Algorithmic Music and the Philosophy of Time

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What is time? This question has captivated philosophy again and again. The present chapter investigates in how far algorithms involve temporality in a specific form, and why algorithmic music is a distinctive way of understanding time.

Its orienting undercurrent is the idea that temporality, by its very nature, gives rise to conflictual perspectives that resist the attempt to be rendered in terms of a unified presence. They are coordinates of a tension field in which the algorithmic is necessarily embedded and invested, and which unfolds in algorithmic music. Drawing from a selection of examples and sources, the chapter leads through a series of such contradictions and touches upon a few interesting theories of time that have sprung from philosophy, music, and computer science, as to actualise their mutual import.

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Introduction

Algorithms are of a liminal character. In this, they much resemble the natural numbers, for which it can be hard to tell whether they come into existence as we count, or whether we are able to count only because they have existed in the first place. An algorithm is on the *verge of time*: on the one hand, it is strictly structural – a formal, unchanging entity. Not only a formula, however, but a formula that prescribes steps to be made one after another, depending on one another. It is a formula that exists in order to unfold, in the form of a process, in time and over time, and dependent on its past inputs.

Yet, it is not clear what kind of time algorithms involve. They describe the course of events in a way that may motivate very different of models of temporality, be they cyclic, path-like, or multidimensional, be they continuous or discontinuous. One could say that here, time and causation are entangled most inseparably. As a mathematical entity, an algorithm not only inhabits a different time from its temporal unfolding, its unfolding happens in a logical time disconnected from immediate experience, or even from its mechanical realisation. Therefore, we can only understand programs if we understand how algorithms constitute temporal experience from without. But just as well one can say that an algorithmic process, and algorithmic music in particular, is always already enclosed within the same time that also accommodates experience, and can only be understood on this level. That is why the distinction between a program, which unfolds its consequences mechanically, and an algorithm, which unfolds them logically, is not at all trivial.

Thus, algorithms are on the verge of time, in so far as they are on the verge between constancy and change, on the one hand, and between concrete and abstract temporality, on the other. A possible first step for a philosophical consideration of algorithms is to better understand what this liminal position means; the consideration of music is likely to help us here. Eventually, algorithmic music will turn out to be not only affected by how we understand temporality, but also it will turn out to be a possible method to constitute and convey the peculiar existence of time.

Clock works

I know of someone who once in sleep heard the chime of the fourth hour and counted as follows: one, one, one, and then in the face of the absurdity of this appearance, which he realised in his mind, called out: "Really, the clock is going mad, it has struck one o'clock four times."[1] (René Descartes, in reply to the Jesuit mathematician Pierre Bourdin, 1642)

One of the earliest designs of automatic calculating machines was a device conceived by the 17th century scholar Wilhelm Schickard, in order to, as he wrote in a letter to the astronomer Johannes Kepler, reckon up numbers "immediately and automatically". The skills that were necessary for such a construction, and which Kepler described as those of a practical philosopher (literally an "ambidextrous philosopher"), came from the art of clock-making – which might have been one reason why the machine wasn't called a calculating machine, but a calculating *clock* ("Rechenuhr"). The transmission between the digits of the numbers involved is strictly analogous to the transmission between hours, minutes, and seconds.[2] Mechanical clocks and mechanical calculators are indeed similar in so far as they depend on the blind constancy of some force, such as a crank

[1] Translation based on The Philosophical Works Of Descartes, Volume II, Objections VII, p. 264.

[2] Although only plans of it survived, Schickard's reckoning clock is a standard fitment within the furnishings of the early history of computation. See e.g. M. R. Williams, A History of Computing Technology. Los Alamitos, California: IEEE Computer Society Press, 2nd ed., 1997, p. 119f. The mechanism combined cogwheels and tables, and the then widely spread calculating rods called *Napier Bones*. Note that in German language it wasn't unusual to call mechanisms clocks, e.g. in words like *Spieluhr* (music box); Napier Bones were also extended for various purposes by the Jesuit Gaspard Scott's *music bones*.

or a spring, which they unfold into interlocking oscillatory movements, movements which end up being measured against the backdrop of a spatial layout or map, such as the clock face or the system of digits and numerals. Clocks serve their purpose best when set rarely, but at a precise moment. Subsequently, they should display the current state at all times without intervention, open endedly. Reckoning machines, by contrast, can be activated at any moment. They swallow all their inputs and intermediate states and make them vanish, only in order to present, after a predictable amount of time that ideally shrinks to an instant, an adequate final result. To this end, much unlike clocks, their inner workings should not be contingent on the time at which the calculation happens. Ideally, the display of clocks depend only on time, that of reckoners only on their input. It is in the state of dysfunction, construction, and invention, as opened black boxes, where they seem to be almost identical; in their functioning, they represent the two ends of a spectrum between the perfect presentation of time and its perfect vanishing.

What can we learn about time from this opposition? Can we say that a clock conveys time, like a thermometer conveys temperature? That a calculator displays the result of a term, like a telescope displays a star? Or are we obliged to say: clocks produce time, like calculators produce results? At least one thing can be noted: time-keeping and reckoning, independent of whether they involve continuous or discrete movements, are both exceptional practices insofar as they oblige us to strictly maintain an internal ratio between otherwise disconnected parts. They are both 'rational' in this sense. While other machines, like pulleys and mills, transmit movements, states, and forces from a source to achieve an effect, in the case of clocks and calculators, it is not easy to tell what it exactly is that they transmit through the movement of their internal parts. For the moment, it seems that, properly speaking, they are best considered as *media*, half way between machines, that exert influence, and instruments, that receive it.

This ambiguity only deepens when we take into account the *sounds* that clocks produce to signal the current time. Whether it is a church bell that assembles the congregation, or the alarm clock that pulls the employees out of their sleep, is only a minor shift: the clock mechanism effectively exerts social power, and its internal contiguity is an agent of social unity. Because sounds from different sources diffuse in space and overlap with each other, a lack of time discipline is instantly noticed as a lack of synchronicity. By contrast, the synchronisation between events, enabled by the dispersion of sound, is both possible and necessary only because events do indeed happen at their own time, take their own time, and in some respect remain completely unaffected by other events. Hence, time signals are not merely an expression of social power. They also mark moments and synchronise otherwise disconnected activities, conveying a specific moment in an internal state of their machinery, that coincides with other events, such as planetary movements. No less than chronography, chronophony deals with synopses[3]: for many centuries, the sound of clocks has essentially been a signal of synchronicity or synchronisation, a signal that combined the unity of the space which it was heard in with the unity of time at which it happened.[4] Sound here appears as a symptom of time. In the ambiguity between active and passive aspects of timing, it functions somewhere half way inbetween actively drawing together and identifying disconnected moments and passively signalling their coincidence.

Sonification of algorithms

In his transcendental aesthetics, Immanuel Kant argues that one should not try to understand time as a phenomenon or an object. Time is already an essential part of the means which our understanding of phenomena or objects requires in the first place: whenever we refer to such things, we refer to them as occurring in time and space, as existing in spatial or temporal form, as coexisting or subsequent difference. Any endeavour to understand it, one has to keep in mind that time will always have been a precondition already, and therefore a horizon for this very understanding. According to Kant, despite this predicament, understanding is still possible through the practice of mathematics (of space by geometry, of time by arithmetics), the laws of which vouch for their respective universality and unity. But in the late 19th and early 20th century philosophy, psychology, and physics, the oppositions between empiricist and rationalist tendencies became ever more irreconcilable.[5] This led to a revision of many of the unquestioned intuitions about the nature and unity of time, rendering, and concerned basic concepts like the continuous and the instantaneous.

