuhan*, selected and edited by Matie Molinaro / Corinne McLuhan / William Toye, Toronto / Oxford / New York (Oxford University Press) 1987, 177

intelligent (algorithmic) manipulation of numerically addressable frequencies.

A "musical" composition (or other code), when effectively, that is: physically, implemented in operative media, is in itself *a priori* already a sonic *Versinnlichung* as temporal affect. In a more advanced interpretation, sound is even a *sonifiction* of time in the strict sense of Latin *fictio*, since it *generates* temporality.

Different from functional sonification as defined by Gregory Kramer as "the use of nonspeech audio to convey information" and, more specifically, "the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation"¹⁵⁴, sonicity is about *implicit* acoustics - which is the "acoustic" in McLuhan's *implicit* audio sense - a processual mode taken as epistemological term.

The present experimental popular music or avantgarde compositions is characterized by an aesthetic multiplicity which extends the limits of human perception to infra- and ultra sound and to micro-temporal events. This pushing of sonic limits is itself a effect of the almost infinitive flexibility of digital technologies. Thus it makes sense to extend the term "sonic" to non-acoustic time-based eventualities: vibrations and their mathematical reversal which is frequencies.

The (h)ear(ing apparatus) is much more sensitive to micro-temporal (time-critical) processes than the eye. While the flickering of an electric bulb (50 times/sec.) can not be noticed by the after-image in the eye any more (the cinematographical effect), the rising of acoustic pitch from 50 to 100 oscillations/sec. is very well perceived indeed.

This hits a deep epistemological dimension. If the experience of being is not a static one (ontologic), but rather processual (being-in-time), then the definition of existence as "being tuned" ("Durchstimmung" with Heidegger) recalls sonic resonance. "Stimmung", in German, relates both to the voice ("Stimme") and to the tuning ("stimmen") of an instrument, and more sublimely, radio reception - constituting "sonic" media temporality.

"In order for one person to understand what another person says, he must be 'in tune' with him. [...] such intrapersonal synchrony is far more fine-grained than that of any *corps de ballet*."¹⁵⁵ Communication, here, is

¹⁵⁴ Gregory Kramer et al., Sonification Report. Status of the field and Research Agenda, *online* <http://sonify.psych.gatech.edu/publications/pdfs/1999-ns-f-report.pdf>, accessed January 2013

¹⁵⁵ Alan Lomax / Irmgard Bartenieff / Forrestine Paulay, Choreometrics. A Method for the Study of Cross-Cultural Pattern in Film, in: Ronald D. Cohen (ed.), Alan Lomax, Selected Writings 1934-1997, New York / London (Routledge)

not simply "a function of social context"¹⁵⁶, but of time-critical signal engineering.

In many respects sound – heard, recorded or transmitted – is radically ahistorical; its specificity could not be captured and subsumed by the logocentrism of traditional narrative historiography. Serious engagement with “the sonic” – sound as sound and sound as time – provides access to a plurality of non-narrative temporalities.

CHRONOPOETICS AS "SONO-POETICS". The Appeal of Sound as Time-Object and Time-Subject for Technology-Oriented Media Theory

So what is "chronopoetics"?

Chronopoetics investigates the ways technological media are time objects and time subjects; for that reason, the analysis stays close to the actual signals. In order to perform such analysis, it first needs a cognitive training: to get distance from the discourse of cultural history. Historical discourse is all too hegemonic when it comes to discuss multiple temporalities. The media-archaeological cold gaze and listening (both technical and as human understanding) is a way to get - at least momentarily - suspended from that supremacy of historical discourse.

Media archaeology describes technological events on the level which is phenomenologically hidden to human perception. Here, a micro-drama unfolds, both *in* time and in the form of its diagrammatic mathematical expression: the frequency domain. It is only by measuring, diagrammatic and calculating media that this world becomes accessible to human knowledge.

Chronopoetics refers 1. to the "hidden" tempor(e)alities within technology, 2. to the phenomenological irritation of human sense of time when being coupled to media timing, and 3. to the philosophical dimension: the revelation of how technical media are position in culturally "deep time".

After getting used to non-historistic ways of rethinking media time, more constructively it takes an active step to develop a new language for the analysis and implementation of such tempor(e)alities. While conventional historiography of technology writes "about" media time (that is, in the intransitive mode), a transitive approach to express multiple media temporalities needs to be developed. Next to non-linear verbal forms of

2005, 275-284 (278), referring to: W. S. Condon / W. D. Ogston, Film Analysis of Normal and Pathological behaviour, in: Journal of Neurological and Mental Diseases, vol. 142, no. 2 (year xxx), 237

¹⁵⁶ Lomax 2005: 277 f.

argumentation, that results in graphical diagrams and even sonic rhythmograms - and in different temporal moods of looking and listening to media-induced events.

Rhythmograms and their media-archaeological *Kehrwert*

The theory of music has been the traditional cultural domain to reflect upon different modes of time-based articulation, and has provided a rich terminology for expressing sonic eventuality. It is not accidental that in electronics, engineers frequently borrow musical terminology to name time-critical processes - like "resonance" (and the "resonant circuit" as its hardware condition in technical communication between a radio sender and a radio reception. This allows for a word-play, a slight shift of signifier: from technical *chronopoetics* to *sono-poetics*. "Sound" is the bridge between technical media and "music" as cultural aesthetics.

The both effective and affective "message" of sound as physical event is not "music" (which is rather its semantic "content") but its temporal form. Therefore the focus of an epistemological inquiry into sound is on its temporal *gestalt*¹⁵⁷. The "hidden" tempor(e)alities with/in technology might be coined as "sonicity". This refers to the implicit temporality in electronic media. In mid 19th century, James Clerk Maxwell explicitly chose a mechanic analogy between electro-magnetic field lines and hydrodynamic oscillations and coined this the "electrotonic state"¹⁵⁸.

Sonic signals in terms of mechanics are vibrational physical events with harmonious partial "tones" - literally ancient Greek *tonos*, "tensions". They have a privileged affinity to the epistemological concept of the "analogue". When, e. g., an archaic computer game is emulated in a current computer but was once created for continuous vector graphics on a cathode rays screen, and if the interface on the hardware level has to be a real vector monitor (which can not be convincingly emulated by a matrix screen with its aliasing pixels), the amplifiers of the present computer soundcard are being "misused" in order to generate, on the x and y axis, such kind of vector graphics.¹⁵⁹

Media Studies at Humboldt University once organized a symposium called *Think Analogue!*, juxtaposing the "dead medium" of analogue computing with the electronic modular synthesizer in electro-acoustics - which in fact are twin machines. Among others, media artist Benjamin

¹⁵⁷ "Zeitgestalt" in terms of Victor Zuckerkandl, *Sound and Symbol. Music and the External World*, Princeton (Princeton UP) 1956

¹⁵⁸ James Clerk Maxwell, *Über physikalische Kraftlinien* (1861 / 1862), *Ostwalds Klassiker der Exakten Wissenschaften*, vol. 102, ed. by Ludwig Boltzmann, Reprint Thun / Frankfurt / M. (Harri Deutsch), 1. Theil, 6

¹⁵⁹ See Stefan Höltgen, *Spiele(n) mit Pfeilen. Computerspiele und Vektorgrafik*, in: *grkg / Humankybernetik*, vol. 56, no. 4 (2015), 143-158 (158)

Heidersberger (co-creator of *Van Gogh TV*, an early experiment in interactive television presented at Ars Electronica in Linz and Documenta in Kassel in early 1990s) projected his electronic Lissajous figures created from an oscilloscope. This is an escalation of what his father - a prominent black & white photographer in post-war West Germany - had photo-mechanically created and called "rhythmograms".

In order to capture the message of Heidersberger's medium, it takes a technology which itself is able to record movement; Ali Altschaffel has cinematographically documented the "Rhythmograph", a mechanical analog computer resulting in visual patterns of photogenic drawings, of Heinrich Heidersberger.¹⁶⁰

There is a remarkable, epistemologically challenging equivalence between a mechanical generation of Lissajous figures, and its electronic expression. Though completely different physical systems, their temporal unfolding is principally (*en arché*) the same. Only in mathematical terms this relation between two incompatible worlds (materiality of mechanical devices vs. immateriality of electro-magnetic waves) can be expressed; therefore the real level of epistemological insight is mathematical. The technical medium to perform this is not the digital but the analog computer.

The hypothesis of analog computing is that an electric voltage circuitry can emulate a mechanical process since in mathematical description (as common denominator) it behaves the same.

What one could actually hear in the studio with Heidersberger's rhythmopoetic machine was not the harmonic oscillations themselves which result from the photographic registering of the light trace produced by the machine movement, but the noise of the machine itself. The visual rhythm emerges by opto-chemical recording: the subject-less long-time exposure of black & white photography. The visual "Rhythmograms" result from the inherent mathematical musicality of a mechanical analog device; Heinrich Heidersberger has built "an analogue computer designed for the combinatorial exploration of mathematical phenomena"¹⁶¹. The truly media-archaeological equivalent to Heidersberger's visual rhythmograms are algebraic formulas: differential equations. Only such radical mathematisation resists the metaphysical, esoteric or aesthetic seductions induced by such visual wave forms such as *Kymatik* (Jenny).

¹⁶⁰ See <https://vimeo.com/89780677>. Heinrich Heidersberger himself appears in a 1959 West German *Wochenschau* newsreel with the second version of the machine; see <http://www.filmothek.bundesarchiv.de/video/589598>, min. 7:00 to 7:30

¹⁶¹ Andrew Witt, Heinrich Heidersberger. *Light Harmonies*, Ostfildern (Hatje Cantz) 2014, 11

Heidersberger's "rhythomgrams" continue what in 19th century had started with Lissajous' tuning fork-based figures and later resulted in Heribert W. Franke's electronic "real time" oscillograms. When in 2014 a selection of Heidersberger's Rhythmograms were re-exhibited¹⁶², the subtitle was appropriately *das gestimmte bild* - the "tuned" image. There is implicit sonicity in such "technical" images. This ontologically recalls Martin Heidegger's philosophical notion of being as "Stimmung", and in terms of media arts has been expressed by video artist Bill Viola in an early essay defining the electronic image as "The Sound of One-Line Scanning"¹⁶³. Heidersberger's rhythmograms are spatial geometrizations of time-continuous oscillations, thereby freezing the sequential into simultaneity.

Marshall McLuhan, the founding father of technological media studies as academic discourse, frequently referred to so-called "acoustic space". This term does not address the explicit audible sound but rather the implicit "sonicity" of technical articulation - the rhythmic structure and temporality of signal processing and algorithmic operations. In cultural time, technology rather unfolds in "resonant intervals" than in straightforward evolution, as expressed by McLuhan in *The Global Village* and his *Laws of Media*. Any algorithm written down as source code has to become implicitly "sonic", that is: electronically implemented as sequential time events, in order not to remain simply an abstract symbolism but effectively computational. This requires temporal *understanding*.

Contrary to Heidersberger's *Rhythmograms* (produced between 1953 and 1965) indeed, today's techno-acoustics is rather beat than oscillations, impulses rather than continuous sound, stochastic noise rather than harmonics.

One way to de-metaphorize sound art is its spectral analysis - the analysis of such *temporal* tones as tabular mathematics. This causes vibration [...] to assume a numerical existence, a return to alphabet-based epistemology - a recursion of the ancient linkage between number and "music".¹⁶⁴

An academic turn to "sound studies" is currently taking place. But is the focus on "sound" justified for a critical approach to digital media culture? The hart-beat of computing (generating its "clocking") is the crystal

¹⁶² *heidersberger: rhythmogramme*, at Petra Rietz Gallery, Berlin

¹⁶³ In: xxx

¹⁶⁴ For the difference between Heinrich Heidersberger's harmonic *Rhythmograms* and early computational drawings, see Frieder Nake's *Achsenparalleler Polygonzug* (1965), in: Justin Hoffmann / Kunstverein Wolfsburg (ed.), *Der Traum von der Zeichenmaschine. Heinrich Heidersbergers Rhythmogramme und die Computergrafik ihrer Zeit*, Wolfsburg 2006, 24

oscillator with its piezo-electric effect. No sinuidal oscillations but sharp saw-teeth impulses.

In Homer's epic *Odyssey*, female sirens have been singing, but mechanical sirens (as invented by Cagniard de la Tour) express air pulses rather than continuous waves, discrete signals rather than tones. Only by addressing the sonic time signal in its mathematical form (counting by frequencies), sound can be "heard" by the digital computer. Computational clock time, by clever programming of its data cycling units, becomes truly algo-rhythmic.

Ubiquitous oscillations (Ørsted)

The human ear is especially sensitive to micro-temporal changes of pattern and rhythm. Time-critical signal archaeology is not simply concerned with so-called "time-based arts" (which start with oral prosody and theatre already, leading to film and other mass media dramaturgies) but with *kairotic*, that is: time-critical media technologies.

1803 Ritter writes to Hans Christian Ørsted: "Aller Sinnesempfindung liegt Oscillation zum Grunde. [...] überall, wo nur etwas geschieht, geschieht es auch nothwendig oscillatorisch."¹⁶⁵ Answers Ørsted: "If we imagine a taut string making its slowest vibrations, we are able to distinguish each vibration with our eyes. Let the speed increase, and now we can no longer distinguish one vibration from the other; we see only the entire space through which the string vibrates filled by it. There is a gap between the point where the visibility of the individual vibrations ceases to the point where the deepest tone begins. Now imagine the vibrations proceeding with increasing speed and producing higher and higher tones; in the end the speed of the vibrations becomes too great to be perceived by the ear."¹⁶⁶

Ørsted further, in 1808: "The vibrations continue to increase, and after an interval like the one between the fastest individuality visible vibration and the lowest tone, the vibrations here will rise to the production of the deepest color. It appears in front of the eye as a faint blue twilight, and with increasing vibrations it clears to higher and higher colors and thus runs through all prismatic colors until they have reached the most vivid red. According to this conception, one sense would become an octave of the other on the grand scale of sensations, and all would be subject to the same laws. Thus all sensations spring from the same original force."¹⁶⁷

¹⁶⁵ Quoted here after Siegert 2003: 300

¹⁶⁶ Hans Christian Ørsted, *Experiments on Acoustic Figures* [1808], in: *Selected Scientific Writings of H. C. Ørsted*, trans. and ed. by Karen Jelved, Andrew D. Jackson, and Ole Knudsen, Princeton (Princeton Univ. Press) 1998, 280

¹⁶⁷ Ørsted 1808 / 1998: 280

Geometrization of sono-temporal patterns

The central sonic event is the sine wave which in its pure form only exists from technical signal generators like tuning forks or electronic circuits, not in nature - just like sculpture in ancient Greek art idealized the actual human body. Instead of writing it on a time axis in its continuous wave form, the sine wave can be alternatively computationally. According to Poincaré, one can divide mathematicians into two types - those with visual and those with auditory intuition.¹⁶⁸ It is the operativity, the inner sonicity of computing which reveals temporal patterns indeed; that is processual media-archaeology. The algorithmic rhythm of digital calculation can be visualized by rectangular versions of the so-called Ulam spiral. In fact, this is no sound-"image" but a time-diagram.

Similarly, the Moiré effect originates from the "pixelized" image by the grid in half-"tone" photo printing (raster). For color raster printing several grids have to be overlaid, resulting in *moirés* which correspond to "Schwebung" in sonic impulse series. The moiré projector, overlaying one stable grid (slide) with a movable second grid (slide), is a sonic composition and device.¹⁶⁹ A temporal sequence is here translated into a spatial order.¹⁷⁰

The Ulam Spiral is a method developed by the mathematician Stanislaw Ulam in 1963 for the graphic representation of prime numbers by means of locations on a rectangular spiral.¹⁷¹ Nikita Braguinski experimented with such data visualization for his Ph.D. thesis on the oblique sounds originating pseudo-randomly from electronic toys and early computer games.¹⁷² The rectangular Ulam spiral representation allows for the

¹⁶⁸ Steve J. Heims, John von Neumann and Norbert Wiener. From Mathematics to the Technologies of Life and Death, Cambridge, Mass. / London (The MIT Press) 1980, 128

¹⁶⁹ See Emanuel Goldberg, Die Berechnung der Moiré-Erscheinungen, in: Zeitschrift für Reproduktionstechnik 8, Heft 12, 1906, 189-195, referred to in: Michael Buckland, Vom Mikrofilm zur Wissensmaschine. Emanuel Goldberg zwischen Medientechnik und Politik, Berlin (Avinus) 2010, 39-42

¹⁷⁰ Wolfgang Coy, Der diskrete Takt der Maschinerie. In: Georg Christoph Tholen / Michael Scholl / Martin Heller (eds.), Zeitreise. Bilder, Maschinen, Strategien, Rätsel, Zürich (Stroemfeld/Roter Stern) 1993, 367-378 (367)

¹⁷¹ See M. L. Stein, S. M. Ulam, M. B. Wells, A Visual Display of Some Properties of the Distribution of Primes, in: The American Mathematical Monthly, Vol. 71, No. 5 (May, 1964), 516-520

¹⁷² *RANDOM. Die Archäologie der elektronischen Spielzeugklänge*, Humboldt University, Berlin, February 2016; published Berlin (Kulturverlag Kadmos) 2018. See Nikita Braguinski, Die Spiraldarstellung - ein experimentelles Visualisierungsverfahren, <https://www.medienwissenschaft.hu-berlin.de/medienwissenschaft/medientheorien/miniaturen/braguinski-spiraldarstellung-03.pdf>

visualization of the calculations by the digital computer PASCAL from the early 1960s for prime number calculation - which is all about the hypothesis that it might be possible to detect repetitive patterns in an apparent random sequence.

["Am Anfang der Suche, das heißt im Zentrum des Bildes, sind keine Muster erkennbar. Wenig später beginnen sich auffällige Bänder von wellenartigen Mustern zu bilden, die jedoch zeitweise von Rauschteilen unterbrochen werden."]

The algorithmic procedure in the PASCAL computer in its time could still be sonified by loudspeakers, since the cycling units of calculation were within the low frequency range of the human ear.¹⁷³

Before the introduction of the electronic tube which allowed for calculating with ultra-sonic speed almost devoid of material inertia, electro-mechanic computing was audible in itself, like the 4 Hz clocking of the early Zuse 1 computer.

The misuse of electronic radio vacuum tubes as digital switch resulted in a quantum leap of speed in computing; therefore the first fully electronic digital computer, the otherwise silent ENIAC at Princeton, requires explicit sonification to make it understandable for human ears again.

[as has been performed in the Signal Laboratory of Humboldt University Media Studies by Martin Carlé.]

In the early days of digital computing, technological devices for short-time data storage like the *acoustic* mercury delay line used the slowness of sound waves itself as dynamic storage medium.

So far, the Ulam spiral has been used for the visual demonstration of mathematical regularities. Braguinski proposes the application of the Ulam spiral for signal analysis as well, as an alternative to the usual tools for sound visualization like wave form and spectrogram, with a focus on the identification of structural regularities or deviations on the micro level.

Looking at such geometric pictures, one may have learned to decipher the implicit sonicity in it. The mathematic construction of a rectangular spiral is step-wise created from discrete elements in succession. Such discrete elements may be the sampling values of any digitized signal,

¹⁷³ See Nijenhuis, W. 1962: Hörbares Rechnen der Pascal, in: Philips technische Rundschau, 24. Jahrgang, 1962/1963, Nr. 4/5, 169-176. See as well Christoph Borbach's and Thomas Nüchel's Cellular Sounds Project / Sonifikation zellulärer Automaten, <https://www.youtube.com/channel/UCAYWbTbWZ5VimoDLYA1CsDg>

thereby translating (rather than simply transforming) the time-domain into the frequency domain which is visual patterns.

This allows to recognize repetitive patterns in the data output of what is called a random generator; immediately it becomes literally "evident" that what sounds like accidental noise, when being produced by a digital device, can only be pseudo-random.

Spatializations of the time axis for the sake of analysis result in a geometrization. Does this deprive the sonic event of its essential message which is time? Is this a re-Pythagorizing of the signal event into a mathematical, "musical" ratio instead of its processual wave event?¹⁷⁴ This is not simply a technological question but a momentum with epistemological dimension. The time function of a sound signal $s(t)$ can only be approximated by the signals of the sample-and-hold operation in analog-to-digital conversion.¹⁷⁵

Fourier transformation allows for translating the physical "time" signal into the frequency domain which can thereby be numerically addressed and mathematically processed - still being the same signal, having lost all its temporality. Fourier analysis supposes that the analyzed signal is *ideally* periodic, reaching back indefinitely into the past and extending likewise into the future. But once again: The pure sine tone does not exist in physical reality. Any physical real signal is time-varying, always being characterized by a beginning and an anticipative sense of ending. Analysis can only focus on the time domain or the frequency domain (that is why Denis Gabor developed his time-windowing of sound analysis in terms of "acoustic quanta").

[Straightforward Fourier Transform of a periodic sound, by supposing a Platonic ideal endlessness, sacrifices the tempor(e)ality of the sonic signal which is always marked by the trace of its beginning: the *transience* of the signal. There is an existential temporality ("being-to-death") of any physical sonic event in Hegel's and Heidegger's sense. Wavelet-Analysis tries to capture exactly such temporality by slicing the sound.]

Not only the composition of sound is analyzed, but its very unfolding in time is visualized.¹⁷⁶

Materiality in being: Temporal sonicity of the monochord

¹⁷⁴ See Hermann Gottschewski, Graphic Analysis of Recorded Interpretation, in: Computing in Musicology vol. 8, 1992, 93-96

¹⁷⁵ See Fig. 4-4 in: xxx Görne, Tontechnik, 2nd ed. 2008, 130

¹⁷⁶ Julia Kursell / Armin Schäfer, Kräftespiel. Zur Dissymmetrie von Schall und Wahrnehmung, in: Zeitschrift für Medienwissenschaft 2, 1/2010, 24-40 (32)

Different from the material artefacts of classical archaeology which are preserved in museums, technical media from past times are not simply monuments which survived into the present, but they are essentially "time objects" ("Zeitobjekte") themselves; Husserl's term refers to objects which are not only a "unit in time", but "contains in itself temporal extension"¹⁷⁷. The *technochronological* object, in the active sense, is not simply subject to historical time, but an active agency in the media-theatre of time. Given the definition that technical objects become media only in the moment they actually process signals, that is: being in operation, then technological artefacts from the past can not be reduced to their materiality but have to be processual. Then they are timing themselves, undoing historical distance, being radically unhistorical. "[T]he vexing relationship between media, time and history can be viewed as variations on one German verb: *zeitigen*. It derives from *Zeit* ('time') and is normally a transitive verb followed by a direct object. "*X zeitigt Y*" means "*X* brings forth (or yields) *Y*", with the understanding that *X* does so in or over time."¹⁷⁸ Central to chrono-poetical analysis of technology and media culture therefore is the intransitive use: *Medien zeitigen*; "*zeitigen* here means to "time-ize" or "put in time" (2014: 406). [...] To deprive *zeitigen* of its direct object opens up two dimensions of "time-ing" which, taken together, drive a wedge between media time and the time of history" (ibid.).

The archaeological model of an ancient monochord becomes a *media*-archaeological object only when it is activated, that is, when the string is activated. Processual archaeology is not concerned with the human behind the artefact, but with the system embracing both.¹⁷⁹

Once a technical medium is intentionally activated, it starts to generate complex non-human phenomena, resulting in a media-active drama. Thereby the medium dis-closes its implicate knowledge in time.

