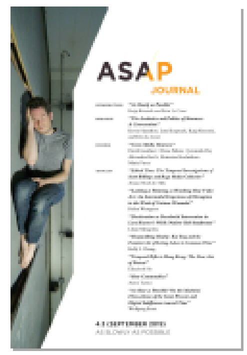
As Slow as Possible? On the Machinic (Non-)Sense of the Sonic Present and Digital Indifference toward Time



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ASAP/Journal, Volume 4, Number 3, September 2019, pp. 671-688 (Article)

Published by Johns Hopkins University Press
DOI: https://doi.org/10.1353/asa.2019.0044

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AS SLOW AS POSSIBLE?

ON THE MACHINIC (NON-)SENSE OF THE SONIC PRESENT AND DIGITAL INDIFFERENCE TOWARD TIME

INTRODUCING TEMPOR(E)AL SONICITY

To unthink time is impossible for human intuition, but it can nonetheless be achieved by switching to the technomathematical perspective of machines. Ontological reflection on time has long been a central domain of philosophy, art, and poetry in cultural history. But once the discursive vocabulary of time is replaced by corresponding technical terms, the totalizing terms of this cultural history implode into a delicate multitude of differential operations. In this regard, contemporary appeals to slowness in the arts may productively be replaced by technomathematical termini technici such as the delta-t for signal delay, where even storage media have less to do with temporal endurance than with suspended channels of coded transmission.

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ASAP/Journal, Vol. 4.3 (2019): 671-688

From the media-archaeological point of view (in contrast to phenomenology), electronic media posit a quantitative rather than affective difference between the kinds of timescales that appeal to the inner time consciousness of humans, such as "slow" or "fast." In terms of Digital Signal Processing, a high or low tone is not primarily processed in temporal terms as wave form but according to numerical frequencies. Slowness thus becomes purely a metaphor when applied to the technological sense of time. Joseph Fourier's implicitly "sonic" analysis of vibrational events in his 1822 Théorie analytique de la chaleur (The Analytical Theory of Heat) *made the temporality of world-signals symbolically calculable that, in cold calculation, allows for electroacoustic manipulation. In the computation of sound, what appears as "time," stretching to human perception, is nothing else but the discrete operations of numbers.*

THE SLOWNESS OF ACOUSTIC SIGNALS AND THE AURAL SENSE OF TIME

The privileged human sense for time-critical perception is binaural hearing, where interaural differences arise because of the relatively slow signal propagation of sound through the air; a microtemporal interval arises from the different moments a stimulus arrives at one ear and then at the other. The slow signal run time of acoustic waves even led to the reversal of the cause-effect relation of combat noise in technological warfare—reversed time. When in World War II a German A4 rocket hit London, the acoustic articulation of its approach already lagged behind the destructive event itself. No longer was danger announced in advance; the sonic barrier had been broken.

Sound as mechanical vibration *is* slow a priori compared to visual presence, which is based on a higher frequency of electromagnetic waves. The speed of light results in an almost immediate live signal transmission, whereas acoustic sensation—based on a slower run time in mechanically elastic matter—becomes recognizable as a time-event. From that slowness, the phenomenal sense of time arises. A machine, though, has no inherent understanding of sound, which is a phenomenological category only for animals. An operative digital mechanism only knows implicitly sonic timing to the extent that it consists

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of rhythms, pulses, and numerical frequencies, just as analog recording media "know" time signals.

UNDERSTANDING SLOWNESS: HARMONICAL ANALYSIS AND THE LIMITS OF THE ORGAN

A recording medium registers movement with indifference. For example, Louis Daguerre's early long-time exposure photography of Boulevard du Temple in Paris resulted in an almost humanless scene, and Hiroshi Sugimoto's long-time exposure photographies of movies resulted in the pure white noise of the theater screen. A less phenomenal but more technoepistemic form of slowing down sound is its mathematical analysis, where the focus is not on musical content of sound as a cultural aesthetic form, but rather on its medium message as a time signal. In the mathematical field of Harmonic Analysis, complicated periodic motions can be reduced to sums of simple oscillations, which can be characterized either according to frequency (which makes them numerically computable) or according to duration in time. In this way, the transcendent category of "time" itself can be replaced by the analytic knowledge of processual being or events.