[3] For a beautifully and wildly varied collection of historical chronography, see D. Rosenberg and A. Grafton, Cartographies of Time. A History of the Timeline. New York: Princeton Architectural Press, 2010.

[4] Borrowing the words of Hans Reichenbach, the sound of clocks marks a superposition between two uniformities: the uniformity of *consecutive intervals in time* with the uniformity of *parallel intervals in space*. H. Reichenbach, The Philosophy of Space and Time. New York: Dover Publications, 1958, pp. 109-147, here: p. 123.

[5] This opposition in mutual entanglement is maybe best exemplified by the work of Helmholtz, in which, in the words of B. Erdmann, "Kant's rationalist thoughts" are "twisted round into their empiricist counterpart", and Husserl, who subsequently founds an a priori from establishing an explicitly phenomenological and thus antipsychological basis. Cf. H. L. F. v. Helmholtz, Epistemological Writings. Boston Studies in the Philosophy of Science, Dordrecht, Netherlands; Boston, USA/Boston: D. Reidel Publishing Company, 1977 [1921], p. 168 (commentary by Moritz Schlick), who refers to B. Erdmann, "Die philosophischen Grundlagen von Helmholtz' Wahrnehmungstheorie," in Abhandlungen der Preussischen Akademie der Wissenschaften, philosophisch-historische Klasse, pp. 1–45: 27, 1921.

The foundational discourses of mathematics from that era onwards, in search for a foundation of science in the apparent certainty of the series of natural numbers (or the inexhaustability of the continuum), have repeatedly returned to the unifying role of time as a condition of experience. But it has also become increasingly questionable whether the inner gaze of pure intuition could be trusted as an orienting limit for the understanding of mathematics, just as well as for time. Indirect means of knowledge, which do not proceed from immediate evidence, may simply be unavoidable – not only for scientific understanding of events that happen in time, even for time itself.

But also the reconceptualisation of causation by relativistic physics has had a lasting impact on the intuition of time and its apparent clarity. From the Kantian perspective, which gave us a provisional starting point, time could have been a formal condition only for the possible content of experience. But relativistic physics has broached the question again about how spacetime is related to the matter and energy that inhabits it.[6] What's more, because in spacetime, simultaneity depends on relative location, the dialectics between form and content is changed: space *passes* no less than time and we *move through* time no less than through space. While relativistic effects proper are encountered at a very large scale only, we do get an adequate analog when we try to synchronise clocks without knowing the speed at which information travels in a medium – this issue is not only relevant in the cognition of time, but has also been both a stumbling block and an inspiration for algorithmic music.[7] The confrontation with situations in which time and space are a combined constraint should thus not be considered a technical detail, but an adequate, even if indirect, confrontation with the structure of spacetime.

The break with simultaneity in physics was closely followed by another foundational break at the interstices between mathematics and logic, and it concerns the unity of arithmetics, as well as of the century long search for a unifying formal system that could serve as an indubitable foundation of all scientific knowledge. The conceptual and technical developments in formal logic and computing have weakened, if not ended, the ambitious and often emancipatory hope that a single system could hold all parts together, and account for all logical contexts at once. Rather than being clear and unambiguous specifications of a schedule to

[6] M. Jammer, Concepts of Simultaneity. From Antiquity to Einstein and Beyond. Baltimore: The Johns Hopkins University Press, 2006.

[7] Everyday clock synchronisation is historically relevant in the history of relativistic physics: P. Galison, Einstein's clocks, Poincaré's maps: empires of time. WW Norton & Company, 2004. For a discussion in the context of algorithmic music, see e.g.: A. Blackwell, A. McLean, J. Noble, J. Otto, and J. Rohrhuber, "Collaboration and learning through live coding (Dagstuhl Seminar 13382)," Dagstuhl Reports, vol. 3, no. 9, pp. 130–168, 2014, 16f. ; J. Rohrhuber and A. de Campo, "Waiting and Uncertainty in Computer Music Networks," Proceedings of ICMC 2004: the 30th annual international computer music conference, 2004.

be fulfilled, formalisations – and programming languages in particular – in fact have turned out to function as media that allow us to navigate and describe the interrelations between plan, process and result.

As it seems, the ambiguous spectrum between persistent following in physical time, and instantaneous conclusion in a formal leap, which we found in the technology of clocks and calculators respectively, has lost nothing of its relevance. For the invention of the computer an elaborate combination of both clock and calculator functions was necessary, and even today, *Rechenuhr* is not at all an inappropriate name for it. The combination of these two different functions fundamentally changes their very character, however. Where calculations become events that are scheduled by clocks, they are dependent on temporal coincidence with other events. Where in turn the mechanism of clocks depends on calculations, the flow of time becomes contingent, and in so far as temporal marks are set algorithmically, the meaning of duration may shift dependent on events that happen. The fact that calculations need to happen at a specific moment, but also take time for their unfolding, can make systems very hard to reason about. But even in the simpler cases, where one central clock pulls instructions and data through the bottleneck of an instantaneous memory, the order of events, rather than becoming clear and definite, is still infected by the structural incompleteness and possible inconsistency of any algorithmic formalisation.

So while clocks were built to illustrate time, and reckoners to speed up a comprehensible process, programming confronted a serious problem of how to still make sense of the logic of computational processes.[8] Different ways of retaining understanding the ongoing computations have come in and out of use, notably among them the early applications of sonification in the design of computers, which deserve a brief consideration. Many of the post war computers had a loudspeaker that was connected to a memory location in the processing unit, which thereby made audible its internal state changes during calculation.[9] This device allowed the

[8]Since its historical beginnings, proofs not only were required to 'work out'. Such written forms of calculation have always had the double role between allowing an individual to perform a calculation and conveying to others an account of how it proceeded. In much the same way (and also with varying success), programming languages not only talk to humans just as to machines, but also accommodate all levels from the processing of numbers to the organisation of tasks. See e.g. M. S. Mahoney, Histories of Computing. Cambridge, Massachusetts, and London, England: Harvard University Press, 2011, 77ff.

[9]As so much in the history of programming, the practice of the audification of computations was mostly forgotten until more recently rediscovered by the Dutch historian Gerard Alberts, cf. G. Alberts, "Das Verschwinden der Konsole und die Vorläufer des interaktiven"User"," in Informatik 2005, Informatik LIVE! (P. M. Armin B. Cremers, Rainer Manthey and V. Steinhage, eds.), pp. 205–209, Bonn: Gesellschaft für Informatik, 2005; G. Alberts, "Rekengeluiden. De lichamelijkheid van het rekenen," Informatie & Informatiebeleid, vol. 1, no. 18, pp. 42–47, 2000. For subsequent research, see also the work of S. Miyazaki, "Algorhythmics: Understanding Micro-Temporality in Computational Cultures," Computational Culture, no. 2, 2012, and S. Miyazaki, Algorhythmisiert. Eine Medienarchäologie digitaler Signale und (un)erhörter Zeiteffekte. Berlin: Kadmos, 2013. See also chapter XXX

programmer to monitor a part of the algorithmic process in the background, just like one would listen to the ticking of a clock. A way of constantly remaining aware of the intermediate state of a computational task, and as an auditory skill of the operator, this practice continued the practice of listening to the relay systems, such as those of large telephone switching stations. Apart from its occasional appropriation for demonstrating the surprising powers of computers at public occasions such as inaugurations,[10] a certain urgency of monitoring was due to the fact that the calculations involved were inherently uncertain: a process could always enter a state where it would fail to conclude and instead continue in an endless loop. In such a case, it had to be stopped, as quickly as possible, to avoid overheating – something that not only meant that one had to waste precious hours while waiting for the computer to cool down, but also that one had to face the embarrassing consequences and inform the lab engineer of the failure, who was the only person who had the privilege to break the loop externally. Background listening allowed the operator to respond to this exceptional moment before it was too late.[11]