Media archeology allows for a *synchronic* perspective or rather listening. As a *method* it concentrates on the functional-operative, processual dimension both in the material and in the theoretical sense. This allows for an archaeology of past media events as "re-presencing" (Vivian Sobchack), resulting in a literally better *mathesis* (understanding) of ancient technological knowledge by retro-active media archaeology.

Radio transmission identified from within its technological infrastructures

¹⁷⁷ Edmund Husserl, *On the Phenomenology of the Consciousness of Internal Time* (1893-1917), transl. by John B. Brough, Dordrecht (Kluwer) 1991, 24

¹⁷⁸ Geoffrey Winthrop-Young, *TS "Timely Matters"*, 2015

¹⁷⁹ Kent V. Flannery, *Culture, History vs. Cultural process: A Debate in American Archaeology*, in: Mark P. Leone (ed.), *Contemporary Archaeology. A Guide to Theory and Contributions*, Carbondale 1972, 105

There are both hardwired (materially embedded) and softwired (algorithmic) structures which govern telecommunication tempor(e)alities from within. Media archaeology identifies literally anachronistic, co-existing layers of contemporary media culture. The technological infrastructure of AM radio endured for almost a century, notwithstanding cultural and discursive breakdowns and transformations. Technological standards create a temporal *epoque* of its own. As long as they are still in operation, its technical concretizations are excepted from the ephemerality of the historical event.

A German "Volksempfänger" radio (DKE) from the mid-1930s can still be operative when receiving radio signals today (applying alternating current of ca. 220 V); "analog" AM radio transmission standards have survived several historical collapses of political regimes in 20th century indeed. The new wall, rather, is digital signal processing and transmission, creating a radical "divide" from analog technique.

Short Wave Radio

The epistemic ground behind the telepathic notion of nonsensory perception¹⁸⁰ is the propagation of electromagnetic waves, as calculated by Maxwell's equations, which falsified Newton's *actio in distans* theoreme in favor of time-based action, and were experimentally verified by Hertz' spark-gap based pre-radio transmission.

While communication studies listen to the content of electro-magnetic "Hertzian" wave propagation such as radio and television or mobile communication devices, media archaeology rather "listens" to their implicit sonicity. The task of a media theoretician now is to find arguments why, e. g., Short Wave radio communication is not an outdated medium in times of Internet radio, and not just for nostalgics of analog technologies. Short Wave radio reception means listening not only to the actual radio program but as well listening to radio as techno-physical medium (try it, if you have an old receiver with AM / SW mode), a more media-critical and media-aesthetic transitive coupling of our ears to the technology. With its fading signal strenght and all kind of noisy interference from the ionosphere sourrounding the globe, we become aware of radio in its true sonicity: the structural affinity between technical media and sonic articulation.

Technical recording vs. symbolic transcription

¹⁸⁰ See David Ray Griffin, Parapsychology, Philosophy, and Spirituality. A Postmodern Exploration, xxx

Since Thomas Alva Edison's phonograph, the analogue audio-recording media have built up a signal-based memory of sound which challenges the symbol-based traditional "musical" score as textual archive, recording even the non-musical articulations, the non-intentional, non-semantic evidence of the acoustic event, such as noise or bird-singing in the background which had been rather inaccessible for alphabetic or other symbolic notation. Wax cylinders or gramophone records constitute a sonic "counter-archive" (Paula Amad).

Once such recorded signals have been transcribed into the symbolic code, all non-musical (non-harmonic) information is irreversibly lost (unless the phonographic record itself is being preserved for later, unforeseen technical "understanding").

From passive archaeological records to active media-archaeology, such signal recordings allow for the electronic measuring of sonic articulation. Instead of the predominance of musicological interpretation which is cultural semantics, this liberates the sonic event to experimentation, enabling a non-hermeneutic analysis on the sub-philological, sub-alphabetic level.

But what has been recorded on analog media is now being re-played from within the computer. With the digitization of endangered audio media, the symbolical order of clocked time sublimely returns within sound itself - which both Bergson and Heidegger denounced as "vulgar" mathematical time, mathematizing the vibrational event.

Sampling and quantizing of acoustic signals transforms the time signal into frequencies as a condition for re-synthesis. Media culture turns from phonocentrism to mathematics. Digitizing analog records equals mathematical sound analysis itself. Hermann von Helmholtz questioned "mathematized" sound on the epistemological level:

"[H]ow can we be sure that what has been proven mathematically also occurs in nature [...]? [...] There is nothing in Fourier's analysis to suggest that it is little more than a mathematical fiction, 'permissible for facilitating calculation, but not necessarily having any corresponding actual meaning in the things themselves'"¹⁸¹]

In fact humans listen mathematically to the continuous sound, with our hearing channel being an implicitly calculating organ since since the inner ear counts frequencies subconsciously (*nesciens*, in Leibniz' term¹⁸²).

¹⁸¹ Helmholtz, *Lehre*, 56; engl. transl. xxx, 34

¹⁸² On the "Zählorgan Ohr" see Georgiades 1985: 42

There is a privileged affinity between sonic resonance and the experience of past time. Ludwig Wittgenstein once confessed that when he imagined a tune recorded for a gramophone "this is the most elaborate and exact expression of a feeling of pastness which I can imagine"¹⁸³ - undoing historicity in favor of a different access to temporality.

[Does the acoustic signal lose its temporal indexicality when being recorded? Binary "recording" on Compact Disc is a punctual temporal moment, while in acoustic recording by gramophone there is a processual time signal. Its re-play generates a different sense of the past. Replicating a sound from a recording medium, even if taken away from the real event, "retains its indexing properties"¹⁸⁴. As engraved index (in Peirce's semiotic sense) a sound forms a sharp contrast to its symbolic notation. Sound, when being re-generated out of electro-magnetic latency, embodies a tempor(e)ality different from the almost scriptural engraving in the gramophone groove.¹⁸⁵ The gramophone groove is literally being in-formed by sound, but this is still a material, physical shaping, whereas digital information is no question of matter or energy any more: a sequence of symbols which can be statistically measured in terms of transitional binary entropy, a new kind of "score".]

"First sounds" (Patrick Feaster), "Time(ly) matters" (GWY)?

It is the media-archaeological intention to listen to early sound recordings in a non-historical way (non-hermeneutical *Verstehen*). From this situation emanates a genuinely signal-based resonance of the past based on waves and simultaneous time. It requires something like the "media-archaeological ear" to make knowledge use of that option. Phonography "avant la lettre" is understood here in its literal sense: Signal recording is pre-symbolical, non-alphabetical, no "letters".

In 1857, the Parisian printer Édouard-Léon Scott de Martinville patented his *phonautographe*. Sound waves would trigger vibrations on a parchment, which would then be transmitted to a stylus which etched out the waves on a page darkened by the carbon of lampblack. Scott designed a pure inscription device lacking any playback feature, since as an expert in stenography his target was that people could and should learn to *read* the graphic traces left by the mechanical acoustic transduction. Scott recorded sounds, but it did not occur to him "that by

¹⁸³ Ludwig Wittgenstein, here quoted after: Gregory Ulmer, *Applied Grammatology*, Baltimore (John Hopkins University Press) 1985, 110

¹⁸⁴ Naomi Cumming, *The Sonic Self. Musical Subjectivity and Signification*, Bloomington / Indianapolis (Indiana University Press) 2000, 90, referring to Charles Sanders Peirce's *Collected Papers* (1.335, 1905)

¹⁸⁵ See Theodor W. Adorno, *Die Form der Schallplatte* [1934], in: same author, *Gesammelte Werke*, vol. 19: *Musikalische Schriften VI*, Frankfurt/M. (Suhrkamp) 1984, 530-523

retracing the grooves and channeling the vibrations back into a funnel it could also do the reverse. "And read they were, though neither in Scott's lifetime nor by human eyes. In 2009, almost exactly 150 years after the recordings had been made, a set of squiggles was scanned, converted into digital waveform, and played back by a computer. At first, a minor mishap occurred. The researchers engaged in acoustically disinterring Scott fell prey to Kittlerian time axis manipulation."¹⁸⁶

"[T]hey thought they were hearing a woman's voice, singing the French folk song '*Au claire de la lune*,' but later they realized they had been playing back the audio at double its recorded speed. When they dropped it down to the right tempo, a man's voice appeared out of the crackle and hiss: Édouard-Léon Scott de Martinville warbling from the grave."¹⁸⁷

Today, opto-digital reading of early Edison cylinders allows for listening again to otherwise unaccessible sound recording; the opto-digital *close reading* of sound as image, though, dissolves any meaningful unit into discrete blocks, which are accessible for human analysis only by operative techno-mathematical diagrams.¹⁸⁸

The recording which became famous by Internet circulation has been the French song "Au claire de la lune" sung into the phonautograph in 1959. But closer to the medium, the very first recording surviving as phonautogramm in the Parisean archives leads to a moment of indecidability, an irritation of hermeneutic and acoustic understanding: sound or noise? Which is the "first sound" - a recognisable artefact, or a media event? But caution, the record from which sound emanates in such acoustic argumentation is not a disc with acoustic grooves any more but a computer storage disc with discrete data sections which need algorithmic processing to become rhythmic music again.

This is an analytic, media-archaeological form of deciphering the sound of the past. To the media-archaeologically sharpened mind, such sounds from a computer audio line-out will never be confused with a "live" sound since such a mind is conscious of the algorithms of which such an animation is a technomathematical, processual function.

In media-*active* archaeology, the technological apparatus itself turns out to be the archaeologist proper. Patrick Feaster and David Giovannoni succeeded in re-sonifying the preserved phonautographic engravings (*Schallbilder*), beginning with Scott's recording of a sound folk tone of 435 Hz in the year 1859.

¹⁸⁶ Winthrop-Young 2015

¹⁸⁷ xxx Johnson 96, as quoted by WGY, Typescript "Time(ly) Matters", 2015

¹⁸⁸ See Patrick Feaster, Pictures of Sound. One thousand years of educed audio: 980-1980, Atlante, GA (Dust-to-Digital) 2012

Here the pure vibrational medium (the sine wave again) is the recorded message, before it became buried and dissimulated in musical "content".

150 years later science realized that with optical "reading" of such acoustic signal lines sound can be re-synthesized and thereby re-sonified.¹⁸⁹

True media archaeology starts here: The phonograph as media artefact does not only preserve the memory of culturalized sound but stores past *technical* knowledge as well, a kind of frozen media memory embodied in engineering and waiting to be listened to by media-archaeologically tuned ears. The noise of the wax cylinder itself which the record articulates whenever it is being re-played is not discursive, but media-archaeological information of the physically real event; listening to this attentively does not exclude it by anthropocentric hermeneutics.

With the micro-physical *close reading* of sound, the materiality of the recording medium itself becomes archivally poetical. Instead of musicological hermeneutics the media-archaeological ear listens to signals. The media archaeologist, without passion, does not hallucinate life when he listens to recorded voices; the media archaeological exercise is to be aware at each given moment that we are dealing with technical media, not humans, that we are not speaking with the dead but operative recording keeps sound un-dead.

"Phonographic reproductions are physical effects of the real. A gramophone inscription surface captures sound waves emanating from Enrico Caruso's larynx. "This is not the case when we write about Caruso"¹⁹⁰ - all the difference between transitive signal recording and intransitive historiography.

From "beyond the grave" (Chateaubriand), "[...] Scott's Parisian recording session is the first undead moment in time. It is the earliest instance of physically recorded history we can directly link back to by means of technologies able to reproduce the recording. Here, media become the subjects of media archaeology by providing a technological link-up that enables us to experience a fully mechanized (and later digitized) Proustian *madeleine* moment: a temporal interface that cuts across time. [...] With the invention of the phonograph, he [sc. Edison] decreed, speech "has become, as it were, immortal" (quoted in Kittler 1999: 21). New media allow us all to graduate to ghosthood; but ghosts are apparitions very much at odds with history. Referring to Edison's phonograph, John Peters notes that it "divides history into two halves, a

¹⁸⁹ For the sonification of Lèon-Scott's phonautogram from April 8, 1860, in Paris (the children song "Au clair de la lune, Pierrot répondit"), listen to <http://www.firstsounds.org/sounds/1860-Scott-Au-Claire-de-la-Lune-09-08.mp3>

¹⁹⁰ Geoffrey Winthrop-Young, Timely Matters. A Story of Media at Odds with History, typescript (November 2015)

before and an after. Prior to 1877, all sounds died" (2004: 177)." (GWY 2015)

At that point, one step further: "Is that which is divided here, especially if it is divided into mortality and immortality, still contained *by and within history*?" (GWY 2015). "First, technological media record and store" - or steal? - "real time (with, as in case of Scott's almost inaudible voice, all the accompanying noise, crackle and hiss - indeed, the very concept of noise has real-time recording as its technological apriori). This storage of time by means of media technology and its subsequent re-production by later media technologies allows for a direct temporal interface between otherwise distinct moments of *human* time." (GWY 2015)

But is this still a human voice, or does it turn out - resulting from analysis into the nature of speech by nineteenth century measuring and recording media - that the human voice in itself is a mechanical event which can be co-originary produced by synthetic devices?

Any audio recording "takes its own time. Technological media operate in accordance with their inner *eigenzeit* ("own time"), which is categorically distinct from the surrounding human time. "The *eigenzeit* of the apparatus world relates to the macro-time of history like self-referential systems to their so-called environment."¹⁹¹

In terms of cybernetical theory, we live in systems of closely or tightly coupled tempor(e)alities.

"*Medien zeitigen*, then, implies that operating in their micro-temporal *eigenzeit* media engage in a 'technopoiesis of time'"¹⁹² - which is chronopoetics. "They create a piece of technologically facilitated time that can be moved along *outside* of the human time of history and then - with ghostlike effects - be reinserted back into it." (GWY 2015)

Chronopoetics aims at replacing the unifying, totalizing signified "time" by a plurality of tempor(e)alities, as expressed by George Dyson: "Time as we know it just does not exist in the digital universe. A computer is not operating on time, it just operates on sequence. [...] this other world exists now, and it is not tied to our form of time at all."¹⁹³

IMPLICIT "TECHNO-SONIC" TEMPOR(E)ALITIES

¹⁹¹ GWY 2015, paraphrasing W. E., Gleichursprünglichkeit. Zeitweisen und Zeitgegebenheit technischer Medien, Berlin (Kadmos) 2012, 306

¹⁹² GWY 2015, referring to Ernst 2012: 286

¹⁹³ This has been expressed in George Dyson's lecture "No Time Is There: The Digital Universe", on occasion of the conference *Time and the Digital Universe* within the festival MaerzMusik, Berlin, Haus der Berliner Festspiele (March 12 / 13, 2016)

***Chronoi* in Music: pre-"temporal" practice as cultural techniques**

In its format called Explorations, the Berlin Einstein Center Chronoi hosts the research project "Audible Temporality. How Time is Structured in - and through - Music"¹⁹⁴. Time here oscillates between its concept of a given (music "in time"), and a generative giving of time by music. In terms of cultural techniques, music has been the performative field of experimenting (with) time, as a symbolic precursor (or substitute) for what has become operative reality in electronic timing.

Phenomenologically, time is experienced as motion or flux of events, processes, changes, movements, and actions, while it is reckoned (measured) in discrete units.¹⁹⁵ The research approach of the Einstein Center Chronoi (Berlin) already substitutes the despotic reference to a transcendent "mega-theory of time" by the focus on "time-correlated phenomena" such as rhythm, dynamics, and synchronization.¹⁹⁶ Within the frame of the Explorations format, the research project *Audible Temporality* remains significantly ambivalent, and undecided, in its subtitle: *How Time is Structured in—and through—Music*. In its music-archaeological approach, such research "investigates the ways time is understood in antiquity by reconstructing music ensembles and conducting tests using modern reproductions and replicas of selected ancient musical instruments from different regions, based on their supposed sound structures and historic performance contexts"¹⁹⁷. "Time" itself becomes thereby historicized by assuming that "ways of understanding time in musical practice, including ritual acts, are reflected in how time is structured in and through music" (ibid.). A counter-analysis would ask: Is there still a need for a "time" concept as long as operative musical practices serve as alternative (or precursor) to such a category at all? Still, even musical archaeology presupposed "time" in its analytic retrospection: "Time as structured by means of music can be identified [...] in incorporated performative practices (music, theater and dance performances)" (ibid.). In analogy to the media-archaeological approach to technology the investigation how time is structured within music assumes that "musical meaning is established through the temporal connection (chronicity) of musical constituents with one another" (ibid.). So-called "time" thereby turns out as a function of practices which do not necessarily require to be called "temporal" (to avoid the anthropocentric point of view). As long as human analytic language is still heavily charged by temporal semantics, concepts like "chronicity" - like "temporeality" - serve as an intermediary substitute to approach this *other* of "time", which is not heterochronicity, or the other

¹⁹⁴ <https://www.ec-chronoi.de/time-in-sound-and-music>, accessed June 29, 2020

¹⁹⁵ See <https://www.ec-chronoi.de/about>, accessed June 29, 2020

¹⁹⁶ <https://www.ec-chronoi.de/about>, accessed June 29, 2020

¹⁹⁷ <https://www.ec-chronoi.de/time-in-sound-and-music>, accessed June 29, 2020

of "time", but an alternative equivalent to time itself. Chronicities such as synchrony and simultaneity characterize musical action, making it possible "to structure units of musical experience" (ibid.) like numerical measuring constitutes "time". But "audible temporality" becomes temporal only in human perception, not in the vibrational signal event as such.

In the operative installation of John Cage's composition for organ Organ²/ASLSP (As Slow as Possible) at Burchardi church in Halberstadt, Germany, every tone from the keyboard lasts for years until the next key is dramatically struck.¹⁹⁸

Systematic musicology investigates "the cognitive processes underlying the structuring of time in music [...] through current neuroscientific research on cognitive mechanisms of (musical) anticipation, prediction and synchronization" (ibid.). "It is expected that a unit of musical-rhythmical experience, based on chronicity, will be identified" (ibid.) - which will result in a analogies to measured "time".

What media archaeology shares with the musicological approach, is its emphasis on the actual, re-generative cultural-technical practices which actually replace the need of a transcendent "time" concept. In this structural perspective, musical performative practices, in cultural "history", are an equivalent to technological operations - while the latter, at the same time, turns out as a radical difference in the escalation from cultural techniques ("musicality") to technology.

Sonic Signals, and the Authenticity of Endotechnical Events

The Berlin Ethnographic Museum contains a large collection of copper negatives of phonographic wax cylinders which early recordings for musical ethnography. For a non-destructive, non-invasive playback of these so-called "galvanos" the Society for Applied Informatics (GFal) in Berlin has developed a system using a hybrid combination of endoscopic image processing and a mechanical sensor. "Playback" has a double sense, in terms of re-sonifying sound recordings from the past, and as a purely technological procedure of signal processing where the time dimension is actually converted into a space dimension. This precisely measured sound track geometry can be converted "back" to acoustic *time* signals "that can be directly transferred to digital sound media"¹⁹⁹ -

¹⁹⁸ See Sabine Groschup / Georg Weckwerth (eds.), (JC{639})#1-89, including a DVD version of the experimental film (JC{639}) by Sabine Groschup (A 2006 / 2012), Künstleredition 2013

¹⁹⁹ Thomas Kessler / Susanne Ziegler, Direct Playback of Negatives of Historic Sound Cylinders, <https://books.ub.uni-heidelberg.de/arthistoricum/reader/download/265/265-17-77845-1-10-20170523.pdf>, accessed June 12, 2020, "Abstract"

which again transforms the time signal into a computational frequency domain. Neither the electro-physical tracing nor its sampling into digital data, and algorithmic processing to achieve a favourable signal-to-noise ratio, has an emphatic sense of the "pastness" of the signals since it can as well be treated in terms of two-dimensional image analysis (and its related Fourier Transform). Below all "digital" abstraction, the actual electro-magnetic interferences are not related to an external time but unfold as a dynamics of its own. In Maxwell's mathematical equations this resulted in the discovery of its speed of light - which itself becomes "time" only when it is symbolically declared so, as a measure parameter.

The actual message of sound as physical, and / or technical "medium", is its temporality. But in a radically reverse perspective, "music" is not a real sonification of an imaginary "time", or its symbolic organization (score), but an alternative concept, and offers an old-European vocabulary to address so-called "time" in different terms - in analogy to the technical language of communication engineering today.

For counting movement, human cultural techniques have been applied. The musical meter and rhythm served as substitute time piece, until Huygens' pendulum, in combination with his mathematics of the "cycloid", surpassed human temporal intuition with its precision in terms of seconds.²⁰⁰ At that moment of automatization, the sense of time itself is replaced by operative discretization which rather refers to mechanical kinematics than to counting "time".

In his seminal essay "... how time passes ...", Karlheinz Stockhausen initially defines music in the tradition of the old Greek *drama*, as order-relations within time ("in der Zeit"). This might be rephrased into "as time" as transitive events. Indeed, Stockhausen rushes to argue next, such a definition presupposes a concept of "time" itself. Humans hear alterations in the vibrational sonic field, and human perception differentiates here varying intervals between such changes, which Stockhausen calls "phases".²⁰¹ "Time" is a conceptual hypothesis for humans to make sense of such sensations. But in a more recent edition of this text²⁰², more technical footnotes were added which Georg Heike from the Institute for Phonetics and Communication Research at Bonn University has created in 1963. They explain, criticize, or correct Stockhausen's idiosyncratic formulations in audio-engineering terms. Note 3 criticizes the imprecision of Stockhausen's notion of "phase" and differentiates between phenomenal cognitive impression and exact

²⁰⁰ See Berz 1993: 171 ff.

²⁰¹ Karlheinz Stockhausen, ... wie die Zeit vergeht ..., in: Die Reihe. Information über serielle Musik, vol. 3, Vienna / Zurich / London (Universal Edition) 1957, 13-42 (13)

²⁰² Revised and annotated version, in: Dieter Schnebel (Hg.), Karlheinz Stockhausen. Texte zur elektronischen und instrumentalen Musik, Bd. 1, Köln (DuMont) 1963, 99-139

measuring which requires a measuring unit (such as "time"), and a measuring device. It is not from the measuring apparatus, but only in its symbolization by application of a measuring unit that the intervals Stockhausen describes become "temporal" at all. In his conclusion (41), Stockhausen claims a new type of instruments to allow for a musical composition, and play, in terms of polymorphous "temporal fields", by means of a band manual or equivalent devices - which is the electroacoustic synthesizer, and computational microsound synthesis, indeed (such as Iannis Xenakis' UPIC for graphical notation in real-time). But different from the human need to conceptualize such sonic events in terms of "time", such sound technologies do not ask for such a concept. The terminology of music (for the symbolic order) and sound analysis (for the real signal event) offers an alternative to the "time" language instead. Stockhausen's notion of noisy time ("Zeitgeräusch"), resulting from the flipping from punctual to stochastic sonic perception, is no more countable musical "time" but ergodic processes (Shannon 1948). "Music" does not simply unfold "in time", but "time" is a function of its operational intervals, which introduce discreteness into variances of movement.

Philosopher G. W. F. Hegel once describes the actual tone not in terms of "time" but as a temporality of its own: "a being which disappears while it is"²⁰³. This corresponds with Heidegger's definition of human awareness of "being-to-death". Such an inherent sense of ending comes close to the physical definition of the damped signal. But with the technological development of the undamped oscillator, such a being-to-death loses all its philosophical "time" metaphysics in favour of negentropic signal control. An alternative translation comes closer to its technological incorporation: sound is "a disappearing of the reality as soon as it is"²⁰⁴. This gets grounded in technology with Paul Virilio's "aesthetics of disappearance" as a function of transportation vehicles and telecommunication media. In terms of physical acoustics, as opposed to the phenomenology of hearing, there is no "tone" at all, but only a periodic function, which alters into frequencies by numerical measurement. Derived from ancient Greek *tónos* for "tension", its electric equivalent is continuous voltage. Only by counting, sound becomes time-discrete, therefore computable.