The acronym of the Association for the Study of the Arts of the Present, ASAP, may play on the bureaucratic idiom "as soon as possible," yet it can also be recast to signify "as *slow* as possible." But what if a tonal pitch itself can itself be radically slowed down, replacing the temporal endurance of a soundwave with the attenuation of its waveform, that is, by decreasing its frequency: as (s)low as possible, in accordance with Karlheinz Stockhausen's tonal analysis entitled "As time goes by . . ."?[1] Like Douglas Gordon's almost chronophotographic slowing-down of Alfred Hitchcock's film *Psycho* to twenty-four hours, showing two frames per second (1993), only in extremely slow frequency does the pulsed, and therefore computable character, of sound become audible, which also becomes apparent in the lowest reed of an organ, when the ear can indeed hear the reed open and close the shallot sixteen times per second.[2]

Indeed, the lowest reed pipe of an organ sounds to the ear like a pulse sequence—telegraphy rather than telephony—with no perceptional transformation into the impression of a pure tone. With an organ, there are mechanical limits of playing a piece "as fast as possible," since a pipe needs time to articulate. Different from musical abstraction in symbolic notation, in sonic media articulation (be it mechanical, electronic, or computational) the time signal matters. As P. R. Masani explains, with a "quarter note (lasting 1/8th of a second) to be played on some instrument, at the very low frequency of 5 oscillations per second, not even one oscillation will be completed, and the air will be pushed, not set into vibration."[3] Referring to lively pieces of music where the notes are of short duration, Norbert Wiener created a thought experiment: "A fast jig on the lowest register of an organ is in fact not so much bad music but no music at all."[4] The technical medium, on the contrary, is never lost in the illusion of a continuous tone, but always understands it for what it physically is: a sequence of repetitive signals between pulse and waveform. John Cage accepted this as "music."

AS SLOW AS POSSIBLE / ORGAN^2/ASLSP (CAGE)

The concept of implicit sonicity does not refer to the acoustic *content* of sounding matter or other vibrational events but to its medium *massage*, which is its temporal form, as, becomes evident in Wiener's interpretation of the organ tone. Slowing down high-frequency to low-frequency oscillations is not simply a matter of decelerating musical time perception but a radical transformation into the numerical regime of data: an organ tone with low frequency dissolves into discrete pulses at around 16 Hz. Thus, when John Cage composed a musical piece for the organ (originally written for piano in 1985) called *ORGAN^2/ASLSP*, the acronym ambivalently expresses not only the durational threshold "as

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slow as possible" (the usual reading), but in a counterreading, the sonic threshold "as low as possible" as well.

In its installation at the St. Burchardi church in Halberstadt, Cage's composition is meant to last from the year 2001 (when it started) to the year 2640. Does a musical performance have a sense of its own ending? Cage's composition *ORGAN²/ ASLSP*, in its four-page score notation, is itself timeless since it is encoded into the symbolical regime from which, in whatever moment or location, the sonic event can be (re)produced as co-originary. This musical score is usually interpreted as a duration of single tones or chords on an enduring, equally sustained pitch (the violin key provides for the standard chamber pitch "A"). Cage's score notation, just as its adaptation for the Halberstadt installation, remains symbolic, but the extended bars indicating the almost Bergsonian *durée* of single notes rather reminds one of a kymographic registration of the real time signal.[5]

Within the experience of actual interpretations of Cage's *ASLSP* for piano (1985) and *ORGAN²/ASLSP* (1987), the question arose of how long is "as long

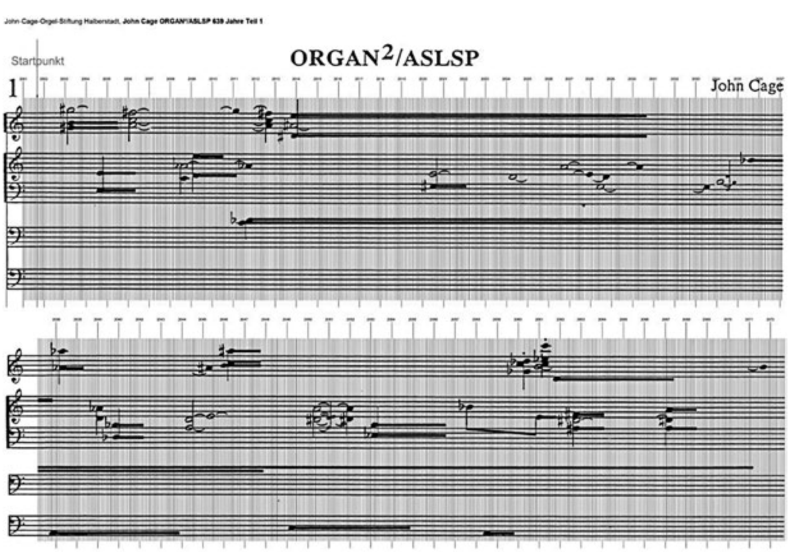

Figure 1.
The opening of the score of John Cage's composition ORGAN²/ASLSP*, Part I, including the timeline for the 639-year Halberstadt installation. Printed with permission from the John Cage Organ Foundation Halberstadt.*