Even if not all calculations convey time, they certainly take time. This time is structured by the material and logical resources that are needed to make them happen. So it seems almost as if all the strange uncertainties of the algorithmic, and its tension between logical and physical time, finally could disappear when actualised in the apparently hard reality of 'time proper', at that point where the algorithmic law is unrolled in the form of a series of events. Time might be imagined as a dense substrate in which all logical and causal relations, which are formalised consequences of an algorithmic set up, can be finally moored in and appear as secondary. Sound would be the realm of such a final order, a ground level of immediacy. Such an idea of a grounding presence however is misleading. Even in the optimal case, the sonification of the progress of internal state changes gives access only to one specific aspect of algorithmic time – here, all that we know about what happens is when it happens, and in what order. The real challenge is a different one. The apparently immediately present and momentary events in fact only happen in their specific way because they are densely coordinated between each other, across past and future. Sometimes, this logic can be made directly audible, but in most cases, it can only be comprehended by taking into account the algorithmic system as a whole, including the different levels of formalism and their semantics. Because the coordination of events is itself subject to changes over time, the causal relations themselves cannot be reflected

(Geoff Cox et al.).

[10]This hack was achieved by producing tunes as side effects of different divisions of clock times, and can really be seen as a very early precursor of algorithmic music in the demo scene.

[11]Gerard Alberts, personal communication. This monitoring practice was common until its usefulness diminished as the clock rates significantly exceeded the audible range, and the diversity of the translation stages between program and process increased.

in their immediate consequences alone. There is, finally, no ground level of immediacy: much less than as a single continuum, time comes into existence in the form of an irreducible diffraction. Both sound and formalisation are possible responses to this abstractness of time, whose understanding must, as it seems, accept an essential diversification of its modes of access.

Historically, the sonification of the time structure of algorithmic processes was motivated by the difficulty to convey how a computation proceeds over time, a difficulty it could not resolve. The behaviour of a process is a shadow of its tacit and untamed laws, laws which are selected, encountered, or even constituted only in the course of events. On a certain level, algorithmic computer music, and also algorithmic music by other means, reflects this paradoxical situation.

Holding the error in suspense

It is instructive to consider here for a moment one of the surprising and notorious results of mathematical logic: there is no formal procedure that could tell us for an arbitrary calculation whether it will continue forever or eventually return a result. This undecidability, usually referred to as the halting problem, has an obvious temporal side to it. Firstly, it implies there is no explicit method once and for all that can *predict* whether the calculation will be conclusive. This means that possibly, a procedure must be unfolded in order to reveal certain properties it implies, and often it is even undecidable if such unfolding will work at all.[12] Secondly, the decidability of such problems itself is posed in formal terms of finality (termination) or recurrence (infinite loop). The minimal, most elementary characteristic of finality is the absence of contradiction – and contradiction, ultimately, is interpreted as an occurrence of an endless and timeless loop, devastating and monstrous because of its unlimited potential of infecting every part of the given system. The determinate rigidity of a formal system thus amplifies its unpredictability. One can say the following: while perfect repetition is the most fundamental elementary operation of computation, reaching a state of perfect repetition globally is a sign of its failure. Repetition is the *real* of computation.[13]

[12]One should keep in mind that the undecidability results are about formal systems and may or may not be equivalent to the description of a computation in a computer language and its physical process. This text is concerned with the liminal nature of algorithms rather than their absolute categorical distinction. Independent of a decision about this relation, the undecidability of a procedure is the best description for the inherent unpredictability of computation where a total enumeration is impossible, for whatever reason.

[13]Originating from the French philosopher of science Émile Meyerson, the concept of the *Real* typically refers to

an absolute, existential precondition of knowledge which escapes our view like a blind spot, not however without giving rise to occasional, seemingly irrational obstacles within

The undecidabilityof the halting problem is the tip of the iceberg. Indeed, the causal relation between descriptions and processes involves a much broader, and perhaps an even more differentiated semantic uncertainty. Algorithms are not always total functions: just as they may fail to complete their task in some situations, they may unexpectedly fulfil a different one than specified. This unfolding of a causal relation sometimes is best understood as a mathematical transformation, for instance when we reason about algorithmic complexity, and it happens in logical time. Or it can be understood as a physical process, a runtime behaviour of a machine. In any way, in the process of investigation, debugging has hitherto proven ineluctable. At the expense of some generality, it is possible to introduce static analysis, so that certain forms of error are being contained within the development process and only conceptual issues may infect the final runtime program. At some level, however, programming retains an experimental character, a dialectical oscillation between the numerous facets of failure and success.

Hence, relying on deterministic means in music makes it in no way more predictable, but rather less so. The difficulty actually doubles: even where it strikes us intuitively clear what sonic character is desired, it is particularly hard to specify; so it seems almost better to avoid formalisations altogether in favour of known instruments or sound recordings. Even so, for most sound qualities, we do not yet have acquired an intuitive or verbal concept, so that formal specification may be the only possible way to approach them even. In algorithmic music, the uncertainty in the formal methods, which assist such a specification, thus finally amalgamate with the uncertainty of sound description itself. What Curry and Feys write in the 1950s remains valid today, not only for formal logic but also for algorithmic music – namely that the "[r]esults of Gödel and the incompleteness and inconsistency theorems make it seem likely that we shall not have other criteria than the empirical ones for the most interesting systems of mathematical logic."[14] Even if music were not already in itself an experimental field, algorithmic music would necessarily have to be.

At first sight, time seems here to take effect as an open future: programming follows an errant path, not only through one specified procedure, but through multiple alternative trajectories of causality. But rather than a global horizon of absolute uncertainty, it operates as an inner distance,

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the field it determines. For Meyerson, the real is a retroactive irrational effect of the attempt of creating identity, and thus unity. Cf. P. P. Wiener, "On Émile Meyerson's Theory of Identity and the Irrational," The Philosophical Review, vol. 44, no. 4, pp. 375–380, 1935. Jacques Lacan's work takes up these ideas in psychoanalysis, and proliferates the now common term. A further reading would have to include works like G. Deleuze, Difference and Repetition. New York: Columbia University Press, 1994. See also: J. Lacan, The Four Fundamental Concepts of Psychoanalysis (The Seminar of Jacques Lacan, Book XI). New York: W. W. Norton and Company, 1998.

[14] H. B. Curry and R. Feys, Combinatory Logic. Volume I. Amsterdam: North-Holland Publishing Company, 1958, p. 276.

which instead of forever banning inconsistency, includes the error by keeping it in suspense. It would be too rash to take this embrace of uncertainty as an obscurantist abdication of rationality; much more it is an experimental formalisation, a contingent search for rationality with the means of rationality.[15] The concept of contradiction illustrates this. A pair of contradictory statements is not problematic by their mere juxtaposition; they become problematic where they both are consequences of general rules, rules that are thought of as synchronously valid, and thus internally connecting a given world. Hence, to diagnose a contradiction is to assume a specific temporality: something is and is not *at the same time*. Undecidability, on the other hand, is a precise notion for the lack of a formal procedure for determining whether such two paths can coexist.