The "Acoustic Quantum" as a Challenge to "Time"

²⁰³ "[...] ein Daseyn, das verschwindet, indem es ist": Georg Wilhelm Friedrich Hegel, *Enzyklopädie der philosophischen Wissenschaften im Grundrisse* [1830], Hamburg 1959, 369, as quoted in Kittler 1993: 182 (translation W. E.)

²⁰⁴ Hegel's *Philosophy of Mind*, translated by W. Wallace and A. V. Miller, Oxford (Clarendon) 2007, 194; see Kittler 2017: 5

The operational autonomy of inner-technical signal processing from its external subsuming under "time" (between the pre- and the proto-temporal) becomes apparent in granular sound synthesis. The implicit signal "sonicity" and logical "musicality" of media events does not reside in any acoustic content but in its qualities as extensional signal ("time" in terms of phenomenology). "[I]t is our most elementary experience that sound has a time pattern as well as a frequency pattern."²⁰⁵ Even human hearing thereby treats sound both as temporal, and computational event. Time and computing merge into one in hearing. But in technomathematical analysis, "[t]his duality of our sensations finds no expression either in the description of sound as a signal $s(t)$ in function of time, or in its representation by Fourier component $S(f)$. A mathematical description is wanted which *ab ovo* takes account of this duality", resulting in quantum theory-inspired notion of "the uncertainty relation between time and frequency" (ibid.). Gabor's epistemic object, the "acoustical quanta" as cells of sound, correlate Δt and Δf , where "time" itself becomes a function of a delay which is a media-technical pre-condition of "time", but not "time" in itself. "Time" is rather a conceptual construct to make sense of such processes. "This method of analysis contains 'time language' and 'frequency language' as special extreme cases" (592) - which thereby reveals "time" as an idealistic, logocentric vanishing point, as a transcendent imaginary of the symbolic order. The media-epistemic condition of sound synthesis - in terms of humans hearing - is the mathematical analysis of "subjective acoustics"²⁰⁶. But the apparatus of hearing, the ear, itself transforms the time signals into the frequency domain, which is processed in the brain as pulse trains. The "time" dimension, even within human neurons, gets lost in favour of the frequency domain. Gabor therefore considers "both time and frequency as co-ordinates of sound, and see what meaning can be given to such a representation" (ibid.). Time, here, is a mathematical quantity, "introduced by the method of analysis"²⁰⁷ for the sake of computability, which Gabor distinguishes from the "intrinsic features of the phenomenon" (ibid.). The notion of "sharply defined states" is an effect of analysis in terms of "integral numbers" (ibid.) and is therefore an epistemic idealization of the actual sonic event. The "time axis" therefore makes sense for media analysis, but not for analytic media themselves.

Occasional formulations of phenomenological intentionality like "the ear will hear"²⁰⁸ are anthropocentric no more once such a mechanism is granted a techno/ógos of its own in scientific language. While for Kittler, "[t]echnical media [...] are defined by nothing else than their strategy of subverting low-frequency ranges by / being able to simulate them"²⁰⁹,

²⁰⁵ Gabor 1947: 591

²⁰⁶ Gabor 1947: 591

²⁰⁷ Gabor 1947: 594

²⁰⁸ Gabor 1947: 592

²⁰⁹ Kittler 2017: 9 f.

such as alphabetic writing as symbolical (speech) time-manipulation and analog signal recording as time axis manipulation in the real (phonography, video recording), the techno/ógos hypothesis grants such processes an (ex-) "temporal" ontology of its own. Indeed, it might be media-epistemologically productive, "though meaningless, to descend even lower into the continuous current domain where the frequency approaches zero and there is no possibility of temporal delay [...]"²¹⁰.

For the granular music approach, "sound is no longer conceived in terms of periodicity or repetition, as defined by the "classical" acoustic model of Helmholtz, but as a dynamic, energetic phenomenon. One of his important references, in this domain, is the work by physicist Ilya Prigogine [...]. This is the theory to which Vaggione is referring when he describes 'dissipative structures of sound energy'."²¹¹

[„One might be inclined to think that sharply defined states, characterized by integral numbers, are peculiar to quantum phenomena, or at least that they require special mechanisms to imitate them classically, such as strings or membranes" (Gabor, 1947: 594). Even before the impact of "acoustic quanta", with its duality of wave and corpuscle, triggered a chain of composers of granular music like Iannis Xenakis²¹², Gabor himself, "[n]ot content with mathematical theory, [...] constructed his own sound granulator, which could compress and expand the time scale of recorder sounds [...]"²¹³. Technologically, analysis here flips to media synthesis. In his *9 Beet Stretch*, Leif Inge digitally stretches a recording of Beethoven's 9th Symphony over 24 hours, with no pitch-shifting. Human listening to such sound-technological time axis manipulation "oscillates between two temporalities, pure duration, and organised musical time"²¹⁴. In computational real-time operations like time stretching, "time" is no longer the name for a symbolical measuring (numerical counting, or computation) of material and energetic changes of state, but in reverse is exchanged by the techno-active numerical synthesis (computing). Another composer in the field of the granular music paradigm, Barry Truax, thinks in terms of such an endo-technological move: "'The technique I have found the most striking in the way it facilitates moving inside a sound is real-time granulation of

²¹⁰ Kittler 2017: 10

²¹¹ Horacio Vaggione, *Composition musicale et moyens informatiques : questions d'approche*, in: M. Solomos, A. Soulez, H. Vaggione, *Formel-informel : musique-philosophie*, Paris, L'Harmattan, 2003, 91-116 (102), as quoted in Solomos 2006

²¹² See Iannis Xenakis, *Elements of Stochastic Music* (1), in: *Gravesaner Blätter* no. 18 (1960), 84-105 (86 f.)

²¹³ Makis Solomos. *The granular connection* (Xenakis, Vaggione, Di Scipio...). *Symposium The Creative and Scientific Legacies of Iannis Xenakis International Symposium*, 2006, Canada, note 25

²¹⁴ Heloisa Amaral, *between speakers and splinters: how musical performance stages the archive*, ed. Kate Nialla Fayers-Kerr, script June 2020

sampled sounds. [...] A dramatic shift of the sound called 'time-stretching' is made possible with this technique. [...] This effect is used not merely to create drones, but to allow the inertimbral character of the sound to emerge and be observed, as if under microscope. [...]"²¹⁵

So-called "time language" and "frequency language" are nothing but "special extreme cases" in Gabor's quantum analysis of the explicit "mechanism" of human hearing (Gabor 1947: 592). The "uncertainty relation between time and frequency" (ibid.), as known from quantum mechanics, reveals both categories as analytic abstractions, and logocentric idealizations of the actual event. Gabor's "Information Diagram" (Gabor 1947: 591, Fig. 1) which captures both $\Delta-t$ (the "mean epoch" of time) and $\Delta-f$ in mathematical terms becomes operative in the hearing mechanism and can therefore be simulated by an analogous technical apparatus. In reverse, such an apparatus only in approximation know extremes like the "time" and "frequency" domain. Gabor separates the mechanistic simulation of human hearing physiology by a set of physical resonators (Helmholtz) which can always only be tuned to a certain bandwidth (privileging the "timeless" Fourier Analysis approach) from the "non-mechanism" (593) of neuronal (cognitive) signal processing. Human hearing cannot be reduced to the "ear resonators" (ibid.). In accordance with the cybernetic paradigm, Gabor describes human sound perception in terms of electronics, as a "phenomenon of nervous conduction" (593), rather than by any metaphysical speculations of the mind. What is defined as "inner sense of time" in phenomenology which accounts for "musical" understanding, therefore turns out as the analytic function of the interlacing of the time and frequency regime which do not actually exist in a purely separable form.

Such a cybernetic terminology is a drastic reversal of philosophical phenomenology. Once the "inner sense of time" is identified in its mechanism, as it is demonstrated by Gabor's meticulous analysis of subjective hearing (since sonicity has a privileged affinity to the question of "time"), Heidegger's notion of being-towards-death, in which the proper quality of human existence is literally de-fined by its anticipated finitude, as well as Husserl's notions of re- and protention in the human perception of the present moment which transforms physiologically acoustic perception into a cognitive musical impression, can easily be reformulated as recursive and predictive neural action and therefore be computed by machinery as well, by-passing any reference to transcendent "time" at all.

²¹⁵ Barry Truax, Real-time granular synthesis with a digital signal processor, in: Computer Music Journal, vol. 12 n°2, 1988, 14-26, as quoted in Solomos 2006, note 32

"It must be understood, of course, that there is an important difference between an acoustical quantum as registered by a physical measuring instrument, and as registered by the ear."²¹⁶ A sonic oscillation between 500 and 100 Hz requires an endurance of 10 milliseconds to be recognized by the human ear as sound at all, instead of noise. There is a threshold for temporal (as implicitly sonic) experience within the human hearing apparatus, whereas to a technical sound generator, such a quantitative threshold makes no qualitative difference at all. It operates without temporal sensation itself. Media archaeology does not only look for cybernetic analogies or resonances between perception in the animal and the machine, but for decisive differences as well. Time itself makes a difference here.

After a sound signal has been *granulated* into segments (tiny wavelets, or "acoustic quanta" in Gabor's term), the sound can be modified. "The granulation algorithm then reassembles the grains in a new time order and microrhythm. The precise manner in which this occurs varies from program to program."²¹⁷ Chronotechnical *poiesis* hereby replaces the semantically emphatic category of "time".

Dissolving Media "Time" into Grains

While "analogue" media like the phonograph, in their allowance for time axis manipulation (Kittler), still affirm the supposition of a parametrical time, granular synthesis (as it is familiar in computational audio processing) re-generates the temporal structure of digitized audio signals themselves by addressing individual sonic „grains“. The former "time signal" for which the audio signal is exemplary is translated into the computational domain, which treats time as symbolic. The computer knows counting and clocking, but no "time". "Treat time as discreet", Turing once advised for digital computing²¹⁸, which thereby translates "time" back into its pre-temporal operativity. "Time", with computing, returns to its strict Aristotelean definition. Since the elementarization of speech into the symbols of the phonetic alphabet, and counting movement by numbers, an operative notion of "time" has replaced the ontological, or phenomenological, time concept.

Composer Iannis Xenakis' graph for the distribution in time of the string orchestra's pizzicati-glissandi in his composition *Pithoprakta* (1955-56) plots something *in symbolic (visually spatialized, diagrammatically inscribed) time*, for which the string events themselves, as periodic "timeless" events, have no sense.²¹⁹

²¹⁶ Gabor 1947: 593

²¹⁷ Curtis Roads, *Microsound*, Cambridge, Mass. 2004, 187 f.

²¹⁸ State of the Art, xxx

²¹⁹ See Makis Solomos, *The granular connection* (Xenakis, Vaggione, Di Scipio...), paper for the symposium *The Creative and Scientific Legacies of Iannis*

This extends to micro-*aisthesis* and subliminal time signal processing. Granular synthesis, in sound computation, allows for operations like time-stretching (keeping the tonal level unchanged) and voice transposition (by pitch-shifting in real-time).²²⁰ Pitch-shifting leaves the temporal structure unchanged. Morphings allows to fuse two different sound sources by applying digital granulation to both audio files. Such techno-sonics takes the place of what has been called "time-based media" itself.

An Alternative to "Time": Resonance

Even if not concretized in the magnetophone or in radio transmission, electro-magnetic communication media are implicitly sonic. One of its key devices, the "resonant circuit", is therefore appropriately named by a musical term. In technical communication, there are signal events that proceed through nonhuman perception while being imperceptible to humans unless they are user-interfaced. It is the resonant circuit, which in radio allows for technical reception, before it can become perceived by human ears through loudspeakers at all. The analog video camera, which is an electronic transducer of physical energy (light) into electrical impulses, "bears a closer original relation to the microphone than to the film camera"²²¹ - in analogy to the electro-chemical, and electro-mechanical transduction within human eyes and ears when communicated to the brain. The concept of interspecies communication has been extended by cybernetics to the animal *and* the machine (Wiener 1948). From that techno-structural equivalence result resonant frequencies in the mutual human and machinic perceptibilities. The actual medium message derives from microperceptions that occur beneath the threshold, and *massage*, the human consciousness.²²²

The electronic image - different from the photographic film still - is not simply a unit in (sequential) time, but - like a melody - "contains in itself a temporal extension"²²³. As an (only apparent) "time object" (Husserl), such kind of electronic media *resonates* with the human perceptual senses in a privileged way. its "temporal" equality, though, emanates from its equivalence in terms of mutual mathematical Fourier analysis (analog computing) rather than by a co-original being-in-"time".

Xenakis, 2006 in Kanada, Fig. 4;

https://pdfs.semanticscholar.org/eca2/ba9631a9a4aec1204351aad1b3c327ea88e4.pdf?_ga=2.222346651.1295010319.1591216841-1789829124.1582045484, accessed June 8, 2020

²²⁰ See Miyazaki, 2009: 394 f.

²²¹ Viola 1990: 44

²²² See McLuhan / Quentin Fiore, *The Medium is Massage*, xxx 1967

²²³ Edmund Husserl, *On the Phenomenology of the Consciousness of Internal Time* (1893-1917), transl. John Barnett Brough, Dordrecht (Kluwer Academic Publishers) 1991, 24

Since Oersted and Faraday, the study of electromagnetism which is a *sine qua non* for contemporary communication media has triggered a media epistemology of its own. The conceptual "resonant interval" (McLuhan) describes media communication in the electro-magnetic field (defined as "acoustic space") as instantaneous present. Sheldrake has extended this media temporality to the concept of an organism's "morphic resonance" with its own past.

Resonance is a media-operative alternative to the cultural semantics of emphatic "time". According to the concept of *sonicity*, the actual message of the sonic signal (beyond its manifest acoustic content) is its temporal form, which becomes most concrete in high-frequency technologies.²²⁴ For wireless analog media transmission, where the speed of electro-magnetic wave propagation is approximately the speed of light, McLuhan identified "an information environment that has basically an acoustic *structure*", since in such broadcasting, "information is simultaneous from all directions and this is the structure of hearing"²²⁵. What McLuhan calls "the aesthetics of the resonant intervals of acoustic space" (ibid.) is the equivalent to what humans experience as time.

McLuhan, when defining his notion of "resonant" acoustic space, refers to Minkowski's concept of spacetime (1908), Niels Bohr's discussion of electron transitions between stationary states within the atom as transcending the frame of space and time, Louis de Broglie's postulate that even matter was constituted by matter waves, and Linus Pauling's notion of the "resonant interval" (for the chemical bond).²²⁶

In physics, resonance names the implicitly sonic quality of a material formation to vibrate at certain frequencies of excitation. This extends to a systems' feedback in biological and technical cybernetics, and to "backpropagation" in artificial neural nets. This even refers to correspondences between present and the past in terms of the energy-matter continuum. Elements that have once interacted can respond to each other's motions thousands of years later (ibid.).

Sonic tempor(e)ality, as perceived by humans and expressed in musical terms, anticipated its technical concretization: "If we sense that the description of sympathetic vibration ["resonance"] bears some resemblance to radio broadcast, it is no coincidence, the same principle is at work"²²⁷, equiprimordially (and in the most literate sense of

²²⁴ See W. E., *Sonic Time Machines. Explicit Sound, Sirenical Voices and Implicit Sonicity in Terms of Media Knowledge*, with a Preface by Liam Cole Young, Amsterdam (Amsterdam University Press), series *Recursions*, 2016

²²⁵ *Letters of Marshall McLuhan*, ed. Matie Molinaro et al, Oxford (Oxford UP) 1987, 466 (italics McLuhan)

²²⁶ Marshall McLuhan / Eric McLuhan, *Laws of Media*, xxx 1988, 45 f.

²²⁷ Viola 1990: 42

McLuhan's notion of "acoustic space"). Technical ensembles with equal *eigen*frequency of electro-magnetic oscillations start to "resonate", as in the tuning of a radio sender and receiver. Such a genuine media operativity is autonomous against the semantics of cultural time and its histori(ographi)cal contexts, and rather performs a processuality of its own.

Paraphrasing Viola further, cybernetic thinking as a science of signal action and feedback reverberation has replaced diachronic materialism - which presupposes an external time - with the concept of synchronicity, which is a technical, chronopoetic enforcement. "Time" thereby loses all metaphysical connotations.

Not only natural, but artificial perceptual apparatuses nowadays "apprehend "temporal and intra-actions"²²⁸; machinic perceivers "communicate the history of their own operations through feedback loops" (ibid.). According to Rupert Sheldrake²²⁹, electron activity resonates with its own past patterns of activity, leading to a non-historicist, a-temporal continuity of "morphic resonance". Such a state is not ordered in "temporal" sequence, but its contemporary superimposition.

McLuhan's notion of the "resonant interval", borrowing from quantum mechanics and applied to the "temporal" existence of analog electronic media, becomes less metaphorical, and can be extended, to the digital computing regime.

The Bulova "Accutron", and Resonant Electronic Synchronization

Media archaeology radically "grounds" an epistemic figure of processuality such as McLuhan's "resonant interval" or "resonance" itself in the concrete technological event. "Time" as a function of technical operations becomes most concrete in the sonic clock.

Resonance is not a "time" figure, but one of its media-epistemic alternatives.

A precisely oscillating tuning fork, inductively coupled to an electro-magnet (as it has been developed before by Hermann von Helmholtz as device to measure the micro-temporal run-time of nerve impulses), provides the time base in the Bulova *Accutron* watch (German "Stimmgabeluhr"). An early advertisement announced it as: "The Tick vs. the Hum". A sine tone here serves as time-giving media event - not for

²²⁸ From the "call for contribution"(May 2020) to an edited collection by Natasha Lushetich & Iain Campbell, RESONANCE. Axiologies of Distributed Perception

²²⁹ Rupert Sheldrake, *The Presence of the Past*, New York (Time Book) 1988

acoustical or even musical sake, but in implicit sonicity. It is the tempor(e)ality of sound which is shared by processual technologies

The core agency of synchronization is communication between nonlinear oscillators which adjust their rhythms due to weak interaction. Christiaan Huygens, in 17th century, observed the emerging synchronization of two pendulum clocks suspended in the same wooden beam. Their motions became "so much in agreement that they never receded the least bit from each other and the sound of each was always heard simulateneously"²³⁰. By such *coupling*, the implicit "sonicity" of synchronization (named "le phénomène de la sympathie, sympathie des horloges" by Huygens²³¹ becomes explicitly acoustic. "These features are typical not only of clocks, but also of many oscillating objects of diverse nature"²³² - kind of a generalized sonicity. "Mathematically, such an oscillator is described by an autonomous (i. e. without explicit time dependence) nonlinear dynamical system" (ibid.) - which means invariant in regard to "historical" or "cultural time", rather an *eigenzeit*. Beyond the acroamatic fixation of that time-critical phenomenon to the audible by human ears, the effect was applied by E. V. Appleton and B. Van der Pol to exact triggering of vacuum tube triode generators as basic condition of radio electronics. Soon afterwards, in 1920, W. H. Eccles and J. H. Vicent coupled to generators which had slightly different frequencies; the coupling actually forced the system to vibrate with a common frequency.²³³ Obviously, "the frequency of a generator can be entrained, or synchronized, by a weak external signal of a slightly different frequency" (ibid.). Such an *entrainment*, therefore, does not only concern the adaption of human neurons to musical rhythm.

But such a synchronization shall not be confused with this other phenomenon in oscillatory systems known as resonance: the response of a system that is non-active, i. e. demonstrates no oscillations without external driving, different from self-sustained oscillations without external forcing - such as the radio-controlled clock where the radio signal from the sender is meant only to adjust or correct the oscillations, vs. the railway station clock which actually stops when the electric impulse from the central master clock ceases.²³⁴

In chaotic multi-oscillatory systems, the occasional emergence of local synchronization can be observed on the oscilloscope: Lissajous figures for

²³⁰ Horologium Oscillatorium, as quoted in: Michael Rosenblum / Arkady Pikovsky, Synchronization: from pendulum clocks to chaotic lasers and chemical oscillators, in: Contemporary Physics, vol. 44, no. 5 (September / October 2003), 401-416 (401)

²³¹ As quoted ibid.

²³² Rosenblum / Pikovsky 2003: 402

²³³ Rosenblum / Pikovsky: 402

²³⁴ Rosenblum / Pikovsky: 403

synchronous regimes, *versus* random distribution for the asynchronous regimes.²³⁵ This kind of strange attraction reminds of the Chua oscillator.²³⁶

Tuning fork-based electronic clocks are driven by frequencies within the audible range ("tonfrequent", 360 Hz /cps) - in reverse of philosophical or aesthetic speculations on "time and music". This chronotechnique ends with the subsequent Accutron 2 series with quartz crystals as *ultra*-sonic clocking device. But here is still sound, this time implicit, in the centre of this system: the piezoelectric *resonator*.

The crystal-based frequency standard is mandatory to coordinate, that is: synchronize complex communication networks, such as the American Telephone and Telegraph Company. National laboratories determine and maintain common standard frequency measurement units, exploiting novel piezoelectric quartz methods and electronic circuits. Exact frequency control is impossible without valve / transistor electronics. It has been Cady's discovery that quartz crystals display very sharp and stable electric resonance.²³⁷ Resonance, as expressed by the very *terminus technicus*, is implicit sonicity. The tempor(e)al of immediately coupled system arises when they are addressed in their *eigen*frequency. The resonant circuit (German "Schwingkreis") is the basis for wireless radio & television (and current mobile communication) devices. The Bell Labs searched for highly accurate methods for measuring oscillations as frequency rather than "time". The replacement of the despotic, transcendent signifier "time" by a plurality of alternative technical (and implicitly "sonic") operations is already taking place: a *chronotópos* which demands for a media-archaeological ear to be listened to, and to be unrevealed by a media-theoretical understanding.

WHERE "TIME" TAKES "PLACE". Media-Archaeological Thoughts on the (Musical) Topologization of *Chrónos* in the Archive, and as (Sonic) *Technológos*

The following text²³⁸ proposes some thoughts from the field of media archaeology, sound archives, and "time". A scholar of media science and technology is deeply convinced that it is not from the convergence between artistic practice and academic research, but that rather from

²³⁵ Rosenblum / Pikovsky: 406, fig. 4

²³⁶ T. Matsumoto, A chaotic attractor from Chua's circuit, in: IEEE Transactions on Circuits and Systems, 31/12 (1984), 1055-1058

²³⁷ See Shaul Katzir, War and peacetime research in the road to crystal frequency control, in: Technology and Culture 51 (2010), 99-125
<http://humanities.tau.ac.il/segel/skatzir/files/2012/03/TC-Cady-published3.pdf>;

²³⁸ Read "online" via Zoom conference within the *Chronotopia Echoes* lecture series organized by Contemporary Music Research Center (KSYME) in Athens, in cooperation with CTM Festival Berlin, March 2021

their asymmetry, productive sparks of knowledge, and epistemic insights on the notion of *chronotopia* arise.

The Chronotopical Question:

In a variation of Marcel Proust's seminal novel title *A la recherche du temps perdu*, and in a word play with the term *chronotopia* itself, this text will ask: Where does "time" take place at all? And to anticipate the answer right away: Not in the institutional archive. Only symbolical, so-called "historical" time takes place in the archive, but not the (implicitly "sonic") time event as such. The tempoR(e)al rather occurs in processual media operation.