as possible" for organs. The ensuing debates revolved around the decisive—in fact time-critical—question of "what would be the most convincing criterion for calculating the duration of *ORGAN²/ASLSP*," which, in the end, is most certainly the lifetime of the machine itself.[6] While the sound of a piano stroke decays, the sound of the organ can be sustained as long as desired. A performance lasting several hundred years transcends human experience of time—which is a true media-time perspective, a media-archaeological chronopoetics. In an autobiographic lecture, Cage once professed his intention that such an oeuvre will transform into a nonpersonal event suspended from both the composer (Cage) and the individual organists. The lifespan of a single organist, by extending the rehearsal to 639 years, by necessity is replaced by the expected life span of an organ as technical *organon*. Cage's notation of *ORGAN²/ASLSP* is not necessarily addressed to human time consciousness at all, but rather to the machinic non-sense of time.

This machinic address corresponds with the traditionally human-performed bellow action providing the air pressure for an organ pipe to generate tones at all, which has in fact long since been replaced by an electric motor, delegating the human energy agency to the precision of an alternating current from the electric network (which, by its 50 Hz frequency, articulates implicit sonicity itself, independently of the Cage organ composition operated upon it). The enduring organ tone is isomorphic, with technical sounds emanating from synthesizers and loudspeakers. Electroacoustic circuitry like the Theremin fundamentally transformed the temporality of Western music. Sound from technical oscillators does not disperse like the natural tone of analog instruments and worldly phenomena, but persists in its repetition, as long as the circuitry compensates for the loss of energy. Such aionic time differs from the kairotic time-criticality of the key attack at any tone change event. Every tone will be enduring for years but will be ending; this ending, though, cannot be experienced within human time life spans and thus appears eternal. The sonic drone at work in the St. Burchardi church installation since 2001 is a way to make *sublime time* audible.

While the ideal sine tone extends from infinity (past) into infinity (future)— an *aevum* in terms of medieval scholasticism—its embodiment in the real world can only be an approximation, an enduring intonation "as long as possible." The St. Burchardi *ASLSP* organ installation actually addresses the dilemma of the Fourier Analysis, modeling its hypothesis of an ideally eternal periodicity of tone oscillations, while any actual embodiment by mechanical or electronic instruments is subject to nonlinear distortions. Any transient key attack actually, even if abruptly, evolves and disappears in time. An organ needs a key as a relay or switch to trigger the air pressure impulse; because of this, the transient momentum of a time-critical control can be combined with a principally endless duration. Any event (narratively defined by a beginning and ending) unfolds temporally, while an endless oscillation is timeless, a transformation of temporality into a mathematical pattern.

“ ***Any event (narratively defined by a beginning and ending) unfolds temporally, while an endless oscillation is timeless, a transformation of temporality into a mathematical pattern.*** ”

Every tone change in the Halberstadt organ installation is abrupt; the keystrokes are not slowed down in themselves. There is an inherent paradox in the tone changes of a performance extended to 639 years:

> Anyone who is present for a sound change in the Burchardi church is confronted with the fleetingness of the moment when a pipe falls silent or with the sudden entrance of a new tone. On August 5, 2011, two deep tones entered with this kind of suddenness. But these tones will resound for so long that they will have exceeded the lifespan of many of those present at this sound change when they fall silent again.[7]

A periodic waveform can be addressed as numerical data by converting (sampling) the signal from the time domain into the frequency domain, which amounts to a calculation reembodied by digital pulse processing; this is the very clock time that both Henri Bergson and Martin Heidegger criticized for missing the durational essence of phenomenological time. Seen under a time lens, any sound is repetitive already: the periodic repetition of its waveforms is what makes the signal endure. The enduring organ tone approximates Fourier Analysis since it is ideally "timeless." In his 1822 publication, Fourier insists that his mathematical decomposition of a complex vibration into its single sine waves is mighty enough to describe not only slowly varying processes like temperature but extremely volatile phenomena such as sound. Fourier Analysis discovers the eternal in the most ephemeral (whereas the temporeal takes revenge with transient signals arising from any physical implementation).