On the level of a program, this structural potential of incompatibility is necessarily reflected in time. It is usually a variant of the above mentioned halting problem: some initially given final condition is never met. It might be of more than simply technical interest that many sound algorithms place timing mechanisms in the very same place that is opened by the possibility of contradiction. By inserting the timing where loops and recursions happen, the relation between input and output (or no output at all) is converted into a relation between the input and the computational process itself (finite or infinite). In computer languages, this temporalisation typically shows two perspectives: either the algorithm has to determine whether a given operation on the current data should be repeated (the imperative definition) or whether a function should call itself again from the current context (the recursive one). The first case is that of an external observer who decides whether and when to make the next step; it corresponds, if you want, to a clock externally attached to a reckoner from the outside, driving its calculation. The second is its inverse, like an internal observer who decides about how to continue. Rather than a clock driving a reckoner, it is a reckoner that commands a clock.

Indeed, these are the two simplest ways to compose a computational process from the two functions of following (clock) and concluding (reckoner). Because the measure of *waiting* originates at their intersection, iterative and recursive time[16] are in many ways equivalent: what can be expressed iteratively can also be expressed recursively. However, they are radically distinct in the way time is conceptualised. As an iterative process that advances *in time*, operating on the past like a given thing,

[15] In a more general context, the philosopher Joseph Vogl has given this tarrying suspension a formidable description in J. Vogl, On Tarrying. London and New York: Seagull Books, 2011.

[16] Temporal recursion occurs naturally where the basic programming paradigm is recursive rather than iterative. While formally exchangeable, the two approaches differ in their specific affordances. Andrew Sorensen gives a thorough description of temporal recursion: A. Sorensen, "The many faces of a temporal recursion," 2013, url: http://extempore.moso.com.au/temporal_%20recursion.html, last checked on 01/07/2015.

which is (partly) lost wherever it is changed. As a recursive process that advances *in its own past*, leaving it untouched, and leaving behind it ever new versions of pastness, that (partly) obscure each other temporarily. Here, the end of an unfolding consists in a jump to a specific level of the past, a recapitulation, a recovery of a beginning.[17] In the imperative conception, by contrast, the end is simply the final present condition. All that was to be done has been inscribed in it already. The two modes are two ways to understand a conclusion from an ongoing process, a final break: one as a return to its beginning, one as a liberation from its future.

Perhaps these observations not only concern events that happen in time and over time, but indirectly give us an impression of the affordances that are characteristic of time itself. After all, repetition, waiting and undecidability are irreducibly temporal phenomena. Algorithmic time might not, we have collected some evidence for this already, be adequately described as a property of events in time, but the form of events, conversely, may prove to be the characteristic way of time to appear in a given world. In any case, to depict the medium of time as a continuous and homogenous aether of presence is likely to be misleading. The suspension of error is a suspension in a situation of the possible mutual contradiction of laws, and thus a non-homogenous temporality. If sound should be an expression of the existence of time, time will have to appear within it in such a form.

The self-alienation of time

Algorithmic music differs from other kinds of music only by degree. Music, perhaps "the temporal art par excellence"[18], organises sound according to explicit or implicit laws, and algorithms are instances of such laws. But also, algorithmic methods, computerised or not, prompt changes in our musical understanding of time in a particular way. Instead of directly laying out the course of events and specifying the musicians' roles on the dot, we just instigate a system of situation dependent laws, which only indirectly give rise to a course of events. In a sense one could say that composing is less about specifying what happens when, but much more about specifying what happens why. As rule systems

[17]This recursive movement itself can again take very different paths. Iterations over data structures are a good example, as they project structural into temporal order most explicitly, for instance the movements implied by left fold and right fold in functional languages. For an accessible overview see e.g. P. van Roy and S. Haridi, "Concepts, Techniques, and Models of Computer Programming," tech. rep., Université catholique de Louvain (at Louvain-la-Neuve); Swedish Institute of Computer Science, 2003, pp. 190-199.

[18]Orig: "L'art du temps par excellence". Cf. G. Brelet, Le Temps musical: Essai d'une esthétique nouvelle de la musique. La forme sonore et la forme rythmique, vol. 1. PUF, 1949, p. 25. Quote after G. Mohr, "Musik als erlebte Zeit," Philosophia naturalis, vol. 49, no. 2, pp. 319–347, 2012.

become more explicit, they require specific representations, and because these systems need not synchronise events relative to an imagined time axis, their representations make it much less obvious why an axis should be the best way to organise or manipulate time either. There is no axis of causality, after all. The mixture between repeatability and variation, characteristic of algorithms, is not organised by a linear order of time: as laws organise both, the resulting music is much more predictable in a certain sense, and far less in another. And as we have seen already, the degree of indeterminacy in algorithms makes experiments necessary despite, or in fact because, of the determinism of rules.

Computers give explicit access to movements that happen over very short time spans, so that the timbral qualities of sound become part of the same temporal organisation as the whole composition. Sound synthesis and algorithmic composition may thereby require different strategies, because their respective frequency ranges concern different perceptual levels. The algorithms involved can nevertheless fill the whole space from sample rate and microsound to long duration pieces.[19] Such practises of generalisation and reconfiguration of temporality have ignited fierce discussion about the nature of music, with regards to the perception as well as to the politics of time. Karlheinz Stockhausen's text "... wie die Zeit vergeht ..."[20], for instance, which was inspired by the idea of an absolute uniformity of temporality, irrespective of apparent differences between rhythmic and timbral qualities, provoked Gérard Grisey to deplore such unifications as a confusion of "the map with the lie of the land", suggesting instead a "rhythm of our lives" as a backdrop, against which experience of time ought to be brought.[21] It is not obvious, however, whether the limits of human experience should coincide with the limits of musical time, and whether they can be clearly delimited at all. If there is a unity of time that can only be known indirectly but not heard directly, does it exist nevertheless? Even under Kant's assumption, that time is a universal form of intuition, there is no reason why this form itself and its structural effects should be limited to what can be immediately intuited. Grisey's originally rhetoric question "*Who* perceives them?" should therefore perhaps be understood literally, namely as a search for an unspecified or alien audience.

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[19]Different temporal levels relevant to sound are comprehensively laid out in C. Roads, Microsound. The MIT Press, 2004. For an approach that places more emphasis on perceptual layers, see B. Snyder, Music and Memory: An Introduction. The MIT Press, 2001.

[20]K. Stockhausen, "... wie die Zeit vergeht ..." die Reihe, no. III, p. 13ff., 1956.

[21]G. Grisey, "Tempus ex machina. Reflexionen über die musikalische Zeit," Neuland. Ansätze zur Musik der Gegenwart, vol. 3, 1982/83. Örjan Sandred concludes (my emphasis added): "Grisey's criticism of some earlier examples is crushing. There has to be a connection between the composer's ideas and what the listener experiences. "They [the ideas] became ridiculous when our elders ended up *confusing the map with the lie of the land*. " He uses Gruppen as an example: "... the tempi have a great structural importance. *Who* perceives them?"." O. Sandred, "Temporal structures and time perception in the music of Gerard Grisey: some similarities and differences to Karlheinz Stockhausen's ideas.," tech. rep., McGill University, Montréal, 1994, p 24.

The proliferation of algorithmic music to a broader public has refreshingly banalised the experimentation with the sublime and the subliminal: where we delegate decisions and actions to algorithmic processes, we are faced with phenomena that are not tuned to the human perceptual apparatus or to social conventions. Not least, this is a political issue, because the knowledge about the potential manipulation of perception goes hand in hand with the liberating, truly aesthetic, potential of practices that are able to change or protect social and cognitive categories. The everyday experiences of the more or less subtle alienation through algorithmic phenomena makes it more plausible that individual and collective learning is able to change cognition and that it may challenge foundational assumptions about what it means to organise time. In such a way, alienation should perhaps be considered deplorable only where it is the symptom of exploitation.