This text will first discuss sonic tempoR(e)ality with a special focus on acoustic reverberation and "echo", as exemplified by Alvin Lucier's site-specific sonic media installation *I am Sitting in a Room* (1970).

Then, the text will (re-)define the very term "chronotope", with a reference to Michail Bakhtin's somewhat misleading definition of "chronotope", in favour of Michel Foucault's seminal text "Of Other Spaces", and from a radical media-archaeological point of view, turning the common definition of *chronotopia* upside down.

Next comes "archivology", with a focus of the archives of the Contemporary Music Research Center (KSYME / CMRC) in Athens.

Further, the musical "archive" will be contrasted with the sonic "recording". The notion of the "timeless" archive will be dislocated from the institutional macro-level to the time-critical media-operative micro-level, with a differentiation the symbolic order of music *versus* actual sound.

In a chronopoietic singularity, one might even "listen" to "time" as an acoustic wave form - the Bulova Accutron watch, and finally question the plausibility of the term "time" itself. The intention of this argumentation is to treat "time" rather like a technical agency, or like a mathematical operator - thereby close to sound, and music, itself.

But in its double sense, after a rather long exposure of themes, there will probably be no time to question "time". It therefore makes sense to anticipate the final argument right from the beginning. While the parameter t , in a truly time-critical analysis, dissolves into a multitude of cultural techniques and technological operations, "time" itself becomes more remote. Some forms of biographical, or collective, "memory" of individual, or cultural "time", which would otherwise be simply forgotten, may still be preserved in, recorded as, and recovered from, the traditional archive. But in a more radical understanding, "time", as a

reasonable and plausible parameter of analysis, itself passes away in the extended present of the media-speculative condition, like the "tone" in philosopher Hegel's seminal definition, fading away like Lucier's site-specific sonic media articulation, and finally dissolving into what the co-founder of The Contemporary Music Research Center in Athens, Iannis Xenakis, once composed: stochastic music.

Close to the Signal: Alvin Lucier's Techno-Sonic Approach to *Chronotopia*

Within the *Chronotopia Echoes* lecture series²³⁹, a media archaeological analysis feels at home not only for the subject of *chronotopia*, but literally because of its *echo* space. Different from the proverbial "live" transmission as the primary mode of analogue broadcasting media, so-called "digital", that is: algorithm- and computer-based communication, is always already delayed since heavy computational, time-discrete intermediary, short-term memory acts, filtering and compression codecs are involved. Like with the return of our own voice as echo, my presence is already past when it addresses your eyes and ears on remote screens and loudspeakers. The computer interfaces are not simply coupling but spatio-temporally dividing us here.

It is the real room-acoustic spacetime which is eliminated by the Zoom videoconferencing software. The phenomenologically decisive human perception of subtle sonic reverberations as paratextual interaction in a dialogue are replaced by an "echo" delay in digital audio signal transmission which favours the symbolically coded sender / receiver communication mode.

A seminal media-artistic installation recalls itself here like a recursive media-cultural echo. In Alvin Lucier media theatre performance *I Am Sitting in A Room* in the early 1970²⁴⁰, his self-explanatory vocal speech was first played from magnetic tape into a closed space. Since the slowly propagating audio signals *via* air - which once induced Aristototele to coin the very term "medium" (*to metaxy*) at all - can be perceived as *temporal* by human ears, different from the apparent "immediacy" of optical signals by the eye, the spatial dimension (*tópos*) is here cybernetically revealed as a function of time signal response (*chrónos*) in combination with an analogue sound recording device.

²³⁹ As organized by Contemporary Music Research Center (KSYME) in Athens, in cooperation with CTM Festival Berlin, in March 2021; see <https://www.goethe.de/ins/gr/en/kul/sup/chr.html>

²⁴⁰ Composed and first recorded in 1969, first performance in 1970. The 1981 publication by Lovely Music, Ltd., is accessible online: <https://www.youtube.com/watch?v=fAxHILK3Oyk>, accessed 26 February, 2021

[Acoustic "background" demonstration of Alvin Lucier, I'm Sitting in a Room (1970), as an operation *from within this* ThinkPad and its script-rendering visual interface, 45 min. Recording: Lovely Music, Ltd., 1981, audible from <https://www.youtube.com/watch?v=fAxHILK3OyK>]

»*I am sitting in a room different from the one you are in now. I am recording the sound of my speaking voice and I am going to play it back into the room again and again until the resonant frequencies of the room reinforce themselves so that any semblance of my speech, with perhaps the exception of rhythm, is destroyed. What you will hear, then, are the natural resonant frequencies of the room articulated by speech. [...].*«

A spatial quality is thereby revealed by the temporality of the echo response of speech. This is processual *chronotopia* as a dynamic cybernetic coupling of human and machine beyond its cultural content, even against Lucier's intention himself, who explicitly *regarded this activity "not so much as a demonstration of a physical fact"* (ibid.). While Lucier's speech loses its semantic meaning, this entropy increasingly allows for techno*lógos* to articulate itself.²⁴¹ Libretto, score and algorithm merge into one.²⁴²

When a recording of Lucier's piece (which has in fact been a re-re-re-recording) is played back to the audience *acousmatically*, from the "off" behind the screen interface a T410s ThinkPad laptop, as an acoustic background to the optical script of this very text, the evolving audio track thereby reveals the background of the actual reading performance, replacing the conditioning room acoustics *in* the Media Theatre of Media Science at Humboldt University, by an operative media theatre *from within* computing.

When discussed "online", in the lack of an actual reenactment of Lucier's piece in real room-acoustic space, beyond the manifest acoustic "content", Lucier's real media message can be transferred into the operative medium itself. When the camera, which records the actual lecture to its audience via "livestream", is directed to a computer monitor which actually receives this transmission, a *mise-en-abîme* opens, which reveals the temporal lag (or delay) which actually occurs in an apparent "live" data stream. The speaking words, as "digitized" *lógos*, already turn

²⁴¹ "Am Ende haben die Klänge ihre semantische Bedeutung gänzlich verloren. An die Stelle der Semantik tritt die musikalische Qualität der Sprachlaute." A comment by Golo Föllmer, Website of "ensemble resonanz", <https://www.ensembleresonanz.com/task/alvin-lucier-i-am-sitting-in-a-room>, accessed March 29, 2021

²⁴² "Der zu sprechende Text ist Libretto, Partitur und Ausführungsanweisung in einem." Föllmer, ibid.

any articulation from the side of the human speaker to the past (or "echo") when received by humans at the other end of the communication channel. There is no logocentrism, or metaphysics of "presence" (Derrida), for techno*lógos*. Due to the Sample-and-Hold mechanism in the very moment of A / D conversion, the micro-storage of time-discretely sampled signals, as materialized in electric condensers, already transforms the apparent co-presence into a "memory" effect.

From the acousmatic "off" within this text's computer carrier, Lucier's piece then runs in parallel to the lecture - like an hourglass, as a kind of "analogue" time piece - to its own reading time. With its increasing entropy of sound and language dissolving into white noise, this acousmatic background *actually* provides a "time arrow" for such a reading in the physical, thermodynamic sense. At the same time, this sonic medium actually articulates the message of this text, which is thereby not simply "about" sonic time by spoken words, but their chronotechnical embodiment itself.

In Lucier's original site-specific installation, the acoustic reverberations (resonances) of the room were themselves recorded and re-played again for the same procedure, until the words (*lógoi*) dissolved first into still structured "pink", but finally to "white" noise.

Only such a materialized "thought experiment", actually "thinking media" with its very *agency* of the reel-to-reel tape recorder²⁴³, allowed human perception to become aware of the very temporality of all kind of signal transmission even in electronic speed. But everything changes with the switch from the analogue to the digital. If Lucier's experiment is applied to cyber"space", that is: the latencies of audio communication *via* teleconferencing software such as Zoom, the apparent "flow" of time is replaced by a temporal artefact: techno-mathematically discrete computing. In the digital signal processing, there is no "time delay", just asynchronous computational communication. Therefore, media scholar Claus Pias dares to ask, in a metonymic shift from "time" to such operations, "if for such processes 'time' is an adequate tool for synchronization" at all²⁴⁴. The language of discourse can actually get liberated indeed by technical terms of tempor(e)alizing borrowed from communication engineering, such as the "delay line".

What we used to call "time" disappears into pure operativity, revealing

²⁴³ See Hanjo Berressem, *eigenvalue. contemplating media in art [sound / image / sense]*, London / New York (Bloomsbury Academic) 2018, 5-21 [*Thinking Media* series, eds. Bernd Herzogenrath / Patricia Pisters]

²⁴⁴ "[...] ob für eine Vielzahl von Prozessen 'Zeit' überhaupt ein geeignetes Synchronisationsmittel darstellt": Claus Pias, *Time of Non-Reality. Mizellen zum Thema Zeit und Auflösung*, in: Axel Volmar (ed.), *Zeitkritische Medien*, Berlin (Kulturverlag Kadmos) 2009, 267-279 (278)

that the human assumption of a natural continuous time itself has been a metaphysical fiction. It is not that all binary data processing operations in real matter and energy consume "time", but is replaced by articulations of the tempoReal. Within digital computing, clocking not only "enables us to introduce a discreteness into time", but such a "succession of instants" replaces the "continuous flow" itself (to paraphrase Turing critically²⁴⁵). The binary "time of non-reality" between two switching states (Norbert Wiener²⁴⁶) in a more radical media-archaeological reading, turns out as the reality of a "non-time".

Within the *Chronotopia Echoes* frame, the memory of Lucier's media-artistic master piece, and its magnetophonic co-authorship, is no simply remembrance, but its chrono-topical object and subject is actually resonance. At that point, the privileged affinity between sonic signal techniques, and the *chronotopia* theme, become apparent. "Where time takes place" is implicit sonicity.

Notably, it has been not human free artistic will, but technology, in fact: technológos itself, which once induced Lucier's chrono-poetic sound (art) piece. Lucier was originally inspired to create *I Am Sitting in a Room* by Amar Bose's tests of the characteristics of loudspeakers "by feeding back audio into them that they had produced in the first place and then was picked up via microphones"²⁴⁷.

While optical signal transmission, with the speed of light, is too fast for humans to be recognized as temporal event (except the star lights from outer space), only the relatively slow acoustic wave transmission *via* air can be experienced by hearing as "spacetime", chronotopically. But it is only with the extension of such delay from reverberation into *echo* that we suddenly experience our own presence as past (reminding of another seminal media art installation, Dan Graham's video setting *Present-Continuous - Past(s)* from 1974).

But what if *technical* "reason" confronts *acoustic* "resonance"?²⁴⁸ As

²⁴⁵ Alan Turing, Lecture to the Mathematical Society on 20 February 1947; printed in Vol. 10 in the Charles Babbage Institute Reprint Series for the History of Computing, A. M. Turing's ACE Report of 1946 and Other Papers, The Massachusetts Institute of Technology, 1986, 106-124 (111)

²⁴⁶ As quoted in: Claus Pias (ed.), *Cybernetics / Kybernetik. The Macy-Conferences 1946-1953, vol. 1: Transactions / Protokolle*, Zurich / Berlin (diaphanes) 2003, 158

²⁴⁷ https://en.wikipedia.org/wiki/I_Am_Sitting_in_a_Room, accessed February 26, 2021, referring to: Alvin Lucier (1995). *Reflexionen*. Ed. MusikTexte

²⁴⁸ An obvious allusion to Veit Erlmann. *Reason and Resonance. A History of Modern Aurality*, New York / Cambridge, Mass. (Zone Books / MIT Press) 2010

opposed to analogue "live" broadcasting of the "bodiless" (Kolb) radio voice, the difference *digital* voice transmission makes is another quality of time-discrete delay arising not simply in the electro-physical media channel, but from within technological computing, that is: Digital Signal Processing itself. In DSP, both the techno-physically "temporal" (entropic, processual, material and energetic) signal, and the rather "spatial", logically geometricized (neg-entropic, "informational") symbol, converge, finally making sense of the combinatory term "technology". This is *chronotopia* in a media-archaeological understanding.

When a "virtual" audience sees and hears an online-lecture "now", the words and gestures have already been ephemerally micro-"archivized" within intermediary computer caches and random access memories. What used to be called "time" is spatialized here, just like Bergson's critique of early film and chronophotography as betrayal of true temporal endurance (*durée*).²⁴⁹ To quote Foucault's thoughts on heterotopy once more: "Time probably appears to us only as one of the various distributive operations that are possible for the elements that are spread out in space". We are therefore invited for a reverse engineering of the collective singular called "time" into its temporal superposition called *tides* in maritime terminology, and "tones" for additive synthesis of acoustic sine waves.

A Technical Chronopoetics of Sonic "Delay"

Electronic signal delay, as a technical modelling of a phenomenon known from room-acoustic reverberation and echo, turns the "time" event into a temporal operator. The tempoReal becomes chrono-symbolical. "Delay [...] is how far in seconds you must shift a waveform to the left on a typical oscilloscope plot to get it to align with a reference unshifted waveform (usually the input signal)."²⁵⁰

"In speaker measurements, the amount of delay [...] depends on the distance from the speaker to the measuring microphone. Remember, sound travels about a foot per millisecond; you get an additional delay of around one millisecond for each foot of speaker to mike spacing" (ibid.). *Spacing* here refers to the "chronotopization" of the acoustic time signal.

But the temporal object termed "delay" may serve to reconsider "time" in a more fundamental sense, insofar as "technically recorded sound" - and its archivally time-shifted playback" - actually describes, as a technical operation, was cultural discourse otherwise metaphysizes into "history":

²⁴⁹ Henri Bergson, *L'Évolution Créatrice*, chap. 4, xxx

²⁵⁰ Anonym., *Time, Frequency, Phase and Delay*, reprinted from *Speaker Builder Magazine*: <http://www.libinst.com/tpfd.htm>, accessed March 9, 2021

"Delay itself is what audio playback is all about. When you listen to your recording of Belafonte at Carnegie Hall" - or to Enrico Caruso's voice from a shellac record, or to Maria Callas from Compact Disc - "there is a delay of over thirty years at work on that signal!" (ibid.).

Time Domain vs. Frequency Domain

"Time domain data is any quantity that varies with time" - or, when analyzed in reverse, actually constitutes "time" by its variations, "which in the case of loudspeakers is usually a sound pressure or signal voltage. Music (as viewed on an oscilloscope)" - and thereby turning from a symbolical concept into an actual signal - "is an example, as are the other various signals (impulses, [...] sweeps, tone bursts, noise)" used in room-acoustic tests."²⁵¹

In the cultural and artistic understanding, frequency is just "another word for pitch, describing the notes of a musical scale", but for media-archaeological analysis, "frequency is a parameter relating only to sinewave-like signals"²⁵², which is the *arché* of sound. Since only a few musical instruments actually "approximate a sinewave shape in their output" (ibid.), human perception is thereby deceived from actually understanding the sonic message and rather listens to its musical content in its symbolic narrative order.

In a more elementary sub-musical media listening, the sinewave, by its periodic repetition, literally *signals* another tempoReality. "An ideal sinewave is forever; it has no beginning or end. It (along with its phase shifted alter-ego, the cosine wave) has a specific value at any specified time. To minimize the confusion, we'll refer to points in time using numbers to indicate positions" - which actually turns the since wave from the time domain into mathematical space, that is: implicitly *sonic chronotopia*. "'Time = 0' doesn't mean 'the beginning of time', but just some convenient reference time with all previous time to be denoted in negative seconds and all later time in positive seconds. [...] The frequency of these waves is a measure of how many times a second the basic sinewave shape repeats itself" and thereby make the apparent "analogue", time-continuous wave actually computable in both analytic, and subsequent synthetic, forms. But literally in the meantime of the media channel, sound is not acoustic any more but becomes implicitly sonic, better addressed as a functional "time signal" (ibid.).

²⁵¹ Anonym., Time, Frequency, Phase and Delay, reprinted from Speaker Builder Magazine: <http://www.libinst.com/tpfd.htm>, accessed March 9, 2021

²⁵² Anonym., Time, Frequency, Phase and Delay, reprinted from Speaker Builder Magazine: <http://www.libinst.com/tpfd.htm>, accessed March 9, 2021

Fourier analysis shows that "any time domain signal can in principle be made from a sum of sized and delayed cosine waves. This means that you could, at least in theory, take a huge number of cosine waves, put them all through a network which adds the voltages (shifted and amplified) together at each point in time, and duplicate any possible time domain signal at the output. [...] If you are uncomfortable with the idea that your treasured recording of Beethoven's Ninth could be duplicated with just a bunch of sinewave generators", a loudspeaker engineer imaginatively comments, one should mention that "it would require an infinite number of them; this is abstract theory" (ibid.) - not actual electro-acoustic implementation.

Abductive Experimentation of / with "Time": Sonic "Quefreny" Analysis of the Echo

As expressed by Bakhtin, "[...] in literature the primary category in the chronotope is time. The chronotope as a formally constitutive category determines to a significant degree the image of man in literature as well. The image of man is always intrinsically chronotopic."²⁵³

On the contrary, media archaeology radically takes the nonhuman, technological point of view, which ultimately refers to the mathematical spatialization, or "geometrization" of *chrónos* by digitization in the symbolic machine²⁵⁴, in contrast to "analogue" time signal processing.

While in literary theory, the "chronotope" deals with configurations of time and space are represented in narrative discourse²⁵⁵, media archaeology attends to the non-discursive machine where the parameter "time" dissolves into a plurality of autonomous operations, both technical, and mathematical (that is: intellectual). "Time" becomes an operator for experimentation itself.

Radical media-archaeological practice "grounds" speculative time philosophy in real technological events, experimenting with their implicit sonicity. In so-called "Quefreny Alanalysis", once developed for analyzing seismic echoes, the sonic signal becomes a chronotopology, and temporal "matheme", rather than spatial "chronotope".

²⁵³ Bakhtin 1981, as quoted in Wikipedia, entry "Chronotope", op. cit.

²⁵⁴ See Hartmut Winkler, *Geometry of Time. Media, Spatialization, and Reversibility*, presentation at conference *Media Theory on the Move*, University of Potsdam, May 21-24th, 2009. Preprint: www.uni-paderborn.de/~winkler/hase_e.pdf

²⁵⁵ See M. M. Bakhtin'S 1937 essay "Forms of Time and of the Chronotope in the Novel"" = <https://en.wikipedia.org/wiki/Chronotope>, accessed February 14, 2021

Chronotopia echoes dissolve into quantifiable time series. For the computation of sound, the Fourier "transform" is paradigmatic which converts a signal from the time domain into the frequency (countable number) domain. It is epistemically significant that various terms in signal processing have been borrowed from music theory (for the macro time domain) as developed in two millennia, like a reentry into technology - just that the signal themselves have not been accessible until time-critical measuring media (the micro time domain) in nineteenth century arrived.

Bogert et al. developed a new analytic tool for the temporal analysis of echoes, appropriately published in a book on Time Series Analysis.²⁵⁶ They "rearranged terms like spectrum, frequency, phase, into anagrams like "cepstrum" and "quefrequency"; even the very operation of analysis turned into "alanysis" "to highlight the unusual treatment of frequency domain data *as if it were time domain data* in generating a new data set which had across its x-axis values (the quefrequencies) in units of seconds" but which still indicated nothing else than variations in the frequency spectrum. This is a form of *alien temporality* indeed. The author on the application of Quefrequency Alanysis to the actual engineering of electroacoustic speakers explicitly prefers "to retain [...] the term 'quefrequency' to remind me that the seconds shown on the plots aren't time as I might normally consider it"²⁵⁷.

Here, the "chronotope" turns into a technomathematical epistemic toy to displace the usual linkage of sound to time: "In general, we find ourselves operating on the frequency side in ways customary on the time side and vice versa."²⁵⁸ The "echo" itself, which in "time" phenomenology serves as an example for sonic "retention" (Husserl), turns from a "time object" into a techno-mathematical laboratory.

It turns out that what looks so natural - to consider of the echo and as "time signal" can as well be re-defined techno-mathematically into a chronotology. The "analogue" wave form might not be the most "natural" form of sonic articulation at all, and thereby its relation to "time" rather be a function of its material measuring, and analytic

²⁵⁶ B. P. Bogert, M.J.R. Healy, and J.W. Tukey, The quefrequency alanysis of time series for echoes: Cepstrum, pseudo-autocovariance, cross-cepstrum, and saphe cracking," in: Time Series Analysis, M. Rosenblatt, Ed., 1963, ch. 15,pp. 209-243

²⁵⁷ Anonym., Reflecting on Echoes and the Cepstrum: A Look at Quefrequency Alanysis and Hearing (originally printed in Speaker Builder Magazine), <http://www.libinst.com/cepst.htm>, accessed March 9, 2021. See as well Alan V. Oppenheim / Ronald W. Schafer, From Frequency to Quefrequency: A History of the Cepstrum, in: IEEE Signal Processing Magazine (September 2004), 95-99

²⁵⁸ Bogert et al. 1963, as quoted by Oppenheim / Schafer 2004: 95

mathematic operation.

Such a media-archaeological "hearing" switches from human application of media-archaeological methods to a media-active archaeology of the acoustic from the side of technology itself, when it comes to sonic "memory" in its strict sense of "storage":

"An early and very novel application of the cepstrum to deconvolution was the work by Stockham et al. directed at blind deconvolution such as the restoration of old phonograph recordings. They focused in particular on restoration of recordings by Enrico Caruso. The objective in the restoration of these old recordings was to compensate for the undesirable frequency response of the [...] recording horn used in that era. Since the recording horn was retuned daily and since its frequency response was typically subject to temperature and humidity variations, the compensation could not simply be based on modern day measurements of an archived recording horn, i. e., the spectral characteristics would have to be estimated from the recording itself."²⁵⁹

This is media-active archaeology, and de-archiving technology of past sound indeed.

Locating Musical Memory:

What happens to the analogue "musical" archive of sound recording media in the digital domain is "no soft mutation"²⁶⁰ or transformation, but a radical transcription. Acoustic signals become - so to say - musical, in fact: "algorhythmic"²⁶¹ again. Therefore, media-archaeological attention is directed not on archival metadata, but on the inner-technical signal event. It is here that *chronotopia* unfolds not as narrative tropes or aesthetic metaphors, but as actual event.

The KSYME Archive

One of the core concerns of the Contemporary Music Research Center in Athens is the customary archive as institution and its archival records, which are registered according to the Dublin Core metadata standard for

²⁵⁹ Oppenheim / Schafer 2004: 99, referring to: T. G. Stockham, Jr., / T. M. Cannon / R. B. Ingebretsen, Blind deconvolution through digital signal processing, in: Proc. IEEE, vol. 63, pp. 678-692, Apr. 1975

²⁶⁰ Akis Sinos, electronic communication from 2nd March, 2021

²⁶¹ Shintaro Miyazaki, Algorhythmics. Understanding Micro-Temporality in Computational Cultures, *online* in: Computational Culture, Issue 2 / 2012; <http://computationalculture.net/algorhythmics-understanding-micro-temporality-in-computational-cultures>

the "items", for the rather museal than archival technical ("physical") item "collection" metadata, and the (still missing) "exhibits".²⁶² The online accessible "Catalogue of Recordings", of course, comes closer to a library than to an archive.

[Fig.: "KSYME archive at the Athens Conservatory. Photo: Rezarta Krougia, 2020"]

When opening the card boxes, what is inside such standardized archival containers? Either paper documents, or actual technical storage media? Both groups make a decisive difference for the function of the archive. The traditional archive has been related to alphabetic writing, actually co-originating in the *archeion* of ancient Athens. Thereby, alphabetic archival metadata, in its inventory and logistics, occur within the same symbolic order as the written records, while signal-recording of sound would truly require signal-space or digitized information retrieval from *within* the medium, in *trans-archival* computing "space".