Philip Glass's minimalistic music compositions for piano or organ, with their slightly varying rhythmic cycles embedded in seemingly static harmonic structures, provide the listener with a heightened sense of time. Instead of long developmental sections, progression is achieved through the increasingly complex repetitions and overlapping lines, as a transgression from time-based art forms (music, dance, theater, literature) to time-basing media arts.[8] Another minimalist musical style

> emphasizes the use of sustained or repeated sounds, notes, or tone clusters—called drones. It is typically characterized by lengthy audio programs with relatively slight harmonic variations throughout each piece. La Monte Young, one of its 1960s originators, defined it in 2000 as "the sustained tone branch of minimalism."[9]

CLOCKING

The reverberant room acoustics of a cathedral already reveals the inherent *delta-t* in acoustics. A sound never disappears completely; even the originary big bang in universal time can faintly be traced by the ultrasensitive measuring technologies of gravitational wave tracing in Fourier Analysis. Such reverberations are currently being sonified by physicist Karsten Danzmann, thereby turning the big bang from an acoustic metaphor into a discrete set of sensible perceptions. Under the programmatic title *Beholding the Big Bang* (2009), Arthur Ganson has constructed a timekeeping mechanism that starts with 200 cycles of an indented wheel per minute; this movement is successively translated and slowed down by successive wheels. The last wheel, though, which will be addressed only in thousands of years, is immutable, closely embedded in a concrete block.[10] Does the first wheel, through its very material embedding in the whole system, have a *dissipative* sense of the ending from the beginning?

“*A sound never disappears completely; even the originary big bang in universal time can faintly be traced by the ultrasensitive measuring technologies of gravitational wave tracing in Fourier Analysis.*”

In his *Syntagma Musicum* (1614–1620), organist Michael Praetorius related the symbolic order of the length of notes to the mechanical beat of the wheeled clock.[11] Volume II of his work, *De Organographia* (1619), illustrates the first Halberstadt (dome) organ introducing the twelve-tone octave key manual from 1361. From that year derives the calculus for the time-reversed extension of the Cage composition from 2000 onward. With the metronome of Johann Nepomuk Maelzel (Vienna, 1814), musical beat found its own medium, setting the terms by which the micro-time of physical acoustics would later become comprehensible through electrotechnical measurement, "the necessary greater exactness [of which] is obtained by the electric current itself."[12]

Mechanical timekeeping is slowed down by friction: the moment of contact between the suspended pendulum and the actual clockwork. Damping of the clockwork signals (like in any mechanical vibration) occurs unless they are negentropically kept constant by negative feedback circuitry. There is always a loss of energy in oscillations. This *momentum* asks for description "in strictly thermodynamic terms, as a dissipative system."[13] Only since Huygens, "[t]hrough isochronic oscillation[,] the pendulum can exist as the autonomous embodiment of natural or physical time."[14] The motions of the pendulum and the moments of its contact with the escapement build "a cycle which converts potential energy to kinetic energy, and energy to information."[15] In information theory, the thermodynamic, physical, one-directional time arrow (Boltzmann entropy) is matched by entropy as mathematical measure of information value (Shannon entropy[16]), which affects musical aesthetics as well.[17]

There is a decisive difference between Cage's first composition of *ASLSP* for piano as percussion instrument (1985), where the duration of a single chord stroke is limited by the vibrational force (volatile, with "sense of ending"), and the 1987 organ composition. The mechanism of an organ as aerophone allows for principal duration as long as there is air pressure—which makes the organ isomorphous to the electroacoustic synthesizer. Its duration in the St. Burchardi church stands for a chronopoetic cultural shift of emphasis from human time experience to media tempor(e)ality, an incommensurability between the technophysical event and its phenomenological experience.

In Cage's composition *ORGAN²/ASLSP*, every tone change counts as an "event," even if there is no inner human time consciousness required to integrate a sequence of discrete tonal steps into the sensation of a temporal musical horizon called "melody" by re- and protention.[18] It simply exceeds the human perceptional time-window of "the present." Why not turn the idea upside down and let an automatic player organ stepwise unfold the tone sequences, with a start/stop mechanism as an interface prepositioned to the actual St. Burchardi organ? Such a sequence, like any algorithm, "beats" time itself.

A typical performance of Cage's piano version from 1985 lasts between twenty and seventy minutes; no two human performances would be the same in their temporal interpretation—which makes all the difference to musical automata like the Welte Mignon Player Piano, with its technical recording and replay mechanism in which the external time basis is indicated chronometrically. Conlon Nancarrow's punched-card-based compositions in *Studies for Player Piano* allow for such inhuman timing and unfolding of musical sequences in time, mechanically endlessly extensible (at least in principle).[19]