As we have seen, algorithmic methods suggest a break with the idea of time as an immediate grounding; brushing against the fur of intuition, their effects sometimes become a stumbling block, which forces us, within experience, to reconsider the limits of possible experience. Electronic composers know very well that, while it is easy to mark certain physiological limits of sense experience, the perceptual limits of perception remain largely underdetermined. It is therefore one of the aesthetic challenges of algorithmic music to find new ways of navigating paths across a space that is not a space of human experience as such, paths that trace out the alienating potential of abstract consequences as a whole. What has this to do with time? Certainly this: every delegation of an action is an alienating loss of immediacy that can only be sustained by an unconditional trust combined with an equally unconditional responsibility. And perhaps at the core of this loss is the alienation of temporality itself, an alienation that counters the structural violence of the idea that everything that appears must appear in the form of presence.[22]

Arguably one of the strongest philosophical breaks with conventional wisdom concerning time is the dissolution of the identity between what is immediately given and what can be indirectly conveyed as existing. This should not be understood as a manipulation, an extrinsic division forced upon the unity of time by technology, but as one of the central characteristics of time itself, which is "out of joint"[23], and that haunts

[22]Paradoxically, compared to the idea of the living presence, the cold and dead mechanism of the algorithmic turns out to be much less dead than expected. As Derrida writes in 'Violence and Metaphysics': "If the living present, the absolute form of the opening of time to the other in itself, is the absolute form of egological life, and if egoity is the absolute form of experience, then the present, the presence of the present and the present of presence, are all originarily and forever violent. The living present is originally marked by death. Presence as violence is the meaning of finitude, the meaning of meaning as history." (J. Derrida, Writing and Difference. London: Routledge, 1978, p. 133, quoted after J. Hodge, Derrida on Time. Oxon and New York: Routledge, 2007, pp. 95-96).

[23]Deleuze opens his book on Kant with this idea: "Time is no longer related to the movement which it measures, but movement is related to the time which conditions it:

technology from within. Hence, algorithmic sound lets us think this dissolution as a *self-alienation of time*, which, rather than alienating us from some assumed original immediacy, is what allows us to inhabit the resulting zone of provisional existence.[24] In the following, we shall substantiate this thesis, and discuss a few implications. This will further lead us to a discussion of the complementary and incommensurability between time understood as *passage* and time understood as *encounter*, which is an opposition that informs philosophical discourse of time still today.

A split between presence and existence

A: "I'd prefer to transform a value which is my composition, rather than arrange the side effects that will result in my composition."

B: "What if the value undergoing transformation is a process?"

A: "Since the value is a music composition then the value is a process by definition."

B: "Perhaps the process that yields the side effects is the composition."

A: "Yes – as an Arrow."[25]

Most non-computer music is divided into two clear realms: the sonic properties of the instruments, and the sonic events caused by playing them. This is essentially a temporal organisation. Its fascinating tension is constituted by the ambiguity between the two aspects: hearing a sudden event means encountering the *existence* of an instrument; but it also means, 'at the same time', witnessing a *change* which it is subject to and which is mediated through it. An orchestra is like a screen that displays the changes in light, and yet it is also like the changing light itself, more or less well-rendered on the screen of its stage.

In computer music, this specific arrangement between instrument and performance grows brittle. Just like in the sound of wind, where the moving air and the rigid bodies become indistinguishable,[26] here, timbral and performative qualities are events as much as anything else. The solid character of objects, understood as a static background condition that

this is the first great Kantian reversal in the Critique of Pure Reason." G. Deleuze, Kant's Critical Philosophy. London: The Athlone Press, 1984, p. vii.

[24]See e.g. Laboria Cuboniks: Xenofeminism: A Politics for Alienation, 12 June 2015. url: http:// www.laboriacuboniks.net/ #firstPage. My notion of the "self-alienation of time" is inspired by their positive embracing of the "self-alienation of thought".

[25]Email conversation between James McCartney (A) and Ross Bencina (B) on live-code@toplap.org, May 2013. For some information on the concept of arrows in computer science, which is here only alluded to, see J. Hughes, "Generalising monads to arrows," Science of Computer Programming, pp. 67–111, May 2000.

[26]T. Wishart, On Sonic Art. Harwood academic publishers, 1996, p. 180.

mediates the interventions of the players, turns into a variable attribute that can occur at any time scale of a given piece, and anywhere in the hierarchy of concepts in a composition or improvisation. And also for events this is the case: they may happen at any level, and may have effects anywhere else. Generally speaking, existence and change are only aggregate states of any part of the system. By consequence, an algorithmic composition is an entity under transformation, just as much as the sound that results from it; it effectively represents a rich spectrum of layers that gradually mediate from one to the other.

Somewhat unfortunately, this lack of a clear distinction between object and event leads to a loss of a fundamental tension between instrument and player. Where there is no clear separation, there seems to be also missing the fascinating, infinitely fine boundary between them, a distinct connector between existence and change. But as we saw, rather than a complete dissolution, the boundary is allowed to disseminate to any part whatsoever of the whole system. Hence, what really comes to the fore as "inexistance" – as, in lieu of Jacques Derrida,[27] Alan Badiou has named this vanishing point of touch –, is the *question* of causality. Rather than taking for granted what follows from what, inexistance prompts us to reconsider the conditions of causality, through which it yields agency in the most general sense, and indifferently spans conscious and unconscious, automaton and automatism[28], human or non-human. If we have assumed so far that we know what it means to 'be an event', it was only as a manner of speaking. Instead of being resolved, the inner tension of time infects any part of the algorithmic system with a distance to itself.

Rather than being clear from the beginning, the programmer encounters these distinctions in the process, as obstacles and surprises.[29] In Jean-Jacques Lyotard's introduction to his article *Time Today,* the event is the agent of such an alienation or disappropriation: "Because it is absolute, the presenting present cannot be grasped: it is *not yet* or *no longer* present. It is always too soon or too late to grasp presentation itself and present it. Such is the specific and paradoxical constitution of the event. That something happens, the occurrence, means that the mind is disappro-

[27] Alain Badiou in his obituary to Jacques Derrida: A. Badiou, Pocket Pantheon. London: Verso, 2009, p. 143. Following instead Marcel Duchamp, I could also have chosen the suitable term *inframince*. I. Becker, M. Cuntz, and M. Wetzel, Just not in time: Inframedialität und non-lineare Zeitlichkeiten in Kunst, Film, Literatur und Philosophie, vol. 20 of Mediologie. Wilhelm Fink, 2011.

[28] Ref. to chapter on automatism by Renate Wieser.

[29] A necessity of the refactorisation of code, for example, may force itself upon the programmer, just as a factorisation of a term may force itself upon a mathematician. There are reasons to believe that these are necessarily social forces mediated by human made technology, but also good reasons not to rely on them too much: J. Rohrhuber, "Intractable Mobiles. Patents and Algorithms between Discovery and Invention," in Akteur-Medien-Theorie, Bielefeld: Transcript, 2013, pp. 265–305.

priated."[30] As we shall see, this constitutive split in time is articulated in sound as soon as we ask: what is it that we hear? The idea that 'something happens', implies that it happens at some specific moment in time. There is an irreducible point, at which that which happens turns from being a future event into a past event, and, in experience, turns from expectation to memory. If we want to know more about *what* it actually is that happened at that time, we can only refer to what happened *at* that very moment, at the same time. A sonic quality, however, is an oscillatory movement, a movement that consists in nothing else but a cluster of multiple moments or a spectrum of frequencies, which in itself have no momentary existence: when one of them happens, the next is still to be expected, and the previous has already disappeared. Each moment has no quality, and quality has no moment. Sound is a case in point for an existence that consists as a split in time: *what* and *when* are mutually incommensurable.