The Edison cylinder as a technical medium, both in its materiality, and in its graphic inscription, actually escapes from archival metadata. Signal storage is opposed to the symbolical archive. A differentiation between the archive as an institutional and taxonomical frame, and the material signal storage and processing, is therefore required - in all its ambivalence of the British term "record".

The Contemporary Music Research Center in Athens "possesses research and educational equipment with computer systems" on the one hand, and "[i]t also possesses a rich archive of Greek music (traditional and contemporary, recordings and scores)" in a musical record library.²⁶³ Why not integrate those two components which are otherwise kept separate, and let computational algorithms retrieve, from within the signal space of recorded sound and voices of Greece which is the "sphere of Greek musical heritage" (ibid.) literally, another media-archaeology of musical knowledge itself, which is not subjected to taxonomic metadata, but unbounds its intelligence mathematically, that is: in the best tradition of cybernetic information aesthetics (Abraham Moles, Max Bense)? Just like Foucault's *Archéologie du Savoir* (1969) once rather referred to computational linguistics and logics rather than to cultural content, the stochastic model of tempor(e)alities in music retrieval, might finally let the message of one of KSYME's co-founders, Iannis Xenakis, become the medium of its very archive / *l'archive*.

KSYME / *Kima*

²⁶² For this inventory, see <http://www.ksyme.org/ksyme-archive.html>

²⁶³ Website "CONTEMPORARY MUSIC RESEARCH CENTER", <http://www.ksyme.org/history.html>, accessed February 14, 2021

But it is more than a pun when one contrasts the archival "record" with the phonographic "record" of acoustic signals. Let us carefully distinguish the only technically recordable analogue, time-continuous acoustic signal from the digital, alphabetically or alphanumerically coded "archival" symbol. While the traditional archival document (such as in the British State Archive, which is called "Record Office") refers to the symbolic order, in music industry, the record refers to the acoustic recording device. To play with the acronym here, KSYMA - for distanced ears at least - recalls *kyma*, the wave.

A heroine of Greek singing culture, Haris Alexiou, has issued a song called *To Kima* in 2003.²⁶⁴ "Come, wave, take me away", she sings: Έλα κύμα πάρε με.²⁶⁵ And further she paraphrases the double temporal-spatial meaning of *chronotopia*: "Just grant me a little moment in time, so I might transgress the distance."

It is in this song that the word (*lógos*) "kima" becomes wave in the recording medium. This refers to the acoustic wave as air pressure, to the wave form of the recording signal as well as to its originary apparatus, the kymograph as "wave writer". This rotating cylinder inscribed micro movements graphically (Marey's *methode graphique*), not alphabetically, and has been further developed by Édouard Léon-Scott, into the "phonautograph" for recording phonetic articulation, for the analysis of air waves which are induced by human speech - actually the predecessor of the Edison phonograph. In phonography, the sonic time signal *takes place* in a recording medium, but not in terms of the textual or score notation, or archival metadata, but as indexical inscription.

Contrary to the anthropocentric narcissism of so-called Sound Studies, though, it is not the human voice only of which such an inscription is "indexical" of. Between the original of, for example, Enrico Caruso voice singing the famous "Ridi Bajazzo" aria ("Vesti la Giubba") from Ruggero Leoncavallo's 1892 opera *Pagliacci*, and its 1907 phonographic recording²⁶⁶, the sound box recording mechanism itself intervenes. There is not just the inevitable - and even nostalgically appreciated - surface noise of the storage medium, but utterly non-human wave forms intervene, *to metaxy*. Thus, unless an abundant archival documentation is available, "it is that in restoring these old recordings, we are faced with a blind deconvolution problem since we know neither the singing signal s

²⁶⁴ For a song recording, listen to <https://www.youtube.com/watch?v=mgfhTrB3G5M>

²⁶⁵ For the text in Greek: <https://www.google.com/search?client=ubuntu&channel=fs&q=Haris+Alexiou+Kima&ie=utf-8&oe=utf-8>, accessed March 8, 2021

²⁶⁶ Listen to <https://www.youtube.com/watch?v=RL7wdUPXpiM>

(t)" as a function time, "nor the impulse response $h(t)$ involved in any particular recording under consideration"²⁶⁷ - resulting in a techno-metonymic shift from the singer's body to the amplifying tube, and sound-box-diaphragm which co-articulates the *technical embodiment*. "Stated in mathematical terms," - which is the true language of radical media-archaeological analysis - "one is given the result of having convolved two unknown signals [...]. It has been our philosophy from the very beginning" - *en arché* - "to approach this problem as a filtering problem in which one is required to separate two signals" (ibid.) - which is impossible for any other historiographic "recording" of past sound, or "historical" music. "[E]stimates involving time averages are possible only if the signals are ergodic. If, on the other hand, the time variations which characterize the non-stationary signals change slowly enough which time," - which actually defines most of conventional musical harmony - "power spectral estimates applied to such signal may still make sense" (686). But to Iannis Xenakis' compositions, this can hardly be applied. There is another tempor(e)ality at work in *stochastic music*.

The phonographic sono-technical medium (rather than popular "media") process became the indicative "trade mark", in its self-understanding, of the weekly research colloquy *Media in our Sense* at the Institute of Musicology and Media Science at Humboldt University, Berlin. What we see, is materialized sound on - or rather: in an analogue recording medium (which makes all the difference between the Edison phonograph and the Berliner grammophone):

[Fig. from: https://www.musikundmedien.hu-berlin.de/de/medienwissenschaft/medientheorien/medien_die_wir_meine_n]

The sine wave - as time signal - is almost metonymic of the additive electro-acoustic synthesizer as such, and the "drone" of the electronic video image (as defined by Bill Viola's seminal text on "The Sound of One Line-Scanning"²⁶⁸ - *versus* the (rather timeless) "drone" in non-Western, Indian music aesthetics which rather filters tones from noise by subtraction.

When the Contemporary Music Research Centre has been founded in 1979 in Athens by Iannis Xenakis and others with the aim to support the *research and development of electroacoustic music in Greece*", the electro-acoustic sonicity paradigm here clearly ruled against the

²⁶⁷ Thomas G. Stockham / Thomas M. Cannon / Robert B. Ingebretsen, Blind Deconvolution Through Digital Signal Processing, in: Proceedings of the IEEE, vol. 63, no. 4 (April 1975), 678-692 (679)

²⁶⁸ Reprinted in: idem, *Reasons for Knowcking at an Empty House*. Writings 1973-1993, ed. Robert Violette, London (Thames & Hudson) 1995, 153-168

supremacy of ethnomusicology. The former is generative media aesthetics, the latter is - literally - "collective". The former related to technical sonicity, the latter to cultural memory.

Similarity-Based "Musical" Content Retrieval

But when searching for Haris Alexiou's song *To Kima* in the Internet, a new kind of "archive" becomes apparent. The United States Patent by Brian Whitman and Tristan Jehan on automatically *Determining the Similarity of Music* for the assignee The Echo Nest Corporation, filed April 2008, exactly mirror Foucault's diagnosis of "other spaces" in contemporary online media culture: "We are at a moment [...] when our experience of the world is less that of a long life developing through time than that of a network [...]."²⁶⁹

[Fig. 1 of Patent Whitman / Jehan 2008]

This music taste recommender system, which is currently applied by the streaming music provider Spotify, clearly distinguishes between "cultural" and "acoustic" information, concretely: between "a comparison algorithm based on acoustic metadata and a comparison algorithm based on cultural metadata"²⁷⁰. Notable is the fuzzy distinction - even confusion - between "acoustic", "sound" and "musical" - in the language of this patent, "[a]coustic metadata may include both temporal information such as tempo, rhythm, beats, [...] or structure, and spectral information such as melody, pitch, harmony, or timbre"²⁷¹. Such signal analytics (Manovich) refers to the *media archive*, while "cultural metadata" refer to the classical paper text archive: "Within this patent, "cultural metadata" refers to text-based information describing listeners' reactions to a track or song. Cultural metadata may be derived from expert opinion such as music reviews or classification of music into genres."²⁷² Finally, there is the archival "inventory": "Within this patent, 'explicit metadata' refers to factual or explicit information relating to

²⁶⁹ Michel Foucault, *Des espaces autres* [lecture 1967], in: *Architecture. Mouvement, Continuité*, no. 5 (October 1984), 46-49; English translation from the French by Jay Miskowiec: *Of Other Spaces. Utopias and Heterotopias*, in: *Diacritics* vol. 16, no. 1 (1986), 22-27 = <https://web.mit.edu/allanmc/www/foucault1.pdf>, accessed February 19, 2021, p. 1

²⁷⁰ Brian Whitman and Tristan Jehan, *Determining the Similarity of Music Using Cultural and Acoustic Information*, Patent No. US 8,073,854 B2. Date of Patent: Ce. 6, 2011, "Abstract"; available online: <https://patentimages.storage.googleapis.com/1d/8f/72/7c27515a59ed9a/US8073854.pdf>, accessed March 8, 2021

²⁷¹ Whitman / Jehan 2011: column 1

²⁷² Whitman / Jehan 2011: column 2

music. Explicit metadata may include album and Song titles, artist and composer names, other credits, album cover art, publisher name and product number, and other information. Explicit metadata is generally not derived from the music itself or from the reactions or opinions of listeners."²⁷³

On the one hand, the procedure bypasses archival pre-classification, with its focus rather on signal-oriented stochastic data, as it is familiar from "cultural analytics" in Digital Humanities for visual culture research.²⁷⁴ Still, metadata logocentrism is still at work when the MusicIP Corporation "provides an acoustic fingerprinting service commonly referred to as Music DNS (Digital Naming System)" which "calculates acoustic metadata from the content of a track [...] used to uniquely identify specific tracks"²⁷⁵.

Like an equivalent to the traditional archival "file, the "Detailed Description" in the patent uses the term "track" to describe a unit of audio content such as a section of a song, or a single melodic movement. While a track is materially recorded and stored on a storage device, such as a hard disc drive, it is symbolically re-arranged to become "a component of a library of audio tracks"²⁷⁶. The real *l'archive* (in Foucault's sense), though, is the technological apparatus and its algorithms. The "storage device" as hardware is differentiated from the "metadata library"²⁷⁷.

A remarkable, truly sono-analytic, media-archivological operation is marginally suggested: "In cases where cultural metadata for the target is not available to be retrieved, at least some cultural metadata may be estimated from acoustic metadata."²⁷⁸

The comparison algorithm is based on a procedure which is well known from artificial neural nets in Machine Learning: "A technique for weighting"²⁷⁹. A value indicates the degree of similarity, "on a predetermined scale, between the target and the reference. For example,

²⁷³ Whitman / Jehan 2011: column 2

²⁷⁴ See Lev Manovich, How to Compare One Million Images?, in: Understanding Digital Humanities, edited by David M. Berry, Basingstoke (Palgrave Macmillan) 2012, 249-278

²⁷⁵ Column 2. See as well W. E., The Media Epistemic Surplus Value of Sonic Surveillance Tools. A Commentary, in thematic issue "Genealogies of online content identification", published online December 30, 2020, in: *Internet Histories: Digital Technology, Culture and Society* (guest editors: Maria Eriksson & Guillaume Heuguet)

²⁷⁶ Whitman / Jehan 2011: column 4

²⁷⁷ Whitman / Jehan 2011: column 5

²⁷⁸ Whitman / Jehan 2011: column 6

²⁷⁹ Whitman / Jehan 2011: column 6

the similarity result may be a number from 0 to 1 or from 0 to 100, wherein a value of Zero indicates no similarity and the maximum value indicates a high degree of similarity approaching identity. The similarity results may be quantized, [...] or may be compared to a predetermined threshold and converted to binary (Yes/No) form."²⁸⁰ At that point, a media "archivology" of sound is closer to mathematics than to "music".

This might be of utmost media-epistemic relevance for the program of sound-mapping Greece by the Contemporary Music Research Center, and, in collaboration with the Polytechnic School of Athens, for its research project of applying melismata of Greek traditional music (group of notes sung to the same syllable) to the synthetic voice, with such similarity-based, and recursive, algorithms as the true media archaeologists of such an articulation of musical culture.

Locating Sonic Tempor(e)ality: The KSYME Machines

When the Contemporary Music Research Center in Athens is described as "Sound Archive", this is a hybrid, if not an oxymoron. Since on the one hand, it is signal storage, consisting of more than 2500 actual sound objects, situated between 1950 and today, which is analogue audio reproduction recording media (tapes, cassettes, including recordings of contemporary, electronic, traditional, and classical music), and digital, regenerative sound "subjects", such as DAT, CDs, hard drives. Its content is chronologically determined by the grounding (*arché*) sound technologies itself. But then, the cultural memory in the Contemporary Music Research Center is an archive in the conventional sense as well, a "documentation of music and educational events (lectures and seminars) that were curated and presented at KSYME".

To allow for a word play, any media-archaeological quest for *temps perdu* requires media-*archivological* investigation as well. Just that for such an analysis, the traditional archival record ("document") is replaced by the machine itself - the technical "monument". The institutional archive hereby extends the technical *l'archive* (in the Foucaultian sense).

Obviously, the Contemporary Music Research Center Athens is torn between two extremes: Greek musical heritage, and the pioneering electronic music "archives and instruments it holds", such as "[t]he center's iconic equipment, such as Iannis Xenakis's UPIC"²⁸¹, once developed to translate drawings and other visual data into sound *via* an electro-magnetic pen. On occasion of the collaboration between CMRC and past documenta 14, another technical masterpiece, the analogue

²⁸⁰ Whitman / Jehan 2011: column 6

²⁸¹ <https://www.documenta14.de/en/artists/16209/ksyme-cmrc>, accessed March 8, 2021

electro-acoustic EMS Synthi 100 from 1971, once built in a limited edition by the Electronic Music Studios in London, has been restored for display:

[Fig.: "KSYME-CMRC, archival materials, installation view, Athens Conservatoire (Odeion), Athens, documenta 14, photo: Yiannis Hadjiaslanis"]

Display though, in media-archaeological terms, is no simple visual exhibition in a museum showcase, but its operative reenactment. A series of *documenta 14* commissions for the Synthi 100 has been performed in April, 2017, at the Concert Hall Megaron in Athens, while the instrument - has subsequently been displayed at the Odeion Conservatory for the remainder of the *documenta 14* exhibition in Athens - silenced again, though.²⁸²

"The reactivation of the instrument after it malfunctioned some twenty years" not only raises the question of "what we might learn from an 'antique' electronic operating system and the cultural heritage it represents"²⁸³, but its reenactment actually defies historicism as such. When a medium, even if rescued from the archive, is reactivated, it is not in a historical time any more. Our ears perceive its soundings as radically present.

Investigating the Musical (Chrono-)Situation (Günther Anders)

The core idea of the *Chronotopia* artistic research project, as an initiative by CTM Festival in Berlin and Goethe Institute Athens 2020 / 21, is "to explore how different historical threads of development within music practices and research that connect to what we understand as 'contemporary' and 'experimental' fold into each other, and connect different temporalities"²⁸⁴. But such "historical temporalities" refer to the concept of a macro-time which is purely symbolic, since it exists only by historiographical narrative. If there is any musical tempo, it unfolds from within music." Where does to "engagement with pre-modern

²⁸² Compare the Subharchord, an experimental acoustic synthesizer once developed by Gert Steinke in the East Berlin radio station of former GDR, restored to operation and sounding by Carsten Nicolai, on displayed at Academy of the Arts. See Helen Adkins (ed.), *Künstler.Archiv - Neue Werke zu historischen Beständen*, Köln (Walter König) 2005

²⁸³ <https://www.documenta14.de/en/artists/16209/ksyme-cmrc>, accessed March 8, 2021

²⁸⁴ As described by Jan Rohlf (Co-Director CTM Festival / Adventurous Music & Art / Berlin / Europe), in his electronic communication to the author from February 10, 2021, referring to: <https://www.ctm-festival.de/news/chronotopia-echoes-antichiseis>, accessed February 14, 2021

musical forms and practices, media-archeological research, and projects with archives" which allow artists, listeners and researchers to "explore / reflect on points of contact between past and present musical/sonic/media practices" (Rohlf *ibid.*) actually take place? The "de-construct[ion of] a simple linearity of time as progress" already happens within sound technologies themselves. According to the media-archaeological premise, "alternative concepts of time and history, e.g. cyclical or spiral ideas of development, folds, forks, trans-temporal transmissions, temporal collapses and so forth, where past and present fall into each other, run in parallel", or tunnel under (Carlé) "historical" distance between antiquity and the present". "Media practices as speculative activities" require "alternative temporal spaces" indeed, which are not simply "alternative histories" (*ibid.*) but an alternative to the concept of the imaginary time order (and writing space) called "history" (and "historiography") as such.

Once "past" musical forms and practices are re-articulated, they lose their pastness, since by its very nature, the sonic event is unfolding in the presence. According to the media-archaeological premise, the narrative enframing of "past" music collapses once such musical information is actually re-enacted. In any "musical situation" (Günther Anders), past and present fall into each other.

Switching from narrative configurations (*topoi*) of historical time to the sonic tempoReal (*chronos*) is best achieved by hypothetically taking the point of view - or "listening mode" - of sound technologies themselves. Composer Philip Glass once made the record of his piece for piano *Metamorphosis* (1988) "using an old amazing [...] Steinway & Sons model O grand piano" where the company had officially stopped its production 1924 already.²⁸⁵ Both Glass' notational score and the actual hardware are from the past, but its performative (the pianist) and operative (the instrument) processing is radically a-historical, as if Minimal Music challenges the "deep time" dimension both media & history as such.

The "musical" machine has no sense of the sonic past, and its "digital" playback such as from a YouTube video, in principle, by its frequencies domain, is indifferent towards the "historical time" dimension.

Günther Stern's (later *alias* Anders) unachieved habilitation thesis on the philosophical investigation of the musical situation (*Philosophische Untersuchungen über musikalische Situationen*) from 1930 / 31 questions archival historicity in the name of sonic *chronotopia*. The "situation" (*tópos*) of music *as* sound is radical presence (*chrónos*).

²⁸⁵ See the YouTube commentary by the composer, <https://www.youtube.com/watch?v=M73x3O7dhmg>, accessed March 8, 2021

While the musical score can be "archivized", since its notation belongs to the symbolic inscription regime, there can be no "archive" of sound. Sound can only be recorded kymographically, since an acoustic (or implicitly sonic) signal requires to be actually re-enacted in order to come in to being (again) als "time object" (Husserl). The "information" of sound, in the digital regime, can be again "archivized" (memory-stored), but again, it requires effective re-enacted as processual signal to resonate again.

On the re-play of a phonographic recording, Stern insists: "Such a repetition does not recur - like human memory - on a specific item in the past, but it presents and realizes always anew: the repetition is not a copy of something listened to in the past, but this past event itself, even if for the second time."²⁸⁶

If memory "rescues" and conserves the past only by representation, it is simply a historical category: a monument ("D e n k m a l"). "But what can not be remembered, but requires repetitive recreation, is unhistorical."²⁸⁷ This description of the phonographic records comes close to Walter Benjamin's almost contemporary definition of the Work of Art in the Age of its Technical (notably photographic) Reproducibility (1936). "No gramophone record renders a representation of Beethoven's Mondscheinsonate, but embodies the Mondscheinsonate itself; no radio simply represents a play, but musical action itself."²⁸⁸

For sound, there is no past, only its equiprimordial re-generation - be it from analogue recording on an Edison cylinder, or from digital recording on a Compact Disc. The acoustic *kyma* / wave has become equally electromagnetic and digitized. Once connected online, the "sound

²⁸⁶ On sonic memory (German *Erinnerung*): "Die Wiederholung rekurriert nicht wie diese auf ein bestimmtes Damaliges [...]; sondern es präsentiert und verwirklicht jeweils neu: das Wiederholte ist nicht A b b i l d des ehemals Gehörten oder Musizierten, sondern immer wieder es selbst, wenn auch 'zum zweiten Male'." Günther Stern, Philosophische Untersuchungen über musikalische Situationen, typescript 1930/31, in: Literaturarchiv der Österreichischen Nationalbibliothek 237/04 (Estate Günther Anders), folio 54. For a published version: Reinhard Ellensohn (ed.), Günther Anders. Musikphilosophische Schriften. Texte und Dokumente, München (C. H. Beck) 2017, 15-140

²⁸⁷ "Was aber nicht erinnert, sondern nur immer wieder neu realisiert werden kann, ist unhistorisch." Stern *ibid*.

²⁸⁸ Keine Grammophonschallplatte gibt das" - in Beethoven's *historical* sense - "Bild der Mondscheinsonate, sondern diese selbst; kein Radio gibt vervielfältigte Bilder des Gespielten, sondern dieses selbst": Stern / Anders 1930 / 1931, typescript, p. 58. Quoted here after its publication in: Reinhard Ellensohn, Der andere Anders. Günther Anders als Musikphilosoph, Frankfurt/M. (Peter Lang) 2008, 68

archive" not about the past any more, but rather short-circuiting the past with the present, "tunneling" temporal distance chronotopically.

According to Stern / Anders and to media archaeology, both musical (rather: sonic) and electro-technical tempor(e)alities differ from the historical (cultural / narrative) time order, and from the historiographic symbolic regime. "Music incorporates a temporal momentum, but does not unfold in historical time proper"²⁸⁹. Musical enactment rather re-generates its appropriate chronosphere equi-primordially (Heidegger's "gleichursprünglich"), just like acoustic media space does not simply make use of, but generates the electro-magnetic field as channel of transmission. And just like any "radio" transmission of an electro-magnetic signal, the signal is exhausted once it unfolds, like philosopher Hegel once defined the "tone". Sonic articulation is, literally, memoryless, and un-archival. It can be recorded only within its own medium: on magnetic tape, to be re-activated by the tape head, like a Xenakis recording on tape which is therefore rather kept in latency, than conventionally "archived", in the Contemporary Music Research Center. Media memory actually asks for media-active remembrance.

[Fig.: KSYME Xenakis tape]

Such electro-magnetic induction is not primarily about "time" in the emphatic sense, but about recursive movement of energy.

Musical Archive vs. Technical Recording:

As kind of chronotopic *différance*, electronic media *dislocate* the familiar "inner sense of time" in human phenomenology (Husserl 1927). Various media not only record, but actually generate diverse temporalities. Such complex tempor(e)alities are not revealed from the textual records in archival shelves, but rather emerge from within the "archived" machines themselves - its electronic hardware and running software, such as the synthesis methods and graphical tools used by Xenakis, and other forms of "algorhythmic" (Miyazaki).

Where the (Non-)Time of the "Digital" Actually Takes Place: The A / D Conversion of Sound

The media-archaeological focus on technological tempoR(e)alities is an effort to "ground" lofty philosophical, or artistic speculations about "space" and "time" in rather concrete analysis of where "time" effectively

²⁸⁹ "Die Musik trägt ... ein zeitliches Moment in sich, verläuft aber doch im eigentlichen Sinne nicht in der Geschichte": Stern 1930 / 31, typescript p. 44

takes "place". The seductive transcendental, literary, or aesthetic allure of the thought figure of the "chronotope" is therefore replaced by the analysis of the technological *Ge-stell* where it actually takes place. In a vmedia-archaeological and object-oriented perspective, technologies are not reduced to pure functional instantiations or applications of chronotopical concepts, but with escalating technologies, and finally the "Internet of Things", become their very foundation - a veritable disposition²⁹⁰ and "collection, in the sense of a technical *legein*. Technological scenarios are understood as "thought experiments" (*Gedankenexperiment*²⁹¹) actually becoming operative. Such a technocentric analysis allows for getting suspended, even "liberated" - at least temporally (to express it paradoxically) - from the transcendent and despotic signifier "time", in favour of a much more creative multitude alternative terms to describe operations of signal processing, both continuous and discrete.