SONIFICATION OF/AS TIME: *AION*, RESONANCE, DRONES, MINIMAL MUSIC

Radioactive waste is physically treated in terms of half-lives, that is, a slow decay of energetic states. Jacob Kirkegaard's audiovisual installation *Aion* took place in the abandoned rooms of a nuclear reactor area, unfolding the sublime temporality inside the Exclusion Zone in Chernobyl, Ukraine.[20] The sound of each room was evoked by a method derived from Alvin Lucier's seminal magnetophonic installation *I am sitting in a room* from 1970, in which the artist recorded his voice and repeatedly played the recording back in the space in which it was recorded. In his October 2005 installation, Kierkegaard recorded each room of the Chernobyl site, first making a recording of ten minutes and then playing the recording back into the room, recording it again. As he explained, "This process was repeated up to ten times. As the layers got denser, each room slowly unfolded its own unique drone of various resonant frequencies."[21] When, decades after the Chernobyl nuclear disaster event, Kirkegaard explored the phenomenon of radiation, this was a sonification of the temporal sublime itself, "recording, mirroring and layering the silence of four radiating spaces he aims to unlock a fragment of the time existing inside the zone."[22] Sound is not only the sonification of time, but is also its coming into existence as waveforms, or as repetitive discrete pulse events.

For the visual component of Kirkegaard's experiment, in turn,

> two of the four rooms employ a recording technique parallel to the sonic layering. A video camera was placed on one particular spot in the

> space and it recorded nonstop from there. This recording was then projected and recorded with another camera time and time again. In this process, some of the rooms turned darker, others turned brighter—they reveal themselves on the screen, they dissolve into white light or they disappear into darkness.[23]

The affordances of electromagnetic recording induce aesthetic and epistemological experimentations with time. If the present is mirrored by itself, as in Dan Graham's closed-circuit video installation, *Present Continuous Past(s)* (1974), the delay in the circuit (a delay of fully eight seconds) results in an irritation of the present.

ELECTROACOUSTIC TIME-STRETCHING/-COMPRESSION

When reverberative sonic feedback and its technical re-recording is accelerated, it becomes a *drone*, with the resonant circuit within a radio being its purest form. In terms of implicit sonicity, the physics of a broadcast is a type of drone.[24] Drone sonicity suspends time through its iterative structure, as a transformation of sonic temporality into space. Electroacoustic time-stretching software allows an adjustment of the timeline in a metric grid in terms of temporal scale—be it hours, minutes, seconds, musical bars, or frames per scene. Such a functional timeline, "zooming in and out, from the microsonic field of the sample to the macrosonic domain of a whole project, provides a frame for possible sonic shapes to be sculpted in time."[25]

In the realm of technomathematical discrete time sampling, durational time ironically emerges out of the most discrete microtemporal segmentation.[26] Once tones within the signal-time domain have been computationally sampled, they do not exist in time at all any more, but rather in its reversal, that is, in the frequency domain. This domain makes tones accessible to numeric algorithms, that is, chronopoetic tools instead of an a priori called "time." Different from Cage's time-stretched organ installation at Halberstadt, such tools enable the "sculpting in time" that Goodman describes.

Dynamic time-warping (DTW) is, for instance, an algorithm that measures similarities between two temporal sequences, in video, audio, or graphics data; any linear time series that can be turned into a discrete data can thereby be computationally manipulated. It is a partial time-shape matching application.[27]

The Ableton Live sound editing software allows for rhythm manipulation. When a rhythm is played by a real drummer, this beat feels human exactly by not being always just in time. In order to layer other rhythms of clips with the present one, Warp Markers allow a bringing of various loops into sync with one another. In reverse, alternative software allows a rehumanizing of electronic drum machines—remediatizing algorithmic music with rhythm.[28]

VERY LOW FREQUENCIES: FROZEN VOICES, FROZEN VIBRATIONS

The functional slowing-down of technical signal processing, even the freezing of the moment, is in alliance with the media-archaeological ambition for the close analysis of temporal momentum. In its incubation phase, photography demanded long-time exposure, which made architecture, fossils, and sculptures its favorite objects. Photography ignored animal motion until, thanks to new chemical means for registering light impressions more quickly (gelatin), the "eternity" of static historical objects escalated into the proverbial photographic "click" that turned photographic timing upside down. Even before Étienne-Jules Marey's and Eadweard Muybridge's chronophotography as a technosymbolic measurement of movement, wherein time is a function of the technical operations of counting (in Aristotle's definition, time comes into existence *only* by counting), photography has essentially always already been chronophotography.