Similar to the idea of the *perpetuum mobile*, which had to be slowly proven to be impossible, so has this incompatibility between frequency and time dawned only slowly upon the engineers.[31] Time really seems not to be composed of intuitive points. So if we want to consider it as being composed of another kind of elementary units (which it somehow seems to be), what would these be then? Inspired by the suggestion of A. Landé and further results from applied mathematics,[32] in the 1940s, Dennis Gabor takes an original step: reinterpreting the Heisenberg principle in quantum mechanics, he defines what he calls an acoustic *logon*, an elementary signal that has *both* frequency and time aspects, respectively corresponding to momentum and position of a particle. Just like the counterpart of Planck's quantum, this minimal "information diagram" does not fix the two variables separately, but conjugates them, so that they lend each other the limit of possible certainty. This model tries to account for the apparently self-evident idea of a "changing frequency", which mathematically speaking is a "contradiction in terms",[33] at least as

[30]J.-F. Lyotard, "Time Today," in The Inhuman: Reflections on Time, pp. 58–77, Stanford, California: Stanford University Press, 1991, p. 59. The engagement with this text was also an inspiration for J. Rohrhuber, A. de Campo, and R. Wieser, "Algorithms today – Notes on Language Design for Just In Time Programming," in Proceedings of International Computer Music Conference, (Barcelona), pp. 455–458, ICMC, 2005.

[31]D. Gabor, "Theory of Communication," Radio Section of the British Thomson-Houston Co., Ltd., Research Laboratory, pp. 429–457, 1945; For a shorter version, see "Acoustical quanta and the theory of hearing," Nature, pp. 591–594, May 1947.

[32]The physicist Albert Landé, after having given up his occupation as a piano teacher in 1918, became one of the influential protagonists in quantum theory. Cf. A. Landé, Vorlesungen über Wellenmechanik. Leipzig: Academische Verlagsgesellschaft, 1930. See also G. W. Stewart, "Problems Suggested by an Uncertainty Principle in Acoustics," Journal of the Acoustical Society of America, no. 2, pp. 325f., 1931. For an excellent phenomenological analysis, see P. Palmieri, ""The Postilion's Horn Sounds": A Complementarity Approach to the Phenomenology of Sound-Consciousness?," Husserl Studies, vol. 30, no. 2, pp. 129–151, 2014.

[33]"If the term "frequency" is used in the strict mathematical sense which applies only to infinite wave-trains, a "changing frequency" becomes a contradiction in terms, as it is a

far as the idea of the necessarily infinite and timeless frequency spectrum of Fourier Analysis is concerned. In other words, instead of deriving frequency from time coordinate, or vice versa, it treats them as two coexistent dimensions of each event. Now as much as Gabor's critique of the unreflected notion of *frequency* in physics is justified – isn't it interesting that in the formal treatment, the notion of *time* is perfectly symmetric with its alter ego? Innocuously represented as a single parameter, it certainly deserves at least as much attention: the self-evidence of a time axis may be just as deceiving as that of a frequency axis. What is called "time" here actually means the "instant". And indeed, for the very idea of the event as a part of time, as it is mathematically articulated here, the two aspects are mutually irreducible, and thus are *both* objective aspects of time.

One way to deal with such a rather unsafe looking territory is the operationalist method, a view that in quantum physics is associated with the so called Kopenhagen Interpretation. According to it, all such contradictory phenomena should be associated with the technical means of observation only, and in fact what is observed should better not even be mentioned in the account at all. The same interpretation of acoustics would imply that two mutually excluding perspectives of sound, its instants and its frequencies, exist *merely* for us hearing subjects, or for our measurement devices. They are distortions necessarily caused by our own limitations. In this, Gabor more or less followed the tradition of psychophysics, and continued to solidify his thesis empirically by identifying the limits of certainty with the limits of human constitution. But this is not the only possibility – also in quantum physics, the operationalist interpretation was never without alternatives.[34] It is possible to elude what with Gabriel Catren can be called a "narcissistic illusion of converting a conjectural limit into an absolute principle."[35] Completely reducing a double-nature to the means necessary for its display has the disadvantage of implying an unquestioned unity somewhere else, which then tacitly tends to get associated with one of the aspects one tried to analyse in the first place. But what is incommensurable does not automatically become irreal. It is not at all unthinkable that the duality which we encounter in acoustics is, instead of merely an observation artefact that distorts our view, an adequate expression of the inherent necessity of the specific, situated structures of temporality. Looking back, we can also say that, rather than a reflection of our own limits, it should be understood as one of several

statement involving both time and frequency." Gabor 1945, p. 431.

[34]A detailed and unbiased historical treatment gives M. Beller, Quantum Dialogue. The Making of a Revolution. Chicago and London: Chicago University Press, 1999, pp. 172ff.

[35]"Indeed, the first step for pushing further the Copernican deanthropomorphisation of science is to reduce the narcissistic illusion of converting a conjectural limit into an absolute principle. We must avoid at all costs being like a congenitally deaf person trying to demonstrate the absolute impossibility of music." G. Catren, "A Throw of the Quantum Dice Will Never Abolish the Copernican Revolution," Collapse: The Copernican Imperative, vol. 5, pp. 453–500: 466, February 2009.

possible manifestations of the self-alienation of time. Finally, Gabor's acoustic uncertainty relation can be read not only as a formalisation of sonic information, but also as a formalisation of time itself. The problem that sonic events have partly incompatible temporal dimensions of "frequency" and "time" turns out to witness the fact that time is not reducible to the instantaneous, but split into pairwise incommensurable aspects already. The acoustic uncertainty relation points to a possible solution to the central problem at hand – namely how something can properly be said to exist that is not present.

A split between presence and existence runs through the event. Already the paradoxes of the Eleatic School connect this insight to the mathematical navigation between continuity and discontinuity, a topic that inspires later Greek, and then early 20th century philosophy till today.[36] The views differ in various ways, many of which matter for the questions at hand, and still need to be left out here. One central issue that informs most of them, however, is the idea that time is not reducible to immediate presence. Something is temporal in so far as it can exist in distance to presence. In such a way, we can take algorithms and sounds to be adequate means in the endeavour to understand time, because they share with time the common characteristic of being neither properly present nor independent of a temporal unfolding. This is one sense in which algorithmic music can be considered a philosophical practice that addresses the question of time through the experimentation with events and their causal structures.

Passage or encounter?

To accept the split between presence and existence means to accept that there is a real contradiction, a contradiction that not only affects the understanding what happens *in* time, but also the understanding of time itself. As Gilles Deleuze showed for film, even though the thinking of movement has been an important task of cinema for a long time, it became possible through this medium, to shift perspective and instead focus on the thinking of time.[37] That algorithms are one of the most complex methods to mediate between laws and their consequences not only

[36] To name only two: H. Bergson, Matter and Memory. New York: Zone Books, 1991, and A. N. Whitehead, Process and reality. An Essay in Cosmology. Gifford Lectures Delivered in The University of Edinburgh during the Session 1927-28. New York: The Free Press, 1929, p. 68. For a rereading of time conceptions in antiquity against the background of media and music technology, see e.g. M. Carlé, "Zeit des Mediums," in Medien vor den Medien (F. Kittler and A. Ofak, eds.), pp. 31–60, München: Willhelm Fink Verlag, 2007.