The media-archaeological ambition is to replace speculative time philosophy by identifying the technical scenes where timing *takes place*. This is not to claim that all cultural thinking is determined by technology; technology, as un-natural logical and physical artifacts, is the finest product of cultural knowledge itself. Technology is considered here as a tool that - beyond the conventional "thought experiment" is not only ideal, but embodied mind, therefore "revealing" not only in the philosophical (Heidegger), but self-operative sense as well. Allow me to name this *technológos*.²⁹²

At that point, the operative pre-condition of the current drama of universal "digitalization" gets into focus: the Analog-to-Digital Converter which allows for time-continuous "worldly" signals - the proverbial "flow" of physical, entropic time - to be processed in(to) time-discrete techno-mathematics (aka computing, or Shannon-entropic information) at all. It is here that the chronotopic mechanism of signal *timing* can be *located* in the most precise sense.

Any alphabetic registering (both the archival "records", and their respective archival metadata) has already "converted" movement in the present (*res gestae*) into the literary code, to be processed in the mode of historiography as narrative emplotment and reconfiguration of *symbolic* time. In one of the technical scenes of A / D conversion, the

²⁹⁰"Das Ge-Stell stellt": Martin Heidegger, *Das Ge-Stell* [1949], in: idem, *Gesamtausgabe*, vol. 79, ed. Petra Jaeger, Frankfurt / M. 2nd. ed. 2005, 24-45 (32)

²⁹¹ See Barad 2007, xxx

²⁹² See W. E. (forthcoming), *Technológos in Being. Radical Media Archaeology and the Computational Machine*, New York et al. (Bloomsbury Academic) 2021 (*Thinking Media* series, eds. Bernd Herzogenrath / Patricia Pisters)

Sampling-and-Hold module, an equivalent to this core operation of traditional "archiving" takes place, but this discretization happens on a micro-temporal event level, below the regime of the alphabetic code.

Technical signal-to-data sampling and the quantizing of amplitudes, as a fundamental system transformation of audio signal processing since the 1970s, has been the precondition for "digital" audio engineering indeed, ranging from the synthesizer, over the drum computer, to the MIDI interface, and related special effects.

"Time", within digital computing, becomes a *function* of electronic clocking, which is: periodic movement (with no need to call it "time"):

[Fig.: Circuit Diagram, and Time Diagram SAMPLE-AND-HOLD]

When respecting the Nyquist / Shannon Sampling Theorem, ideally the "original" time-continuous audio signal can be restored from its intermediary time-discrete existence in numerical space. But restored to what: to its more natural continuous time?

Whatever happens to sound refers to the transformation of "time" as well. This is no coincidence, since the essence of sonic articulation is its being a(s) time signal as such. For media-archaeological analysis, sonic analytics is not primarily driven by musical aesthetics, but by enables an experimental epistemology (or laboratory) of "time".²⁹³

This would be the moment to discuss whether it is a metaphysical supposition that the "continuous" acoustic wave is the more natural form of sonicity, while digitized sound is a technical artefact²⁹⁴ - as much as (according to Turing) from the digital computational perspective, time has never been a flow, but a high-frequency sequence of binary "nows". But when quantizing the actual audio signal amplitude - as a kind of dynamic micro-*chronotope*, a different entropic, or ergodic "time comes into play, since any such conversion induces an irreducible "quantizing noise". which can not even be mathematically mastered by a signal-to-noise ratio.²⁹⁵

²⁹³ See W. E., *Sonic Time Machines. Explicit Sound, Sirenic Voices and Implicit Sonicity in Terms of Media Knowledge*, with a Preface by Liam Cole Young, Amsterdam (Amsterdam University Press), series *Recursions*, 2016

²⁹⁴ See David Friedrich's Master thesis *The Duality of Sound. Eine medienwissenschaftliche Zeitkritik des sonischen Signalwesens*, Media Science, Humboldt University, Berlin, forthcoming summer 2021

²⁹⁵ See Alexander Lerch / Stefan Weinzierl, chap. 14: Digitale Audiotechnik: Grundlagen, in: Stefan Weinzierl (ed.), *Handbuch der Audiotechnik*, Berlin / Heidelberg (Springer) 2008, 785-811 (791)

The Musical Archive vs. Sound Recording

The institutional archive is still space-centered, a topological "other space" in the Foucauldian sense, where metadata autopoietically refer to the alphabetic world and the symbolic order of textual libraries. But in the words of Friedrich Kittler, "discourse analysis cannot be applied to sound archives"²⁹⁶ that consist of signal traces.

There can be an archive of "music" (symbolical notation: "musical" score, and digital code), and a careful archival enframing, registering, documentation (preserving the provenance) and inventory (metadata) of phonographic sound recordings, but no actual sound archive, since actual signals are not symbolical beings, no arbitrary characters like the alphabetic text

Sound signals can be enframed by archival metadata and institutional administration, but cannot be embodied in the archive, only in recording techniques.

Therefore there can be no sound "archive", but only sound "storage", to be processed an-archivally (or dyn-archivally). This requires a conceptual shift of the "archive" from its institutional meaning to the analysis of its pre-conditioning technology - *l'archive* in Foucault's sense. The very distinctive use of the term *l'archive* in his *Archéologie du savoir* (1969) does not refer to the totality of all received documents²⁹⁷ nor its bureaucratic institutions but, more abstracted, to the system which governs the emergence and the processing of enunciations. In terms of digital sound signal processing, this is the hidden (but accessible) agency within computing itself: the Turing machine as "defined by *constraining* laws or by an *algorithm*"²⁹⁸ - rather than the traditional notion of archives as textual record depositories.

For the virtual emulator of one of the earliest fully electronic digital computers in Britain, the EDSAC, one metaphor has actually informed the design: "the analogy between a computer program and a musical score - once described as 'frozen music' needing only an orchestra to melt it."²⁹⁹ This corresponds with Shintaro Miyazaki's neographism of computational "algorhythmic" of computing in its sonic (time-signalling) sense, rather than reducing the computer to computation in the musical

²⁹⁶ Friedrich Kittler, *Gramophone - Film - Typewriter*, Palo Alto, Cal. (Stanford UP) 1999, 5

²⁹⁷ Michel Foucault, *Archaeology of Knowledge*, New York 1972, 130

²⁹⁸ Moles 1968 / 2011: 264

²⁹⁹ Martin Campbell-Kelly, *Past into Present: The EDSAC Simulator*, in: Raúl Rojas / Ulf Hashagen (eds.), *The First Computers. History and Architecture*, Cambridge, Mass./ London (MIT Press) 2000, xxx-xxx (399)

(conceptual) sense of the algorithm. Considered simply as source code, and not in its implemented action, algorithm is simply "archival", but not "musical".

It is a different temporality which is embodied in human performers of a musical score, against the implementation of a computer program in technical matter. A different kind of *chronológos* unfolds.

The functional emulation of a vintage computer by a present operating system makes all the (in itself time-critical) difference to re-enactment as actual simulation. As expressed by the designers of the virtual EDSA, the "musical" approach to emulation "is textual rather than artifactual in spirit. [...] the attention that other projects have given to physical authenticity has been directed at obtaining authentic program texts. However, as with musical scholarship, this textual approach permits the informed and explicit filling in of lost textual fragments where this will produce a richer experience for the user." (ibid.)

So the musical *archive* should not be confused with sonic *memory*, and the *storage* mechanism not confused with dynamic *remembrance*; ("Er-innerung", in Hegel's sense). The archive is not about memory at all, but about administration; different from institutional archive, the media-archive refers to signals from within storage, and their technical condition: the apparatus (like the electroacoustic synthesizer, or Innis Xenakis' UPIC composition machine).

Where "Time" is Converted to "Space" Precisely: Locating *Chronotopia* in technical Storage

Any introduction into theories around technological archives in relation to media temporalities and nonhuman memory³⁰⁰ requires the media-archaeological unfolding of knowledge about *chronotopia* from *within* technology, instead of extending seductive aesthetic metaphors for human perception. If the function of media machines - beyond the traditional cultural techniques and tools - is to transmit and to store signals, this is a technical translation of *chronotopia* in its most literal sense. Storage media convert time signals into spatial records, and allow for the inverse operation at any arbitrary time-delayed moment.

Different from the scriptural document archive, the signal-based media archive technically (not metaphorically) is a *chronotope* indeed, since it literally transduces temporality into spatial storage as a pattern, such as on magnetic tape. hereby, the "temporal" channel is interrupted, waiting for its nonlinear reactivation. By storage, information as a time function

³⁰⁰ Electronic communication by Jan Rohlf, February 10, 2021

(embodied in the time signal) is converted into a space function³⁰¹ - unless it becomes unbound in so-called "dynamic memory" which turns storage into a time object itself. Spatial storage of information - different from its transmission via EM waves - depends on strict coupling to matter. In contrast, regenerative delay lines as intermediary storage for reverberative memory (once more a term borrowed from sonic terminology), such as in acoustic memory delay line in early computing (which has been described by Turing himself) dependent on permanent energy and die out with no electricity supply. After its recording, even the local signal may entropically deteriorate, since another thermodynamic and material time passes, measurable as a Δt . The interval between recording and reproduction is not no-time.

There is a privileged affinity between electronics and sonic signals in its one-dimensional time axis quality, as opposed to two-dimensional, spatial images. Traditionally, "[a]ll signal storage takes place in space"³⁰², be it for the one-dimensional acoustic signal, or the two-dimensional "image". In analytic geometry, "time", considered as the 4th dimension, is still thought as extension of Cartesian space. Thereby, no "sound" can reemerge. For the actual replay of magnetic sound recording, the inert groove on a gramophone record, or magnetic storage on tape needs to be moved to be re-enacted: which is a temporal, time-consuming process in the present, as sensed in the inductive coil. Video recording overlaps both processes, the temporal and the spatical. The ferrit core magnetic memory medium, in digital storage, finally allowed for nonlinear access to every single stored bit.³⁰³ But every such electric "reading" actually destroyed the magnetic storage; therefore the store had to be reinscribed immediately re-inscribed.

Replacing "Time" by Stochastics:

Clock "Time"? Mechanical Hindrance ("Beat") vs. Sonic Tuning Fork

If it is not in the archive, where does time take place at all? In order not to get lost in lofty philosophic speculations about "time", media archaeology "grounds" its analysis in the technical scenes where such dimensions actually take place - or even emerge at all.

Radical media-archaeological and truly archivological analysis focuses less on the human (performative) cultural techniques of symbolic timing

³⁰¹ See Horst Völz, Versuch einer systematischen und perspektivischen Analyse der Speicherung von Informationen, in: Die Technik 20 (1965) 10, 650-659 (651)

³⁰² "Alle Speicherung erfolgt im Raum." Völz 1965: 651

³⁰³ Völz 1965: 654

such as religious rituals, dance, and prosopoietics, but on the operative (inner-technical) level of signal events as actual tempor(e)alities: where strict laws govern, *l'archive* in the Foucauldean (not in the institutional) sense, rather non-artistically; "grounding" (archaeologically) signal event autonomous from human perception in inner-technical event (against anthropocentrism in most musical / sonic research)

It has been the so-called "Anchor escapement" which once introduced discreteness into time, the proverbial acoustic "ticking" of the mechanical clock, which finally, as indicated in the technical term of electronic "clocking", allowed for digital computing in Alan Turing's imperative of "Treat time as discrete".

[Fig.: Animation showing operation of an anchor escapement", from: entry "Anchor escapement", https://en.wikipedia.org/wiki/Anchor_escapement, accessed March 26th, 2021]

Does one see "time" in this mechanical condition of a so-called "time piece"? What can be seen is rather a kinetic movement which is made "countable" only by a mechanical trick (in the old Greek sense of *mechané*).

Aristotle's definition of "time", in Book IV of his *Physics*, first of all questions whether "time" is a form of being at all; allowing to decompose its apparently transcendent reference into operational units such as change, intervals, and movement. The mechanical clock, as well as digital computing, turns signal change into the countable, therefore: computable. "The before and after are attributes of movement, and time is these qua countable."³⁰⁴

A constructivist understanding considers "time" as an abstract measuring unit, that is: as numerical symbolization. But in its actual materialization, a clock mechanism is not a "time piece" at all, but a loco-motive machine, a mechanization of Aristotle's definition of "time" as a function of numerically counting - and thereby discretely integrating - movement.

With Claude E. Shannon's Master Thesis at the M.I.T. in Boston, August 1937, *A Symbolic Analysis of Relay and Switching Circuits*³⁰⁵, the mechanical "hindrance" as known from the mechanic clock became a technical embodiment of binary Boolean logic, that is: of the "digital"

³⁰⁴ The Complete Works of Aristotle. The revised Oxford translation, edited by Jonathan Barnes, vol. I: *Physics*, Translated by R. P. Hardie and R. K. Gaye, Princeton, New Jersey / Oxford (Princeton UP) 1984, Book IV, p. 50 - 78 (on "space" and "time"), here: p. 77: 223a28

³⁰⁵ Publication (reedited and abridged) in: *Transactions of the American Institute of Electrical Engineers* 57 (1938) 713-23

symbolical "zero" and "one" in electro-mechanical switching relays.

A dynamic alternative to musical "time" and "space" is resonance which short-cuts the emphatic difference between "presence" and "past", the distant and the near. Resonant electronic synchronization becomes most concrete in the The Bulova "Accutron" watch³⁰⁶, where the "time base" becomes audible, since it is a combination of tuning fork and electromagnetic induction, as a truly "sonic time machine".

If that sonic time piece is positioned close to the microphone, for a "live" transmission of the "sound of time" *via* videoconferencing software, it may still happen that one does not hear the 360 hz sound. Maybe the battery has expired. Obviously there is still the Heideggerean "decay-to-death", physically known as thermodynamic entropy, more mighty than archival memory ever has been, and what culture uses to call "time".

Finally questioning the plausibility of (sonic) "time" itself

Chronoi in music, as they have been once described in Aristoxenos' writing on rhythm, have been rather proto-"temporal" practices as cultural techniques, and have now become autonomous and chronopoetically autoreferential *within* sound technologies. Sonic Signals are endotechnical events. The "Acoustic Quantum", as defined by Denis Gabór and technologically developed as sound spectrography, is a challenge to any linear concept of "time", and dissolves musical "time" into micro-"temporal" grains, or even stochastic music as defined by Iannis Xenakis. Probability here replaces any temporal direction.

As it has been described in a notorious chapter of Norbert Wiener's *Cybernetics* from 1948, Newtonian time is "mechanic", both in the mathematical and the technical (astrolab) sense: reversible, and certainly measurable. Bergsonian time, on the contrary, is about endurance (*durée*), and probabilities. That is why Xenakis' compositions deserve to be media-archived processually, not simply "archived" as documents: They remind of another stochastic, ergodic time, and in its very terminology, they offer a rich alternative to the chrono-despotic signifier "time" at all.

AURALIZATION AS RE-ENACTMENT OF THE SONIC PAST

Introduction

³⁰⁶ For an *operative media demonstration*, see a TV commercial from the 1960s, advertising the Bulova *Accutron* tuning fork against the traditional balance wheel: <http://www.youtube.com/watch?v=x2ZFsqw9QHg>

For centuries historical research has privileged the visible and readable archival records, thus fulfilling Marshall McLuhan's 1962 diagnosis of the *Gutenberg Galaxy* being dominated by eye-based knowledge.

But with auralization, a new kind of "virtual", that is: computational, simulation-based historical research has emerged: the research into past sonospheres and ways of listening long-time ago. Auralising makes random acoustic signals audible within a computer-modelled spatial surrounding.³⁰⁷ This algorithmic tool has mostly been applied for the design of new, that is: *not yet existing* concert halls, or for the restoration of *still existing* halls. But in the interest of historical research even the acoustics of rooms which *exist no more* can be derived from auralization on the basis of computer-based simulation - with all the epistemological ambivalence of "(re-)construction".

Already with the arrival of the phonograph the question arose if soundscapes for the time previous to Edison can be reconstructed. With auralization, a new kind of "virtual" (that is: numerical, simulation-based) method has emerged: the research into past sonospheres and ways of listening long-time ago. An extended notion of sonic heritage emerges from auralisation as re-enactment of the sonic past and acoustic simulation as historical method.

Methods of exploring the sonosphere of ancient Greek theatres by application of measuring technology have been developed long ago. In the meantime, audio communication has extended its research methods to re-enactments of ambisonics of the past - be it historic concert halls or other architectural spaces and even pre-historic landscapes. Thereby a veritable acoustic media-archaeology is emerging where the term "archaeology" is more than just a metaphor for digging for new records from the past. The paper discusses in case studies its technological means and the kind of new cultural knowledge which stems from that approach. Hermeneutic chances and limits of such re-auralization as new form of historical method and research are being discussed.

To what degree can auralization (sonic simulation based on measurement) provide a new kind of algorithmically synthesized record - and can this record still be called "historical"? Can the strict criteria of what is defined as historical record (German "Quelle") be applied to ephemeral settings like sonospheres? Here a double meaning of "record" is implied: the traditional textual document in symbolic (alphabetic) code, but recently signal recording of time-varying signals as well. There is a new possibility for tele-communicating with the past, embodied and transmitted in the acoustic records and channels.

³⁰⁷ As defined in Weinzierl 2002: 20

As a result of media culture since nineteenth century, the traditional range of text-based, symbolic records of the past has been supplemented by auditive and visual signals. Acoustic signals are defined as time- and/or space-varying physical quantities. In the context of signal processing, not arbitrary on-off-signals but only (analog and digital) signals that are representations of analog physical quantities are considered as signals³⁰⁸ - thus necessarily always being *embodied* in the material world which remains from the past. To what degree can such an ephemeral time-varying signal like sound be reconstructed? Sounds from the past are commonly associated with recording media like the Edison phonograph. In a more active sense, media-archaeology of past sonospheres implies the technologically active agency of reconstruction, with the measuring media and signal processing methods (impulse response) themselves being the active archaeologists.

Since Edison's phonography sound, noise and voices can be technically recorded and thus memorized, resulting self-expressively in extended possibilities of sonic heritage. Research into past ways of listening have emerged in Science & Technology Studies as a new branch of historical knowledge. Here, the term *sonic environment* is commonly associated with industrial and other sources of noise.³⁰⁹ Complementary to the social *history* of such sonospheres there is a need for an *archaeology* of sonic expressions.

By auralization as re-enactment of the sonic past, the historical method is not only extended but even pushed to its margins, since the temporal affect which arises from such media-archaeological auralization as "re-presencing"³¹⁰ is different from the familiar text- or image-based historical sensations. Historical argumentation as a cognitive operation of organizing past data will never be audible but only readable in complex textual argumentation; the historical method, though, will certainly be extended to sonic articulation as well - pushing the notion of history to its margins.

To what extent is the auralization of past sonospheres a valid historical or an archaeological method of research?

³⁰⁸ Entry "Signal Processing", online <http://en.wikipedia>, accessed November 25, 2010

³⁰⁹ See Karin Bijsterveld, *Mechanical Sound. Technology, culture, and Public Problems of Noise in the Twentieth Century*, Cambridge, Mass. / London (The MIT Press) 2008, 11 f., referring to R. Murray Schafer, *The Soundscape. Our Sonic Environment and the Tuning of the World*, Rochester, Vt. (Destiny Books) 1994 [*1977]

³¹⁰ See Vivian Sobchack, *Afterword. Media Archaeology and Re-presencing the Past*, in: Erkki Huhtamo / Jussi Parikka (eds.), *Media Archaeology. Approaches, Applications, and Implications*, Berkeley / Los Angeles / London (University of California Press) 2011, 323-333

The discipline of history treats the past as a sender system whose receiver are the present historians themselves - a telecommunicative dispositive. Johann Gustav Droysen who in his *Historik* once differentiated between records from the past which were intentionally constructed for tradition ("Quellen") and unintended records as remnants ("Überreste"). When an old building as a piece of the past is still in use, it turns out "historical" only when being perceived as such by research.³¹¹

More recently Michel Foucault criticized the discipline of history for turning *monuments* of the past into *documents* to be memorized, even if they are often of non-linguistic nature and of different enunciative qualities.³¹² He rather proposes to investigate remnants from the past by reconfiguring them into new elements - elements whose smallest units nowadays are *binary digits*. Even if acoustic spaces which derive from previous times are algorithmically re-sonified, they remain silent in the Foucauldean archaeological sense.

Mesasurement and simulation as two modes of auralization of past, therefore silent sonospheres are not historical methods *per se* but rather what historians call "auxiliary sciences" to the discipline of history (*Hilfswissenschaften*, in German).

The British historian R. G. Collingwood subsumed source-critical history under the general name of "archaeology" for which he lists "departmental sciences such as palaeography, numismatics, epigraphy, and so forth."³¹³ The ambition of the present paper is to add auralization to this list. "These archaeological sciences are a *sine qua non* of critical history. They are not themselves history; they are only methods of dealing with the sources of history" (ibid.). "They form, as it were, the bones of all historical thinking."³¹⁴

In its narrative discursive form, "[H]istory itself must be flexible, but it must have rigid bones [...]. [...] the concreteness of history can only be reached through the abstractness of the archaeological sciences" (ibid.). Collingwood in fact describes the archaeological method in terms which can be applied to auralization as well: "The archaeologist feeling his way towards new advances is constantly asking himself whether this or that detail [...] can be proved characteristic of a certain date or a certain origin" (ibid.).

³¹¹ Johann Gustav Droysen, *Historik*, edited by Rudolf Hübner, Munich / Berlin (Oldenbourg) 1937, 37

³¹² Introduction to his *Archeology of Knowledge*, xxx

³¹³ "Outlines of a Philosophy of History" (manuscript 1928), in: Collingwood 1946 / 1993: 426-496 (490)

³¹⁴ Collingwood 1946 / 1993: 491

But without historical imagination (usually supplied by philosophy of literature), inquiries into the past remain poor, Collingwood insists. Inbetween now a rule-governed kind of scientifically controlled imagination has emerged: digital simulation and modelling.

The *unprocessed data* provide the archaeological material upon which historiography might be based: "As historical evidence, records are largely unconscious, and not slanted for the consumption of posterity. In this they are therefore akin to the vast majority of archaeological artifacts".³¹⁵ At that point, algorithmic data processing comes in - the computer as active media-archaeologist.

Auralization method has been proved to be capable of reproducing predicted room acoustical properties: "When listening to the auralization and comparing to dummy head recordings in the same position in the same room, the differences are hardly audible. The auralization technique has matured to such a level, that the human ear can hardly tell whether it is a simulation or not."³¹⁶ From that an ambiguity of a different kind arises: Uncertainty in human judgement about the validity of an acoustic record concerning a "historical" room. If echoes and reverberations are simulated correctly, "the auralizations from simulations actually sound more natural than the auralizations using the measurements the real room"³¹⁷. Such hyperreal (in Jean Baudrillard's sense) *Verunsicherung* is well known from an ancient sonospheric setting itself as described in Homer's *Odyssee* - the acoustemic challenge embedded in the Sirens' song with its turning the notion of human singing upside down: "Some have said that it was an inhuman song - a natural sound (is there such a thing as an unnatural sound?) but on the borderline of nature, at any rate foreign to man; almost inaudible [...]. Others suggested that it [...] simply imitated the song of a normal human being, but since the Sirens, even if they sang like human beings, were only beasts [...], their song was so unearthly that it forced those who heard it to realise the inhumanness of all human singing."³¹⁸

Here, a methodological provocation emerges. Acousticians have a different judgement of the validity of aural simulation than historians. When soundscapes of the past ("auditory cultures") are being reconstructed by historical research, they become nothing more or less

³¹⁵ D. P. Dymond, *Archaeology and History. A plea for reconciliation*, London (Thames & Hudson) 1974, 67

³¹⁶ Jens Holger Rindel / Claus Lynge Christensen, Room acoustical simulation and auralization. How close can we get to the real room?, keynote lecture at WESPAC 8 (The Eighth Western Pacific Acoustics Conference), Melbourne, 7-9 April 2003, Manuscript No. 1025], chap. "Conclusions". On the *approximative* reliability of room-acoustical simulations, see as well Weinzierl 2002: 143 f.