Ernst Florens Chladni, in his *Akustik*, published around 1802, made visible the *Klangfiguren*—literally "sound figures," the nodal patterns of sound vibrations—by freezing them in print. Slowing down a high-frequency technical process that is not immediately accessible to the human senses, Chladni's figures yielded a truly process-oriented ontology. In the mid-nineteenth century, Édouard-Léon Scott de Martinville created his phonautograms as slowed-down graphic inscription of speech, in order to enable a close—albeit at the time purely visual—analysis of the signal-event. In media-archaeological aesthetics, for the *analytic* purpose of close reading technical processuality involves monumentalizing the signal, slowing it down, even freezing it. In ancient Greek music theory, Aristoxenus (in his fragment on *Rhythm*) coined the term *chronoi* ("times") in the plural, for rhythmic prosodic articulations in micro-time. All kinds of rhythms and tempor(e)alities unfold as chronopoetics from within the machine. There are oscillations that cannot be received by the human ears, but which rather represent the implicit sonicity of technical timings. Beyond (or beneath) the acoustic content of a sound event, the real message of such processuality is its time-figurality.

In science fiction, Rudolf Raspe's *Baron Münchausen's Narrative of his Marvellous Travels and Campaigns in Russia* tells of the thawing-out of frozen trumpet signals (which are the physical vibrations of a medium), which had literally been frozen during the winter like icy waves on the shore. They defrost in a warm oven and once again become sound: sonic time in latent form.[29] The signal structure of unfreezing is the sinusoidal wave: the *tide*. "Tide" links to the epistemology of the term "time" itself. In chapter four (on unfreezing the captured vibrations) of François Rabelais's *Gargantua et Pantagruel* (1532), a boatsman tells of a frozen lake where the noise and cries of a battle have crystallized in the icy air, waiting to be released in the warmth of springtime—a fictitious, though plausible, anticipation of phonographic sound recording and replay.[30]

In media archives around the globe, celluloid film reels are frozen in order to withstand time. It takes around twelve hours to dehydrate film material for archival preservation and storage before it can be viewed in a nondestructive way. The archive here is not a metaphor for an icy memory, but serves instead as the very apparatus of "cold" media memory. Freezing slows down entropic degradation. Among his other analytical engines Charles Babbage, in his *Ninth Bridgewater Treatise* (1837), considers the air as a "vast library" of every vibration ever articulated, a superimposition of sine waves in eternity; like Münchausen's unfreezing process, moreover, Babbage's ideas about the possibility of archiving implicit sonicity presume that those waveforms can actually be retraced (just as Patrick Feaster achieved it for "lost sound").[31] But whereas the Fourier Analysis of heat waves (a computational process conceived in tandem with Babbage's work) ideally presupposes timeless signals, in reality (that is: implemented within physical/technical matter), oscillations are subject to increasing decay; they "die away . . . for which reason they are called transient."[32]

> ***"Electronic media can clearly analyze what, to humans, appears like a continuous tone, by isolating it as a single wave or pulse. It is the beat or the oscillation that generates what is metaphorically called 'time.'"***

With an ultra-slow turntable on a record player, the pickup no longer reveals the recorded sound but rather the granularity of the recording medium itself, such as shellac. The noise of the apparatus becomes audible when signal processing slows down. Imagine playing the phonographic record Martin Heidegger refers to in his speech *Die Kunst und der Raum* at St. Gallen: as the record starts to spin on the turntable, infrasonic vibrations become unfrozen, accelerating to uncanny articulations until a deep recognizable voice slowly emerges from one and the same signal storage medium.

The elementary unit of a technological being-in-time is the time-varying signal. A phonographically recorded acoustic signal, when not in motion, is not in its signal state but frozen in a state of graphic storage. It becomes an operative media diagram only when turned back into a time object once again, un-frozen and transduced by the movement of the apparatus and the sonic pickup.[33] The phonographic record waits for the mechanical player to unfreeze its signals in a technological act of represencing.

The human optical sense perceives only a fraction ("light") of the electromagnetic spectrum, while highly sensitive technical instruments extend human capabilities and detect radiation across the entire spectrum, from gamma to radio waves. Electromagnetic temporal beings occur in the ionosphere (indirectly audible by shortwave radio) as well as in cosmic background radiation. Electromagnetic events (such as light) occur at regular intervals millions of times; "but what if they repeat merely 10 times, five times, or only once? Identification of the defining limit cycle is elusive with so few cycles."[34] Bergson explains that one does not have sufficient capacity to retain at once the 400,000 million vibrations per second of the electromagnetic field, which defines (roughly) the chromatic band of the color red. "[O]ne could take the case of a sound-vibration too, simply it is less impressive."[35] If one is condemned to capture only one vibration at once, it will take 25,000 years (about) to register red. And of course, this won't "look red," but be 400,000 million simple shocks. "This is the case, says Bergson, for the 'pure' material point" on which radically nonphenomenological media archaeology insists.[36]

Vibrational matter is analyzable into its parameters: amplitude, period, frequency, duration, and resonance, which are all technical terms substituting the imprecise transcendent signifier "time." Repetition is a challenge to time since it both affirms and questions this dimension. While research on global climate change, for instance, is based on long-term temperature fluctuations measured over time, meteorology aims at short-term predictions, which in a memoryless, almost ergodic, atmosphere is a challenge for discrete hydrodynamic computation. The technomathematical answer to this challenge is the Fast Fourier Transform (FFT), an algorithm that computes how temporal sequences can change from the time domain (continuous "temperature") to the frequency domain (discontinuous data "clouds").