[37] This work takes up the thread of the discussion of the "Kantian turn" under completely different conditions. G. Deleuze 1986: Cinema 1. Movement-Image, University of Minnesota Press. G. Deleuze, Cinema 1: Movement-Image. University of Minnesota Press, 1986. G. Deleuze, Cinema 2: The Time-Image. University of Minnesota Press, 1989.

provides us with a good means for specifying sound. Given the internal incommensurability of sound, algorithmic music is an appropriate way to understand the ramified consequences of the self-alienation of time.

For this, let's consider how some of the typical temporal attributes come to bear in algorithmic sound events, like temporal succession, causation, date, duration, futurity, presence, and pastness. Regarding the last three, futurity, presence, and pastness, one can easily see that what is irreducibly temporal about an event is its change in modality – that an event implies a *passage*, from laying ahead to becoming present, to becoming past. For example, it is certainly an essential property of a date with the dentist whether it is still scheduled or has already happened. It is an essential property of a sound to have sounded or not. It is an essential property of future that it is ahead, and of history that it has ceased to exist.[38] According to this view of time as passage, temporality corresponds to such an irreversible and inevitable shifting.

Already a brief consideration shows how different approaches to computer music orientate themselves within these three classical modalities of futurity, presence, and pastness, relating them in particular ways, and distribute them relative to a possible listener and her environment. The use of nondeterministic methods, for instance, has intensified a mode of time where the future becomes an open space of unspecified or systematically underspecified events.[39] A phenomenological perspective, deriving from Husserl's work on time consciousness, is common in electroacoustic composition: the phenomenological closure of the experience of time "fuses" overlapping acts of expectation and memory (protension and retension) into an extended field.[40] Such an extension of the present into the non-present is not specific to computer music at all, the possibilities of analog and digital recording and reproduction technologies have enabled an understanding of the past as a condition for producing an infinitely malleable material, a phenomenological sound object (*objet sonore*), which is experienced in the multiple perspectives of random, and thus poeitic, access to a time axis.[41]

These are just two most familiar cases which exemplify how *pastness* and *futurity* (rather than just time) can function as necessary conditions

[38]The different orientations in this 'field of passage' has distinguished many philosophies of time from each other, and is often retrospectively arranged to make sense as a movement of progress. A detailed discussion of these positions would exceed the scope of this chapter.

[39]The classic source is I. Xenakis, Formalized Music: Thought and Mathematics in Composition (Harmonologia). Pendragon Press, 2001.

[40]E. Husserl, *On the Phenomenology of the Consciousness of Internal Time* (1893–1917). Collected Works Vol. IV., Dordrecht: Kluwer Academic Publishers, 1991. For a discussion of these ideas in the context of electronic music, see Mark Fell (CROSSREF?).

[41]P. Schaeffer, Traité des objets musicaux. Paris: Seuil, 1966. See also: B. Kane, "L'Objet Sonore Maintenant: Pierre Schaeffer, sound objects and the phenomenological reduction," Organised Sound, vol. 12, no. 1, pp. 15–24, 2003. Following F. Kittler, media have been characterised as those technologies which allow a "time-axis manipulation".

and themes for algorithmic music. The relevance of *presence* seems to be obvious, in so far as sound, much more than image or text, is typically associated with the momentary. As discussed already, there is indeed a particular path-specific dimension of the algorithmic, which requires an 'acting out' that cannot safely be circumvented. Within computer music, a specific understanding of presence and a corresponding desire for interactive immediacy has been predominant for many years. It has drawn its inspiration from the 1990s technological turning point where computers became powerful enough to calculate faster than the sampling rates necessary for sound output, which, after a long period of rendering static recordings, made it possible to closely interact with complicated computational processes at runtime. Algorithmic music became live music. This focus on real-time, however, shared the spirit of the era that made programming predominantly an activity of producing a framework of parameters to be modified later when it is in use, in the case of computer music over the time of the performance. In such a way, the requirement of real-time interaction has led to a widespread misunderstanding of the algorithm as a set-up for production, a mere precondition of events. Paradoxically, synchronicity is thereby indebted to an even more severe asynchronicity.

This implicit philosophy of time casts a very specific light on algorithmic music. Anticipation of presence, it tends to conceive of the event as something that happens *inside* a formal structure, rather than *to* it. This explains how it could be that through the very focus on real-time systems, programming itself remained a strictly preparational activity – programming has not much to find out about time, it is a way to preclude it. While it may have seemed a relief that this practice finally acknowledges the performative aspect of the formal, the embodied aspect of the program, if you will, it carries with it a peculiarly unsatisfying deemphasis of the causal structures that are otherwise so central to the reasoning of programming. Even within the paradigm of time as pure passage, the algorithmic should instead be allowed to remain on the verge of time.

Now indeed, the word 'programming' shares a semantic field with 'prediction' and 'predicate', all of which mark an activity that is interested in the relations between possible moments, relations that can be qualified as causal in the broadest sense. Because from this point of view, events are specified as complicated maps of causes and dates, the experience of events is that of an actualisation of a hitherto implicit or virtual entity. Rather than *passing* from future to past, we *encounter* events, just like we encounter an unknown thing we stumble upon. Thus, even though this encounter may be surprising, it is nevertheless a latent reality that had been given already 'before' we encountered it. The programmatic, and usually textual representation of algorithms, like calendars and other models of time, are a way to reason about why and how something has happened, is happening, and will happen. In a world where many things happen, algorithms coordinate encounters, waiting times, postponed plans, prognoses and retrodictions. Change becomes a function of the relations between events, as a result of the logic that underlies a certain world, a logic which is not immediately experienced, but can only be conveyed indirectly, through such media.

In algorithmic music, the distance from immediacy has several aspects. Certainly one of them is the difficulty to intuit what it is that caused an event, where it is that it comes or followed from; it is a difficulty abundant in the logic of proofs, as we have seen, and it has found its way into the logic of music as well. In such a way, even in a completely deterministic algorithmic composition, both composer and audience may be justified to wonder why a certain sound appeared, and how it came about. In the early period of computer based algorithmic composition, composers were familiar with the immense temporal distance between a program and its rendering, which led to the understanding of musical compositions as carefully and explicitly specified workflows of any kind. Its precision notwithstanding, the final outcome was nevertheless able to surprise and often contradict original intentions and aesthetic expectations. This tension between the presentation of a plan and the presentation of its implications sheds quite a different light on time than its architectonic understanding as anticipation of presence.[42]

As we have seen, the idea of passage is essentially captured in an emphasis of a continuously changing state; the idea of *encounter*, by contrast, conceptualises time as something like a spatial dimension, a location without place. In this sense, events are situated in time. In computer languages this style of reasoning is epitomised by the concept of a pure function. The program 'text'[43] represents general laws, whose propositions are held true over the whole of its unfolding, and whose actualisation has no side effect on the laws themselves – it is the immobile relations between events only, which determine the cause of events. Happening figures as an effect, not as a cause. Time is, at least in those systems where it is understood in terms of the purely functional idea, an external parameter that causes a specific state of the runtime system for each of its values. A program represents a model of past and future independent of its particular state, a time-geography[44]. So in a certain sense,

[42]This experience brings about an architecture beyond the architectonic as anticipation of presence. In his theory of music, Iannis Xenakis has emphasised (and formalised) a strict separation between an *algebra outside-time*, a *temporal algebra*, and their combination of an *algebra in-time*. See: I. Xenakis, Formalized Music: Thought and Mathematics in Composition (Harmonologia). Pendragon Press, 2001, p. 155ff, in particular p. 160f. See also D. Exarchos and Y. Stamos, "Inside/Outside-Time: metabolae in Xenakis's Tetora (1990)," in Proceedings of the International Symposium Iannis Xenakis (A. Georgaki and M. Solomos, eds.), (Athens), pp. 169–177, University of Athens, 2005.