³¹⁷ Rindel / Christensen 2003, chap. "Subjective Verification"

³¹⁸ Maurice Blanchot, *The Sirens's Song. Selected Essays*, Bloomington (Indiana University Press) 1982, 59-65 (59)

than an extension of the historical method - a new "auxiliary science" for historians. Soundscapes of the past are thus integrated (if not subjected) to the discourse of historiography - with terms like "history of sensory perception" (claimed e. g. by Karl Marx and Walter Benjamin).

While the discourse of history as cognitive dimension is bound to writing acts (or oral narrative), auditive evidence (as archived in the past) asks for an alternative approach: media-archaeological re-enactment, leading to a different temporal regime of auditory memory. Media archaeology, which is media studies as exact science, analyses media-induced phenomena on the level of their actual appearance, that is: enunciations in Foucault's terms. In our context this is physically real (in the sense of indexial) traces of past articulation, sonic signals which differ from indirect, arbitrary evidence symbolically expressed in literature and musical notation.

Knowing past sonospheres before Edison

The traditional *a priori* of the Humanities has been extended by signal-recording and signal-processing media which preserve and transmit what has previously been inaccessible to experience and thereby to understanding in historiography and as history. A different reality of the past is memorized by media which can register more than simply what only exists in writing or in narration - such as the noise of the battles and the sonic effects of artillery.³¹⁹ A Phonograph actually registers the acoustic events.

In his novel dating from 1880, *L'Eve Future*, Vielliers de l'Isle-Adam lets the inventor of the phonograph, Thomas Alva Edison, lament on the loss of sonic information which has been lost in world history as long as this cultural memory was indeed reduced to what could historiographically be written down by the alphabet alone: "Voici tantôt soixante-douze siècles [...] qui, d'ailleurs, à titre de précédent immémorial, controuée ou non, eût échappé à toute phonographie."³²⁰

Technical repeatability of recorded sound leads to the option of an almost a-historical sonic re-enactment of the past. But this "archival" approach comes to its limits when research is interested in sonospheres which have never been intentionally be recorded at all such as the acoustics of concert halls from long time ago. At that point, auditory evidence splits into physical and historical. The experimental approach to the reconstruction of auditory perception in the past is a method familiar

³¹⁹ See Bernhard Siegert, *Das Leben zählt nicht. Natur- und Geisteswissenschaften bei Dilthey aus medienschichtlicher Sicht*, in: Claus Pias (ed.), *Medien. Dreizehn Vorträge zur Medienkultur*, Weimar 1999, 161-182 (175)

³²⁰ 1880 / 1979: 34

from sciences: to *actually re-enact* the sound-generating setting. When we pull the string on a monochord in its subsequent intervals we actually experience the technical dispositive which has been the Pythagorean basis for musing about music and mathematics in the past - invariant towards entropic, historical time.³²¹ In fact, the vibration of the string short-circuits us with that past, undercutting the "historical" divide inbetween.

Delayed presence: Micro-tuning of space and time-reversal in acoustics

"Time machines" are frequently associated with movie-like time travelling such as in H. G. Wells' novel. But it is rather sound and music which allow for the most flexible and dynamic time travelling: a kind of uchronia rather than utopia.

Musical performance is a time machine indeed which on the basic level allows for time axis manipulation on the time-critical micro-level like electroacoustic delay lines or electromagnetic tape delay in early electronic music studios for phase shifting and superposition of sound events.

From the microsonic field of samples up to the macrosonic domain of a musical composition, sound can be sculpted in time.³²² Jacob Kirkegaard's installation *AION* acoustically unfolded the abandoned space inside the forbidden zone of the collapsed nuclear plant of Chernobyl in the Ukraine.³²³ In each of the abandoned rooms, Kirkegaard made a recording of 10 minutes which he played back into the same room, then recorded this again - to be repeated up to ten times. As the layers got denser, each room slowly began to unfold a *drone* with various overtones. Kirkegaard's sonic time layering explicitly refers back to Alvin Lucier's installation *I am sitting in a Room* (1969) where the technical set-up created a tempor(e)ality of its own.

Space can be explored by time-critical sound operations; the engineering of room acoustics by measuring operations such as pulse-response (developed by Walter Sabine around 1900) has even been extended to auralization as re-enactment of the sonic past. Architecture is not just an

³²¹ "Zeitinvariant sind Systeme dann, wenn sie zu unterschiedlichen Zeiten gleich reagieren, d. h. wenn eine Zeitverschiebung am Eingang ein zeitverschobenes, ansonsten aber unverändertes Signal am Ausgang produziert." Stefan Weinzierl, Grundlagen, in: same author (ed.), Handbuch der Audiotechnik, Heidelberg (Springer) 2008, 1-40 (15)

³²² Steve Goodman, Timeline (sonic), in: Matthew Fuller (ed.), Software Studies. A Lexicon, Cambridge, Mass. / London (MIT Press) 2008, 256-259 (256)

³²³ DVD, created for his MA degree at the Academy of Media Arts, Cologne, January 2006; see <http://fonik.dk/works/aion.html>

empty vessel to be filled by arbitrary acoustics; the sound is rather been actively processed by the architecturally defined space itself. Spatial extension thus turns out to be the medium of temporal delay, while at the same time space itself becomes a function of temporal measuring. But it takes the memory capacity of an electronic device and its computational processing to provide fugitive sound articulation with a recurrent index of temporal depth - a sonic phenomenon of immediately passed / past tempor(e)ality.

Audio and vision belong to separate spatio-temporal worlds; bringing them together is not possible without doing violence to their tempor(e)alities.³²⁴ The hearing apparatus is much more sensitive to micro-time-critical processes than the eye. While the flickering of an electric bulb (50 times/sec.) can not be noticed by the after-image in the eye any more (the cinematographical effect), the rising of acoustic pitch from 50 to 100 oscillations/sec. are very well perceived indeed. "History" commonly refers to emphatic, narrative time scales. But there is a micro-history in every sonic event which is a time-signal by definition.³²⁵

There is a difference between time-based concepts like "cultural history" and time-critical micro-histories based on time signals - smallest run time differences (intervals) between direct sound waves and reflected sound waves in terms of Δt as remarked by Aristotle in his treatise *On perception as to metaxy*.³²⁶ Acoustic signal delay makes "the inbetween", in fact: the *medium* channel sonically opaque. Theater architecture, in terms of its time-critical acoustical feature, becomes "media theatre" in its truest sense: *to metaxy* as run time difference. Binaural acoustics turns out as implicit time-measuring instrument

This difference (not remarked as long as the reflection is so fast in small distance that it is for human ears indistinguishable from the original direct *schall*) amounts to perceptible (and in terms of music halls and audio technology even disturbing) echo effects as soon as the distance amounts to perceptible wave propagation (ca. 330 meters / sec. for sound waves in the air - depending on temperature).

It is by such time-critical measuring methods (impulse response as tool for the analysis of room-acoustics) that spatial models can be constructed, such as with the simulation software EASE. If the acoustic beam is micro-chronologically traced back to locate a listener position, micro-historiography is at work. Spatial order is thereby reconstructed from time-critical pattern.

³²⁴ Michel Chion, *Audio-Vision. Sound on Screen*, Columbia UP 1994

³²⁵ See section "4.1 Temporal structure of the sound field " in Weinzierl et al. 2014

³²⁶ See Aristoteles, *Über die Wahrnehmung und die Gegenstände der Wahrnehmung*, in: same author, *Kleine naturwissenschaftliche Schriften (Parva Naturalia)*, Stuttgart (Reclam) 1997, 47-86 (76, § 446b)

Recorded sound is temporarily suspended from fading out and thereby becomes time-shiftable in replay, thus escaping historical time. Sonic events evolving in time might even be time-reversed by immediately sending them back to the source, as long as they propagate without losing too much energy to heat consisting of the random motion of individual air molecules instead of their collective movement in the sound wave.³²⁷

More than just a metaphor: Acoustic archaeology

Let us differentiate between the socio-cultural respectively "collective" (Maurice Halbwachs) memory of sonic events (auditory memory) and the actual (media) recording, measuring and simulation of sonic articulation from the past.

In the research group around the journal *Explorations* and especially in the *Culture and Communication* seminar at the University of Toronto the psychologist Carl Williams borrowed from E. A. Bott the notion of *auditory space*. The phrase was not only metaphorically electrifying, but Marshall changed it to "acoustic space" as the quality of electronic communication spheres.³²⁸

For an archaeology of the acoustic in cultural memory the human auditory sense does not suffice. The sonic trace can rather be tracked with genuine tools of media studies which is technical media themselves. One way of "acoustic archaeology" is to play a musical partition on historic instruments. But the real archaeologists in media archaeology are the media themselves - not mass media (the media of representation), but measuring media which are technically able to decipher physical signals, and representing them in graphic forms alternative to alphabetic writing since sound is articulation in time: the oscilloscope, or by numerical auralization.

Traditional archaeology - associated with digging artefacts from the past in sand and earth - is performed by humans. Let us rather focus on technologies themselves as new kind of archaeologists of acoustic and sonic phenomena. Electronic autopoiesis here becomes an argument: What has been electro-acoustically created, can be re-created by virtual archaeology, such as the *Virtual electronic poem* (an audiovisual 3-D projection) reconstructing Edgar Varèse's *poème électronique* installed once at the Brussels World Fair 1958 in the afterwards deconstructed

³²⁷ Mathias Fink, Time-reversed acoustics, in: Scientific American, November 1999, 91-97 (92)

³²⁸ See Michael Darroch, Bridging Urban and Media Studies: Jaqueline Tyrwhitt and the *Explorations* Group, 1951-1957, in: Canadian Journal of Communication, Bd. 33 (2008), 147-169 (156)

pavillion designed by Le Corbusier and Xenakis.³²⁹

The immersive environment developed in *The Virtual Electronic Poem* makes the remarkable aspects of the *Poème* experience accessible again half a century after the event, thereby phenomenologically annihilating the difference in terms of time; the "historical" distance at least becomes massively condensed. When it comes to recorded signals instead of printed alphabetic records from the past, re-play becomes possible by techno-mathematical means. What historical research demands here is a differentiation between reproduction, simulation and emulation as known in retro-computing.

Let us separate mere functional emulation from simulation which includes the precise micro-temporal characteristics of the original as well - which is crucial when it comes to reconstruct past sonospheres. Lowenthal terms *emulations* as "respectful yet creative reworkings of earlier forms and styles [that] transcend mere copying" and views an emulation of past artefacts as an on-going and evolving activity that is always of its time but yet an essential original feature persists in all the variations and derivatives. "A reincarnating simulation seeks to bridge the ever changing gulf between past and present [...]."³³⁰

Archaic sonospheres

Is there an option to catch the authentic visual of sonic gesture previous to the age of technical recording media, the phonograph, the Welte-Mignon recording piano, and cinematography? The historical performance practice (for dance, theatre and music) can not only be reconstructed by scriptural sources, or indirectly by re-using ancient hardware - be it historical architecture, or historical music instruments³³¹. The sonosphere itself waits to be re-sonified by acoustic archaeology.

Archaeoacoustics and sonic archaeology as ways of making acoustic properties of the cultural past "understandable" have been established as proper academic disciplines by now. Past sonospheres ask for a media archaeology of the acoustic - with digital media themselves being the active archaeologist. Digital Signal Processing and computer-based tools like wave field synthesis (which media-archaeologically recaptures Christiaan Huyghens's approach to the nature of sound propagation) and

³²⁹ The *Virtual electronic poem* has been installed at Medienkunsthaus TESLA, Berlin, in January 2006

³³⁰ Martin Campbell-Kelly, *Past into Present: The EDSAC Simulator*, in: Raúl Rojas / Ulf Hashagen (ed.), *The First Computers. History and Architecture*, Cambridge, Mass./ London (MIT Press) 2000, xxx-xxx (399), referring to: David Lowenthal, *The past is a foreign country*, Cambridge U.P. 1985, 301

³³¹ See Peter Donhauser, *Elektrische Klangmaschinen. Die Pionierzeit in Deutschland und Österreich*, Wien - Köln - Weimar (Böhlau) 2007

other technical dispositives now allow for the virtual (which is: digitally computed) reconstruction of "historic" acoustic spaces.

One can only tentatively re-create the soundscape of past cities like Berlin around 1900. But by measuring remaining rooms by acoustic beams³³², one can digitally *render back* the acoustics of architectural spaces such as ancient Greek theatres.³³³ Even if media-culturalized ears may have been *tuned* differently since, there is a acoustic tempor(e)alty which *endures* in Henri Bergson's sense. Once technically recorded, sound is equipped with an "historical index" (Walter Benjamin's term) which transcends the purely historicist chronology. The positivist illusion of simulating past acoustic space is deferred by the more difficult task of reconstructing acoustic time: time-tuned sound. Such a sonosphere refers a) to the surrounding space and b) to the sources of sound, f. e. early music instruments.

Auralization of *Teatro Olimpico*, Vicenza

A test case for the epistemological gap which occurs between discovering the sonic dimension as new kind of historical source and its simulation is the reconstruction of the acoustic condition of Italian Renaissance theatres by auralization. This form of audio communication with the architectural past is no understanding in the hermeneutic sense, but first of all a co-original reset.

The Teatro Olimpico in Vicenza (opened in 1585) is preserved until today (even if not in the original condition) and are thus radically present (enduring) in terms of architecture to the contemporary spectator and listener. Still it is characterized by what by definition constitutes the past as archaeological site: the absence of humans - the audience which once filled the theatre in its performative meaning. The sonic retro-projection of listening subjects (receiver positions) based on impulse response measurements appropriate for auralization therefore is an additional virtual information. "Only an acoustical reconstruction of the historical conditions including the effect of the audience would give reliable evidence of the original performance conditions."³³⁴ Acoustic information derived by measurement is archaeological evidence, but only by subsequent simulation of the occupied state this information turns into a "historical" one. If such auralization is computationally folded upon a reconstruction of the original theatre which itself is a computer model, a

³³² See the media art work *Echo Rotation* by Robert Schwarz and Emad Parandian, exposed at the Ars Electronica festival in Linz, Austria, September 2009

³³³ On the "musical" tuning of ancient Greek theatre architecture, see François Canac, *L'acoustique des théâtres antiques*, Paris (Centre national de la recherche scientifique) 1967

³³⁴ Weinzierl et al. 2014

new kind of historical imagination emerges which transcends its data-archaeological source base. The epistemologically critical qualitative jump occurs exactly between the measurement of physically given spaces and the simulation of virtual sonospheres. Reverberation times for the unoccupied case of the theatres under analysis are derived from the measurement, while impressions for the occupied case are derived from the non-human, software-based simulation of human presence. Here, the differences between measuring of real conditions and simulations oscillate: empty room *versus* occupied condition (including a partial reconstruction of the historical state).

Different from historical imagination which tends to fill the lacunae in the archived sources, a disciplinary virtue of archaeology is the transparency of uncertainties. An impulse response in the *Teatro Olimpico* for a central source and receiver position can be reproduced, but the simulation reaches its limits when it comes to correctly reproduce a cluster of simultaneously arriving reflections from complexly structured surfaces which in fact make the "historical" identity of the concrete room - the individual material fingerprint.

The Teatro Olimpico integrates elements known from Roman theatre design into a large and reverberant enclosed space. From the room acoustical measurements according to ISO 3382 a remarkable conclusion can be derived:

"With reverberation times of more than two seconds and speech transmission indices (STI) close to 0.5 even for the occupied condition, modern standards of theatre acoustics with their predominant focus on speech intelligibility seem inappropriate for buildings of this period. Their acoustical properties along with their reception as documented by historical sources, instead, strongly supports the notion that theatres of the 16th and early 17th century have to be equally, if not primarily, considered as musical performance spaces. They represent the Renaissance concept of a theatre of antiquity to be reborn in buildings based on antiquity, and anticipate elements of the new genre of the opera emerging at the same historical point in time."³³⁵

The strategic link between the auralization of the Palladio theatre in Vincenza and sonic media archaeology is in its "musical" conclusion: The measurements revealed the prevalence of the musical performance part in such Renaissance auditories which were closer to the ancient concept of the theatrical choir (and Monteverdi's early forms of opera) than to the speech-focused modern theatre.

³³⁵ Stefan Weinzierl, Paolo Sanvito, Frank Schultz and Clemens Büttner, The acoustics of Renaissance theatres in Italy, forthcoming in: Acta Acustica united with Acustica 2014 (Summary)

In terms physical room acoustics, speech transmission in the Vincenza theatre - concluding from the measurement results - seems deficient, but literally sounds different taking into account the cultures of articulation and listening in its contemporary moment. Only the coupling of measurement data and its derivative simulation with the textual archive turns media-archaeological research into an historical argument. Respecting the numerous preserved reactions to the opening performance of *Edipo tiranno* in the Teatro Olimpico, all sources underline the positive overall impression of the performance space properties. "They also give evidence of the importance of the musical part of the theatrical performance" (ibid.) and its acousmatic effects, since the instrumental effects turned out from behind the stage. Whereas the the choir was acting on stage, the musical instruments were not located in the orchestra space in front of the stage, but inside the backstage scenery, providing for a soft and gentle sound. "With respect to the instrumental parts, Angelo Ingegneri, stage director of the opening performance, reports that after the curtain had fallen to the ground in front of the stage, an instrumental and vocal music, the sweetest one may imagine, and at the same time equally soft, would begin to resonate from behind the stage. It appeared as if it would resonate "from far away".³³⁶

Here the new quality of supporting evidence provided by historical records is revealed by auralization - a research method which differs from the traditional text- or score-based archive: "The duration of the purely instrumental parts is unknown, since no score is preserved" (ibid.).

Since the Teatro Olimpico stands for the idea of an ancient theatre to be literally reborn, the musical composition, with its predominant focus on text intelligibility and a subordination of instrumental parts, anticipates elements of the opera which emerged only a few years after the opening of the Olimpico such as known from Monteverdi. "That the Teatro Olimpico provided appropriate acoustical conditions for this new theatrical genre seems clearly confirmed both by contemporary reports and by the acoustical data of the current investigation" (ibid.) - thus mirroring re-enactment idea of "Renaissance" both in the macro-temporal (cultural history) and micro-temporal (auralizing) sense, short-cutting the "historical" distance.

Operative aurealization is able to "tunnel" the temporal difference which separates the present observer from the situation in the Renaissance past; a temporal *momentum* flashes which can not be grasped by macro-temporal concepts like "history" or sociological terms like "collective memory" any more, but rather constitutes a short-cut between present and past - a *resonating intervall* in terms of McLuhan who apparently got

³³⁶ Quoted in Weinzierl et al. 2014

this expression from Werner Heisenberg's quantum mechanics.³³⁷ Computer-based acoustic modelling here acts as virtual archaeology, allowing for an acoustic time travelling. Next to simulating life and physics in laboratories as practiced in nineteenth century science, the experimentalisation of the sonic past emerges. This is by no means a metaphysical assumption, but based on the most physical techno-mathematical computation.

"Re-enactment" of past sonospheres (Collingwood)

The "musical" conclusion of both case studies in the exploration of past sonospheres leads to a final re-entry of the discussion of such operations for historical sources. Even for the most critical historian, musical temporality is of a specific nature which requires precise reconstruction of historical contexts but at the same time transcends the supposed historical distance which separates the present from the Renaissance past, as expressed in R. G. Collingwood's methodological *Idea of History*: "re-enactment". The sonic sphere allows for a temporal time-tunneling in a special way since it consists of time matter itself.

The rehearsal of a musical piece from the past transcends the unique location of its score in archival time (what Walter Benjamin called "historical index"). Collingwood's notorious claim that historians have to "re-enact" the past event partly derives from his astonishment that a present performance of a musical piece composed at some earlier time can still be understood at all. This requires that the auditor performs it again in imagination. Different from historical imagination in its literal visual sense, "the *sine qua non* of writing the history of past music is to have this past music *re-enacted in the present*"³³⁸. This practice of re-presenting (well known in its technological equivalent as hardware and software replication and emulation in Retro Computing culture today) escalated in audio recording media such as the phonograph. A gramophone disc, according to Günther Stern's (*alias* Günther Anders) habilitation thesis *The musical situation* (submitted in 1929/30 but rejected by Theodor W. Adorno), does not reveal an acoustic image of the *Mondscheinsonate*, but the *Mondscheinsonate* itself³³⁹ - just like the radio does not reproduce speech and music, but actually displays them (as argued by Adorno³⁴⁰). Auralization, in a further escalation of re-

³³⁷ See Marshall McLuhan / Bruce R. Powers, *The Global Village. Transformations in World Life and Media in the 21st Century*, Oxford et al. (Oxford University Press) 1989

³³⁸ Collingwood's 1928 lecture "Outlines of a Philosophy of History", published in: R. G. Collingwood, *The Idea of History* [*1946], rev. ed. Oxford et al. (Oxford University Press) 1993, 441

³³⁹ As quoted in Reinhard Ellensohn, *Der andere Anders. Günther Anders als Musikphilosoph*, Frankfurt/M. (Peter Lang) 2008, 64

presenting the sonic past by algorithmic means, finally provides archival silence with sound.

Time-based signal processing media share with musical performances the power of generating the real-time affect of presence³⁴¹ - while at the same time undoing its transitive experience by the repeatability of any acoustic record. Sonic temporality thus turns into technical sonicity.

Challenging historicity: the "musical situation"

When artistic research deals with past musical practices, many performer-scholars consciously seek to recreate it. What actually has passed, is the unique acoustic embodiment of a musical composition in performative human variances, and the tuning of ears by musical theory. But musically (in terms of composition), there is no "historical" past at all. According to Stern's inquiry on the relation between music and historical time, when listening to music "one falls out of the world"; nonetheless, "even in this hiatus, one remains in the medium of time".³⁴² There is an a-historic *momentum* of experiencing time in listening to music (the aesthetic affect) and in experiencing presence-generating devices (chrono-phenomenological *aisthesis*): "Musikalische Zeit ist nicht geschichtliche."³⁴³ Listening to music is a non-historic form of being-in-time.

Humans, once actively coupled to a technical music instrument, are subject to its temporal *Eigenwelt*. Such a scene where humans and machines meet, in cybernetic terms, is a system.

Genuine sonic media theater, though, is a further escalation. A past musical performance is usually associated with the human performer. But there are musical performances which are rather operative for not bodily but machinic implementation. While a theatrical drama (time-ordered action) from the past can be re-enacted by humans (which is always individual performative re-interpretation), music machines do not re-interpret but re-operate, in equiprimordial repetition of the musical (symbolic) or sound (signal) event. This is, then, no historical quotation or re-call, but a time-shift of the same class of sonic event.