FOR DIGITAL MACHINES THERE IS NO "TIME"

A machine has no "sensation" of acoustic tone in the phenomenal sense, as defined by Hermann von Helmholtz in 1863; but it does have a clear comprehension of sonicity as the activity of periodic waveforms or pulse trains.[37] Electronic media can clearly analyze what, to humans, appears like a continuous tone, by isolating it as a single wave or pulse. It is the beat or the oscillation that generates what is metaphorically called "time." The technological recourse to live (for analog media) and realtime (for digital media) signal transmission has become a metaphor for the speed of transfer that accelerates discourses, people, and financial trading. Whereas digital data transmission is much too fast to be perceivable directly to human senses, the archaic telegraph's "dots and dashes," when connected to an acoustic mechanism, serve as a way of sonifying the nature of coded signal transmission.

What if there is not even multilayered temporalities, but no more time at all? The situation escalated with Shannon's technomathematical definition of information, which is—more than ever—the enduring foundation of digital media communication today. In principle (*en arché*), the "bit" is timeless in its lossless reproducibility and calculability. More than this, binary computation even generates new epistemic time-objects, like ergodic time, Markov chains, and Wiener's poetic expression of a "time of non-reality" for the switching interval between two alternating voltage states: a very tempo*r(e)al*, in Lacan's sense. For digital machines, there is no sense of time; the finite automaton and the Turing machine, for instance, only know discrete

"
What if there is not even multilayered temporalities, but no more time at all?
"

states. There is no slowness, but high-frequency, time-critical data processing within the microchips. The very term "realtime" is purely functional in the sense of just-in-time processing, deconstructing the human impression of a temporal window called "the present" itself.

Notes

[1] Karlheinz Stockhausen, ". . . wie die Zeit vergeht . . . ," *Die Reihe. Information über serielle Musik* no. 3 (1957): 13–42.

[2] Special thanks to Hans Fidom for discussing with the author the low-frequency events that occur in organs.

[3] Pesi R. Masani, *Norbert Wiener, 1894–1964* (Basel, Switzerland: Birkhäuser, 1990), 116.

[4] Norbert Wiener, *I Am a Mathematician: The Later Life of a Prodigy* (Garden City, NY: Doubleday, 1956), 106.

[5] Jules-Étienne Marey, in his *Méthode graphique*, had already compared his graphic method to musical notation. See Jules-Étienne Marey, *La Méthode graphique dans les sciences expérimentales* (Paris, 1868), https://archive.org/details/lamthodegraphiq00maregoog/page/n10.

[6] Christoph Bossert, *What Prompted the Halberstadt John Cage Organ Project?* (2013), 53. Brochure accompanying *(JC{639})*, directed by Sabine Groschup (2012), DVD.

[7] Ibid., 57.

[8] Christopher Bowers-Broadbent's brochure accompanying *Philip Glass, Music for Organ*, composed by Christopher Bowers-Broadbent and Philip Glass, performed by Kevin Bowyer, Nimbus Records NI 5664, UK, 2001, compact disc.

[9] "Drone Music," *Wikipedia*, accessed July 1, 2010, http://en.wikipedia.org/wiki/Drone_music.

[10] See *Labyrinth :: Freiheit* (Bozen, Italy: Athesia Verlagsanstalt, 2009), 128. Published in conjunction with the exhibition of the same name, shown at Festung Franzensfeste, Italy.

[11] See Grete Wehmeyer, *Prestississimo. Die Wiederentdeckung der Langsamkeit in der Musik* (Hamburg, Germany: Kellner, 1989), 15.

[12] Hermann von Helmholtz, *On the Sensations of Tone as a Physiological Basis for the Theory of Music* (1863; Whitefish, MT: Kessinger, 2005), 398.

[13] Adrian Mackenzie, "The Technicity of Time. From 1.00 oscillations/sec. to 9,192,631,770 Hz," *Time & Society* 10, nos. 2–3 (2001): 255. Mackenzie refers to Stengers and Gil.

[14] Ibid., 244.

[15] Ibid.

[16] Horst Völz, *Grundlagen und Inhalte der vier Varianten von Information. Wie die Information entstand und welche Arten es gibt* (Wiesbaden, Germany: Springer Vieweg, 2014).

[17] Jem Finer composed a piece for millennia, *Longplayer*, while by mathematical combinatorics, Benjamin Heidersberger's Pentatonic Permutations Player discretely calculates the time of the universe itself: an algorithmic piano composition that started 14 billion years ago and will continue another 16 trillion years, tagging every moment of time. After the last permutation the piece will stop. Benjamin Heidersberger, *Pentatonic Permutations*, recorded at St. Johannes Evangelist, Berlin, October, 19, 2016, online recording, https://soundcloud.com/benjamin_heidersberger/ppv_20161019mp3.

[18] Edmund Husserl, *On the Phenomenology of the Consciousness of Internal Time [1893–1917]*, trans. John Barnett Brough (Dordrecht, Netherlands: Kluwer Academic, 1991).

[19] When Italian priest Angelo Barbieri, from the 1930s onward, developed automatic player organs to enable such music during a Catholic service even in the absence of an organist, the Vatican did not grant permission for such inanimate machine timing in liturgy.

[20] Also see *Aion*, directed by Jacob Kirkegaard (2006; Denmark: Fonik Works, 2011), DVD.

[21] Jacob Kirkegaard, *4 Rooms*, *Jacob Kirkegaard*, 2011, http://fonik.dk/works/4rooms .html.

[22] "Kirkegaard / Castro," *ausland-berlin*, 2007, https://ausland-berlin.de/node/1366.

[23] "Aion, Jacob Kirkegaard, 2006," *Waves*, 2006, http://rixc.lv/waves/en/txt24.html.

[24] See Bill Viola, "The Sound of One Line Scanning," in *Sound by Artists*, ed. Dan Lander and Micah Lexier (Toronto: Art Metropole; Banff, AB: Walter Phillips Gallery, 1990).

[25] Steve Goodman, "Timeline (sonic)," in *Software Studies: A Lexicon*, ed. Matthew Fuller (Cambridge, MA: The MIT Press, 2008), 256.

[26] In his composition *9 Beet Stretch*, Leif Inge slowed down Beethoven's *Ninth* by such granular synthesis to (online) twenty-four hours, applying realtime pitch-shifting technology. Also, it has been the option of transposing a male voice into a female one in realtime without a Mickey Mouse effect that once induced Friedrich Kittler to advance from electroacoustic synthesizer wiring to coding a microchip in time-critical Assembly language.

[27] According to Wikipedia, sequences are "'warped' non-linearly in the time dimension to determine a measure of their similarity independent of certain non-linear variations in the time dimension." "Dynamic Time Warping," *Wikipedia*, Accessed August 5, 2014, https://en.wikipedia.org/wiki/Dynamic_time_warping.

[28] See Shintaro Miyazaki, "Algorhythmics. Understanding Micro-Temporality in Computational Cultures," *Computational Culture* 2 (2012), Accessed August 5, 2014, http://computationalculture.net/algorhythmics-understanding-micro-temporality-in -computational-cultures/.

[29] See Gottfried August Bürger, *Wunderbare Reisen zu Wasser und zu Lande, Feldzüge und lustige Abentheuer des Freyherrn von Münchhausen* (London, 1786).

[30] See Anthony Moore, "Transactional Fluctuations 2: 'Reflections on Sound,'" in *Variantology 4: On Deep Time Relations of Arts, Sciences and Technologies in the Arabic-Islamic World and Beyond*, ed. Siegfried Zielinski and Eckhard Fürlus (Cologne, Germany: Walther König, 2010), 294.

[31] Charles Babbage, *The Ninth Bridgewater Treatise: A Fragment* (London, 1837), 113. See Patrick Feaster, *Pictures of Sound: One Thousand Years of Educed Audio: 980–1980* (Atlanta: Dust-to-Digital, 2012).

[32] György Buzsáki, *Rhythms of the Brain* (New York: Oxford UP, 2006), 142.

[33] On "temporal objects" (*Zeitobjekte*), see Husserl, *Phenomenology*.

[34] Buzsáki, *Rhythms*, 142.

[35] Jean-François Lyotard, "God and the Puppet," in *The Inhuman: Reflections on Time*. (Stanford, CA: Stanford University Press, 1991), 161.

[36] Ibid.

[37] See Herman von Helmholtz, *On the Sensations of Tone as a Physiological Basis for the Theory of Music* (1863; London, 1875).