³⁴⁰ In: Theodor W. Adorno, *Current of Music. Elements of a Radio Theory* [1940], hg. v. Robert Hullot-Kentor, Frankfurt/M. (Suhrkamp) 2006

³⁴¹ See Hans Ulrich Gumbrecht, *Production of Presence. What meaning Cannot Convey*, Stanford, Calif. (Stanford UP) 2004

³⁴² Stern 1930, as quoted (in English translation) in: Veit Erlmann, *Reason and Resonance. A History of Modern Aurality*, New York (Zone Books) 2010, 325

³⁴³ Günther Stern, Typescript *Die musikalische Situation*, State Library Vienna, 1930/31, 46; now edited by xxx Ellensohn: xxx

Epistemogenic things: Listening to the monochord

There are epistemogenic things like the setting in a laboratory which is the *dispositif* for knowledge to emanate.³⁴⁴ In reverse, from a media-archaeological point of view, there is (technologified) knowledge materialized, embedded and implemented within operative media themselves which deserves to be extracted and derivated by explicit academic inquiry and theoretical verbalization. There is, e. g., the *phonisches Rad* as element in the otherwise optically oriented electro-mechanical image transmission Nipkow system.³⁴⁵ The electro-magnet "phonetic" wheel (inside the apparatus) is meant to synchronize the image lines here between transmitter and receiver - a kind of *tuning by resonance*. The sonic is rather implicit here (with no sound to be heard), as implicit chrono-technical sound knowledge (sonicity), while visible tuning here takes place with the stroboscopic disc (attached to the Nipkow disc) which is on the front side ("Interface") visible to the user parallel to the actual television image. The message of the medium process is *timing* here.

When Pythagoras' experiment with the monochord in the 6th century B.C. is re-enacted today, that is: when such a string is mechanically subdivided and activated, the techno-physical insight of the relation between integer numbers and harmonic ("musical") intervals which once led Greek philosophers to muse about the mathematical beauty of cosmic order in general is re-enacted. The experimenter certainly is not in the same historical situation, since the circumstances, even the ways of listening and the psycho-physical tuning of contemporary ears, is different. But still the monochord is a time-machine in a different sense: It lets the present share, participate at the original discovery of musicological knowledge, since the repeatable *is* the co-original.³⁴⁶

In the Italian rebirth of such ancient knowledge, Vincenzo Galilei undertook a number of experiments with a lute to investigate the nature of musical harmonics³⁴⁷ - a kind of media-based archaeology of the

³⁴⁴ Hans-Jörg Rheinberger, *Experimentalsysteme und epistemische Dinge*, Göttingen (Wallstein) 2001; same author, *Experiment, Differenz, Schrift. Zur Geschichte epistemischer Dinge*, Marburg (Basiliken) 1991, chap. IV "Das 'Epistemische Ding' und seine technischen Bedingungen", 67 ff.

³⁴⁵ E. g. the Nipkow-Televizor (30-line), produced by the Tratri Novakove Company in Prague, 1934, on display in the *60 Years of Television Broadcasting* special exhibition at the National Technical Museum, Prague, May-December, 2013)

³⁴⁶ Martin Heidegger, *Sein und Zeit*, xxx, 385: "Die Wiederholung ist die ausdrückliche Überlieferung, das heißt der Rückgang in die Möglichkeiten des dagewesenen Daseins."

³⁴⁷ As described in: Vincenzo Galilei, *A Special Discourse Concerning the Unison*, trans. in Claude V. Palisca, *The Florentine Camerata. Documentary Studies and Translations*, New Haven / London (Yale University Press) 1988, 203

acoustic: "Galilei employed the lute here not as a musical instrument but as a piece of laboratory equipment [...]." Once within experimentation time, it can be re-enacted. On the diagrammatical level, the re-enactment is time-invariant; on the operative level of implementation, the materiality of the medium itself seems to impose certain vetoes rooted in the historicity of the instrument, but in fact, the epistemological operation remains intact in principle (that is: *archaeologically*): Claude V. Palisca set out to replicate this experiment using a lute built in the 17th century by an unknown maker. "The present condition of the instrument required the use of some substitutions for the materials originally used by Galilei in his experiment; however, these did not affect the basic tenets of the experiment."³⁴⁸

Once human senses are coupled with a technological setting, phenomenal experience is captured within its temporal field, in an autopoietic chrono-regime with its specific dynamics (or mathematics, when data are registered digitally). Such couplings create moments of literal exception: Man is taken out of the man-made cultural world (Giambattista Vico's definition of "history") and confronts naked physics.

In Martin Heidegger's late philosophical work, the fundamental notions of *being* (Sein) and *time* (Zeit) converge in the notion of the *event* (Ereignis).³⁴⁹ In this double sense, the experiment allows a unique experience and at the same time for communication across the temporal gap (bridging a temporal distance. In the processual moment of the re-enacted experiment, one shares the same temporal *field* (a notion which implicitly refers to the episteme of electromagnetic dynamics).

Can such experimentation be extended to macro-temporal eventuality as well? Experimentation does not give access to historical experience, since past culture can not be re-enacted (except in experimental archaeology, maybe). This is the argument of historians usually applied to differentiate their hermeneutic discipline from the natural sciences. At the climax of historicism in Germany, Hermann von Helmholtz doubts the possibility of re-enacting ancient musical experience; research has to refer to its symbolic, indirect representation (so-called "history of music") instead, since direct observation and experimentation is not possible any more, and the mind which is trained in modern musical listening can not be open for previous, archaic ways of listening.³⁵⁰

ff.

³⁴⁸ Claude V. Palisca, Was Galileo's Father an Experimental Scientist?, in: Paolo Gozza (ed.), Number to Sound. The musical way to the scientific revolution, Dordrecht / Boston / London (Kluwer) 2000, 191-199 (195)

³⁴⁹ See Martin Heidegger, Beiträge zur Philosophie (Vom Ereignis), [Gesamtausgabe III. Abt. Unveröffentlichte Abhandlungen Vorträge - Gedachtes, vol. 65.], Frankfurt / M. (Klostermann), 3rd edition 2003

³⁵⁰ "Die Beziehung auf die Geschichte der Musik wird [...] auch deshalb nötig, weil wir hier Beobachtung und Experiment zur Feststellung der von uns

But with re-programmable tools of research, in the meantime, media-archaeological experimentation (simulation as opposed to historiographic historicism) gives access to the invariant elements of knowledge in time indeed: as a kind of "experimentalisation of history" by simulations, allowing to short-cut the historical distance, since ancient knowledge of music begins to become re-enacted by computing which is an implicitly "musical", algo-rhythmic technology itself.³⁵¹

BETWEEN PHYSICS AND INFORMATION: AUDIO RECORDINGS FROM THE PAST AND THEIR TEMPOR(E)ALITIES

Technical recording vs. symbolic transcription

Since the invention of the phon(aut)ograph, the analogue audio-recording media have built up a signal-based memory of sound alternative to the symbol-based archive of musical notation. A collection of wax cylinders or gramophone records is rather a "counter-archive"³⁵² of sonic memory in the sense of Henri Bergson's and Edmund Husserl's emphasis on the human form of temporal experience, which is affective rather than clock-like integration. Signal-based records constitute a different kind of memory than the alphabetical scores which constitute the traditional "audio" archive.

Long time ago, an early Greek adaptor added single symbols for vowels to the known Phoenician alphabet for the purpose of making not only the

aufgestellten Erklärungen meist nicht anwenden können, denn wir können uns, erzogen in der modernen Musik, nicht vollständig zurückversetzen in den Zustand unserer Vorfahren, die das [...] erst zu suchen hatten" Hermann von Helmholtz, Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik [*1863], Braunschweig (Vieweg) 1913, 411

³⁵¹ "Sofern im Rahmen von Medienarchäologie und Simulationstechnologie heute ganze Theorien simulierbar sind, beginnen wir beständig tunnelartige Verbindungen durch die Historie zu graben, wodurch selbst unwägbar scheinende Zusammenhänge erkennbar werden und erforschbar sind. Indem wir aber Zeitobjekte vergangener Zeiten als solche reinstanziiieren, läuft das 'Wissen von der Musik' immer mehr selbst und von selbst in Musiktechnologie." Martin Carlé, Geschenke der Musen im Streit ihrer Gehörigkeit. Die antike Musiknotation als Medium und Scheideweg der abendländischen Wissenschaft, in: MusikTheorie. Zeitschrift für Musikwissenschaft, vol. 22, no. 4 / 2007 (thematic issue "Peri mousikes epistemes". Zur Aktualität des antiken griechischen Wissens von der Musik, edited by Sebastian Klotz), 295-316 (313 f.)

³⁵² Paula Amad, Counter-Archive. Film, the Everyday, and Albert Kahn's Archives de la Planète, New York / Chichester (Columbia University Press) 2010, 153. The phonographic equivalent of Kahn's cinematographic project have been the Archives de la Parole, founded by the linguist Ferdinand Brunot in 1911 at Sorbonne University, Paris

rough content but the very musicality of oral poetry explicitly recordable. But even this advanced notation inspired by the Muses is still symbolic, like the score transcriptions which Béla Bartók provided for Milman Parry's recordings of songs by Yugoslav singers of tales on aluminium disc. What these discs were able to record, though, was not only oral poetry itself but the non-musical articulations as well. This acoustic supplement extends even to non-intentional, non-semantic evidence, such as noise or bird-singing in the background or the singer's coughing during performance - information which might be important for a realistic interpretation of the circumstantial conditions of oral poetry. Acoustic media both keep and reveal a *mémoire involontaire* of past acoustics which was never intended for tradition - a noisy memory, unaccessible for symbolic notation in the traditional sense.

Different from transcriptions into scores, technical signal-recording of musical articulation allows for the electro-physical measuring of recorded events by "sampling". This enables a non-hermeneutic analysis of cultural articulation on the sub-philological, sub-alphabetic level.

Entropical and negentropical sound memory

Analogue recording media consist of two bodies. There are two complementary approaches to the conservation of analogue audio carriers. The one cares for preserving the physical, especially chemical and electro-magnetic properties of the concrete media body - since all media technologies are hardware in the first place. The other, sometimes opposing approach is to preserve media-based memory as information, up to the extreme point of view that the material body might be abolished after its essential transcription into its pure binary information units. "We no longer collect the carriers, clay tablets, books or floppies, just the information."³⁵³ But to which degree does the archival authority of an audio record still depend in its material physical embodiment? Is it no longer important by which carrier one generation passes on its information to the next?

Soon after the emergence of photography as the oldest analogue signal-based medium in the technical sense, in 1859 Oliver Wendell Holmes pointed out the symbolic trade between information and materiality: "From now on, form is separated from material. In fact, the material in visible objects is no longer of great use, except when being used as a model from which the form is constituted. Give us a couple of negatives of an object worth seeing ... that's all we need. Then tear the object down or set it on fire if you will ... the result of this development will be [...] a

³⁵³ Tjebbe van Tijen, We no longer collect the Carrier but the Information, interviewed by Geert Lovink, in: MediaMatic 8 No 1/1994, xxx

massive collection of forms that [...] will have to be [...] placed in great libraries."³⁵⁴

Indeed, once the mechanically engraved sonic signals on material carrier (phonograph) or magnetically embedded (magnetophon) has been transformed into binary code, it can be (virtually lossless) "migrated" from one computing system to another.

Archival endurance in preserving the sonic heritage thus is not achieved in the traditional way any more (which used to be monumental fixation), but requires repetitive dynamic refreshing. In the early days of digital computing technological storage devices like the mercury delay line and the Williams Tube resembled the human memory mechanism in its predominantly "regenerative" character between the passing and the repetitive. From this derives a fundamental change in the philosophy of how to secure media-archival data for future use. In such machines, memories are dynamically permanent (no oxymoron); they are constantly refreshed so that either their ephemerality endures or random access allows for immediate change.³⁵⁵

Such repetition of the identical differs from the variable mechanism of oral tradition, such as Homer's epics across the "dark" centuries without writing. But such pre-technological variation (rather "cultural technique") itself became evident only by signal recording. Bartok comments on occasion of his transcriptions of phonographic recordings: "Folk-songs are a living material; and [...] subject to perpetual changes, preserving constancy only of certain general formulae. [...] the same poem has been recorded from different singers, in order to show what are the [...] traits depending on the individual singers, and what are the permanent ones, beyond the personality of the singer."³⁵⁶

["In musical notation, time signature denotes the basic unit of time duration in a measure of music manuscript and describes how many units constitute the measure [...] thus ordering the spacing of bar lines that in turn delineate rhythmic units" (Foster). Doch "[t]here are no time signatures in Bartók's or Erdely's transcriptions (excluding Ugljanin's gusle solo) because, presumably, the guslar's rhythmic and melodic phrasing has no precedent for those who would read the transcriptions. [...] time signature broadly suggests musical form [...]. In his transcriptions of South Slavic epic song, Bartók faced the challenge of interpreting rhythmic groupings that had no archival body of traditional (art music) reference."³⁵⁷ Even if Bartók's transcription is an accurate

³⁵⁴ Quoted from: Wolfgang Kemp, *Theorie der Fotografie I (1839–1912)*, Munich 1980, 121

³⁵⁵ Wendy Chun, xxx

³⁵⁶ Bartok op. cit.

³⁵⁷ H. Wakefield Foster, *The Role of Music*, in: "eEdition" of *The Wedding of Mustajbey's Son Bećirbey*, sung by Halil Bajgorić, edited and translated by John

notation of the performance event, "it inevitably falls short of recording every aspect of Ugljanin's art. For example, Ugljanin holds the second half of beat 3 in the third measure of the introductory gusle solo slightly longer than one half beat. Ugljanin's exclamation "Ej!" at the start of the voce part (measure 1) is longer than one beat. There is a point beyond which we fail to reproduce completely any performance event" (ibid.)]

Material media are marked by their individual degree entropy and characteristic probabilities of physical endurance. The *Eigenzeit* of physical media differs from the software-based media by embodying fundamentally different temporal regimes. Bartók optimistically commented the media memory conditions of the phonographic recordings of oral poetry made by Parry: "The records are mechanically fairly good [...]. Aluminum disks were used; this material is very durable so that one may play back the records heaven knows how often, without the slightest deterioration. Sometimes the tracks are too shallow, but copies can be made in almost limitless numbers."³⁵⁸

But physical recording media are subject to macro-temporal entropy - known as the chemical deterioration of Edison cylinders and magnetic tapes. Digitised signals at first sight resemble the tradition of music notation, but are endowed with operational activity; they are algorithmically executable. Symbolic techno-archival permanence is almost time-invariant, sublated from change, leading to ahistorical immediacy in the moment of re-play.

A Counter-Archive? Acoustic Archaeology

There is a distinctive difference between so-called "social" respectively "collective memory" of musical events and the actual media recording of sonic articulation from the past. For an archaeology of the acoustic in cultural memory the human auditory sense does not suffice. Let us, therefore, track the sonic trace with the genuine tools of technical media. One such way of "acoustic archaeology" is to play a musical partition on historic instruments. But the real archaeologists in audio archaeology are the media themselves: measuring devices which are able to de-cipher physically real signals and to represent them in forms alternative to alphabetic writing, resulting in sinusoidal articulations in time, operative diagrams such as being indicated by the oscilloscope.

Media-active archaeology can be applied to past sound, generating a different kind of audio-archive. When listening to "ancient" recordings

Miles Foley, <http://www.oraltradition.org/zbm/music>; accessed June 28, 2018

³⁵⁸ "Parry Collection of Yugoslav Folk Music. Eminent Composer, Who Is Working on It [sc. Béla Bartók], Discusses Its Significance", in: *The New York Times*, Sunday, June 28, 1942; on Website of Milman Parry Collection, Harvard University

from Edison wax cylinders, nowadays being restored with technomathematical software as digital re-production of sound, we might ask with Michel Foucault (in a slightly different context³⁵⁹): message or noise?

Today, opto-digital reading of early Edison cylinders allows for listening again to otherwise inaccessible sound recording; the opto-digital *close reading* of sound as image, though, dissolves any meaningful unit into discrete blocks, which are accessible for human analysis only by operative techno-mathematical diagrams. This is a truly analytic, media-archaeological form of deciphering the sound of the past. It requires a media-archaeologically tuned ear to make knowledgable use of that option as an alternative to the cultural emphasis on musical semantics. To the media-archaeologically sharpened mind, sonic articulation visible on a computer screen will never be confused with a "live" sound since such a mind is conscious of the algorithms of which such an animation is a technomathematical, processual function.

At that point, the archival operation extends from restauration and conservation to re-animation and thus becomes a true media-archaeological operation. In a novel called *Time Shards*, the science fiction author Gregory Benford imagines a research laboratory which reconstructs "fossil voices" out of the grooves of mediaeval pottery.

In media-active archaeology, the technological apparatus itself turns out to be the archaeologist proper. Patrick Feaster and David Giovannoni succeeded in re-sonifying phonautographic diagrams preserved from pre-Edison times, beginning with Léon-Scott's recording of a sound folk tone of 435 Hz in the year 1859. This self-referential (and auto-poietic) memory of sound technology itself is as worth to be preserved for eternity as any other more articulate cultural sound (the ethno-musical sources). With a delay of 150 years science finally realized that with optical "reading" of such acoustic signal lines sound can be algorithmically re-synthesized, and all of the sudden the children's song "Au clair de la lune, Pierrot répondit" (recorded by Léon-Scott on April 8, 1860 in Paris) resounds again.³⁶⁰

What has been metaphorically described as the pick-up of sound images by a "virtual, digital gramophone needle"³⁶¹, in fact is something media-epistemologically different, a picking-up of a completely new kind: digital sampling.

³⁵⁹ Michel Foucault, *Message ou bruit?* [*1966], in: same author., *Dits et Écrits I*, Paris 1994, 557-560

³⁶⁰ Hear <http://www.firstsounds.org/sounds/1860-Scott-Au-Claire-de-la-Lune-09-08.mp3>

³⁶¹ Harald Haack, *Die erste Klangaufzeichnung. Eine Audiografie*, *online* <http://newsbattery.blogspot.de/2008/05/07/die-erste-klangaufzeichnung-eine-audiografie>

As the primary scene of sonic media memory, almost immediately after its invention, the Edison phonograph was announced in the journal *Scientific American*. It obviously triggered phono-archival phantasms (in the Romantic tradition of the historian of the French Revolution Jules Michelet, who in early Nineteenth century believed to hear the murmurs of the dead in the archives), as a true *Lautarchiv*: "That the voices of those who departed before the invention of the wonderful apparatus [...] are for ever stilled is too obvious a truth; but whoever has spoken or whoever may speak into the mouthpiece of the phonograph, and whose words are recorded by it, has the assurance that his speech may be reproduced audibly in his own tones long after he himself has turned to dust. [...] A strip of indented paper travels through a little machine, the sounds of the latter are magnified, and our great grandchildren or posterity centuries hence hear us as plainly as if we were present."³⁶²

Natural language is evasive, liquid, in itself unrecordable beyond the bodily range, but technical media (different from alphabetic phonetic writing which "freezes" the human voice into a range of a very limited symbolic code) are able to de-freeze recorded voices in almost all frequencies by re-play. After two millennia of supremacy of the phonetic alphabet there are new kinds of cultural technology in sound recording.

There is a record in the Vienna Phonograph Archive of emperor Franz Joseph I of Austria-Hungary written deep into the wax cylinder (a recording from Bad Ischl, 2nd August 1903). At this point, you probably expect me to play this recording. There is a reason why I don't, since I want to prove that sound recording has already developed a true media memory which differs from the remembrance of its content. The experiment is very simple: Please imagine yourself the phonographic recording of His Majesty's voice. I am sure that whatever you think the timbre of his voice sounds, you will acoustically hallucinate as well the scratching, the noise of the recording apparatus.

True media archaeology starts here: The phonograph as media artefact does not only preserve the memory of cultural semantics but stores its own past *technical* knowledge as well, a kind of frozen media memory embodied in engineering and waiting to be listened to by media-archaeologically tuned ears.

One step further in the experiment, emperor Franz Joseph's actual statement can be quoted. Significantly, this statement - which is one of the first voice recordings preserved at all - turns out to be the pure

³⁶² Anon. (The Editor), A Wonderful Invention - Speech Capable of Indefinite Repetition from Automatic Records, in: *Scientific American*, November 17, 1877, 304. See chapter 6 "A Resonant Tomb", in: Jonathan Sterne, *The Audible Past. Cultural Origins of Sound Reproduction*, Durham / London (Duke University Press) 2003, 287-334 (297 f.)

message of the medium. When a new technical medium emerges humans are very aware of its technicality (which afterwards, when it becomes mass media, tends to be forgotten in favor of so-called "content"). The emperor expresses his joy to literally "incorporate" his voice into the Vienna phonograph archive.³⁶³ Indeed we are able, today, to listen to human voices which exterminated hundred years ago, by applying laser reading of the wax cylinders which do not destroy its source in the act of re-play. But once more, what we hear is not only the message (the emperor's enunciation) but as well noise (the phonographic scratch). That is what the medium tells us. The noise of the wax cylinder itself which the record articulates whenever it is being re-played is not discursive (cultural) but media-archaeological information of the physically real event. Let us listen to this attentively and not exclude it hermetically like in the proverbial Cocktail party effect of auditory communication between humans.

With the micro-physical *close reading* of sound, the materiality of the recording medium itself becomes archivally productive. Complementary to musicological hermeneutics the media-archaeological ear listens to the poietics of signals.

Different from passive symbolic writing systems like the phonetic alphabet which still require the human mind and imagination to become "alive", the power of signal-based technical media lies in their ability to actively (re-)create real presence. Let us quote once more from Bartók's comment on his transcriptions of recordings of Yugoslav oral poetry from the 1930s: "It gives you a thrilling impression of liveliness, of life itself" <op. cit.>.

Media as active archaeologists

All of the sudden, audio recordings are not just archival objects any more, but media decoders become active archaeologists of past sounds themselves.

The frozen voices on the analogue, vulnerable storage medium of wax cylinders are currently being de-frozen by digital means. The Berlin Society for Applied Informatics has developed a method to gain acoustic signals from negative traces of galvano-copies from Edison-cylinders by opto-endoscopic „reading“ - scanning visual information into sound.³⁶⁴ Making stored acoustic waves actually sound does not demand rhetoric

³⁶³ "Es hat mit sehr gefreut, auf Wunsch der Akademie der Wissenschaften meine Stimme in den Apparat hineinzusprechen und dieselbe dadurch der Sammlung einzuverleiben."

³⁶⁴ See Gerd Stanke / Thomas Kessler, in: Artur Simon (ed.), Das Berliner Phonogramm-Archiv 1900-2000. Sammlungen der traditionellen Musik der Welt, Berlin (VWB) 2000, 209-215

imagination but on the contrary a hermeneutically distant ear, an exteriority of interpretation which only the *aisthesis* of the opto-technical scanner can provide.³⁶⁵ Technical media provide a different option of reading: listening without (premature) understanding. The archaeological ear tries to mimick this ascetic confrontation of signals, resisting the narrative temptations.

With the media mystery of the recordability of the physically real of sound and images, humans get a multi-media mirror effect (in Lacan's sense), blurring the clear-cut difference between presence and absence, present and past. It is possible, today, to listen to music-ethnographical play-backs in almost exactly the same quality as the natives once experienced in the past. Only the media-archaeological operation of opto-digital reading of the inscribed traces makes the otherwise unaccessible sound recording audible again. One can see a spectrographic analysis of an ancient music recording - a straight look into the sonic archive.³⁶⁶

³⁶⁵ See Jeffrey Sconce, The voice from the void. Wireless, modernity and the distant dead, in: International journal of Cultural studies, vol. 1, no. 2 (1998), 211-232

³⁶⁶ Spectrogram of a digitally reconstructed recording of Wedda songs from Ceylon 1907 on <http://www.gfai.de/projekte/spubito/index.htm>