[43]Considering that technically, *text* is now more broadly understood as *inscription*, *program text* seems to be a good term for any initial representation of an algorithm. This prime mover may have a geometrical or even a sonic form.

[44]N. Thrift, "An Introduction to Time-Geography," Concepts and Techniques in Modern

with respect to algorithmic music, from this perspective programming is purely preparational as well, but now in a completely different sense: an event does not happen inside a formal system, but the event actualises itself as the formal system itself. Programming is a throw into a future, an anticipation of certainty,[45] which may be unknown, but confronts experience from the outside.[46] One can characterise this conception as hauntological:[47] in a program we encounter a *past future*, which, as we can infer from mathematical logic, can neither be reduced to its presence nor its end.

Algorithmic music as a theory of time?

Passage or encounter: many of the disagreements in the philosophy of time can be shown to be a disagreement between these two conceptions. Following the philosopher John McTaggart, they are often called *A-series* and *B-series,* or *tensed* and *tenseless*, respectively.[48] It may not come as a surprise that he has shown the interdependence between the two to be contradictory. The argument is instructive: if I say every event is characterised by *passage*, I need to accept that the pastness, presence, or futurity of an event is prone to change over time like any other attribute. 'Having rung' is an attribute of nothing else than the alarm sound itself. For this to be true however, events must be *encountered* relative to an absolute order of dates: e.g. the alarm rang at half past seven, or in the year that Schönberg was born, pocket calculators were still hard to imagine, but now they are almost forgotten. From this perspective, the moment of the invention of the pocket calculator, as a presently experienced moment, is not really a proper part of time, and neither is pastness and futurity. Here, McTaggart finds a deadlock: the very order of dates that we encounter and which orders temporal attributes, in turn can only be assigned to events that have actually been recorded, and thus happened in a moment. This however would have required a passage in time in the first place. Refuting the idea of "real-time" avant la lettre, McTaggart thus claimed the "unreality of time".

Geography, no. 13, 1977.

[45]The classical discussion of the idea of a logical time as an anticipated certainty is J. Lacan, "Logical Time and the Assertion of Anticipated Certainty: A New Sophism," in Écrits: The First Complete Edition in English, W. W. Norton and Company, 2006.

[46]In this way, all writing is a kind of programming, whose future will have been always that of a ghost of its past. J. Derrida, Specters of Marx. New York and London: Routledge, 1994. For a discussion on Derrida's and Blanchot's work on time, cf. J. Hodge, Derrida on Time. Oxon and New York: Routledge, 2007, pp. 91ff.

[47]The term *hauntology* was coined by Jacques Derrida to describe a past future befalling the present as lack (in ibid. p. 10), and has been reestablished more recently in the context of political theory and sound, especially by Mark Fisher.

[48]J. E. McTaggart, "The Unreality of Time," Mind: A Quarterly Review of Psychology and Philosophy, no. 17, pp. 456–473, 1908; as well as: R. M. Gale, The Philosophy of Time. New York: Doubleday, 1967.

In the thinking of time, the frontiers between different, and sometimes contradictory, concepts are renegotiated, a negotiation that can only work indirectly, that is through experimental use of those media which convey and organise time. Within algorithmic music, such a renegotiation can be found in live coding[49], which shall serve us as a final example. It is meant to demonstrate how the specifically acoustic complementarity between frequency and instantaneous time, as established through Gabor's theory, has its counterpart in a different, namely an *algorithmic complementarity*.

The practice of live coding is born out of the negation of the idea of programming as preparational activity, as 'anticipation of presence': it counters the understanding of computer language as a means to build an interface, and instead takes the rewriting of language as its very means of interaction. Its particular difficulty lies not so much in the act of writing a running program from blank slate; this is only a specific stylistic decision; the pervasive subtle challenge is the intervention in an ongoing process through the modification of its laws rather than of its immediate state. Thus, live coding becomes a particular cross section of different modes of experience and reasoning through formal writing and its computational processes.

Paradoxically perhaps for a form of performance, this brittle focus on the liminal aspects of algorithms deemphasises the interactive control of a present state by parameters. It is not about real-time control. A peculiar variant of temporal incommensurability becomes manifest in it, which is well expressed in the vocabulary of physics (even though it applies not only to physical temporality, but also to logical time, or pure sequence). Like in sound, this incommensurability has two sides, or conjugate dimensions. But what was understood as a frequency spectrum is here the law – a representation of causality, like a plan, the descriptive side of an algorithm. Indeed, a frequency spectrum is also a specific form of law that tells us once and for all what is bound to happen. The program as description, which is often a text, figures here as an indispensable means for reasoning about the causation in an unfolding sound process. In a way, this aspect is a model of time as encounter, a model which can be called a *causal picture* insofar as it implies time in the form of a prediction of encounter. Live coding as a practice is only possible, however, by combining this implicit anticipation by a second aspect, namely the intervention into the program text at a specific moment of its unfolding process – that is, in fact, by changing its laws, by changing the past of what constitutes this moment and of what motivates the very change that is made. This reformulation responds to the passage of time, with its momentary changes of states – it is, in technical terms, made relative to a *state picture* of the passing current moment.[50]

[49] See chapter XXX (live coding).

[50] In the physics literature, these two perspectives have become associated with the protagonists in the debate in the quantum physics of the mid 1920s, as the (causal) *Schrödinger*

There are cases where such a change to the state of affairs can be made to precisely coincide with the change of a program: think of a global variable that has one single accessible state at each point in time. A change in the description of its value has an immediate counterpart in the change of the process. But in all those cases where the value depends on an algorithmic description which is changed, the modified program text is not a valid representation any more: it fails to convey the reasons *why* things are now as they are. To retain this causal picture, it would be necessary to reset and completely unfold the program once again, this time with new premises. But this is not a general solution either: by the time we would reach the moment of intervention, its corrected state may have become completely inadequate with regard to the respective moment in time. This may be the case because time has passed, or because other states have now turned out differently as well. But the measure of what counts as 'now' has no absolute reference, which it could use as a comparison. Under these conditions, also in algorithms, causal aspect and state aspect are conjugate, or in other words, complementary perspectives: where we focus on the first, we partly lose the second, and vice versa. If laws are real and subject to change, this is the logical consequence.[51]

Concerning itself with intervention and law, live coding – independent of it being understood more as a performative or compositional practice – marks a point of greatest tension in a wide field of algorithmic methods. As we found, this can be read a result of the characteristic of time to appear in the form of a split between presence and existence, as alienated from itself, as a tension that essentially remains irresolvable. In such a way, time functions as a hinge between different registers, such as physical, cognitive, static, and dynamic. Just as sonic complementarity, but in another way, algorithmic complementarity is a typical dilemma in the rethinking of time: unable to resolve the contradiction, it gives rise to numerous partial solutions, each of which provide a medium of time, and inform their own theory of time.

As I have tried to argue, by being incommensurable, concepts do not automatically become irreal. Some aspects of reality may by inner necessity require incommensurable, and seemingly 'irreal' perspectives. To still account for them, we need mediating structures, which only indirectly convey them. Drawing from all kinds of cultural, aesthetic, physical, or formal resources, such images of time often seem irreal, as if those who make and use them were acting out of an irrational ideology. But, as the social anthropologist Alfred Gell argues, the paradoxical cultural differences in the models of time "do not arise from disturbances in the logic

picture and (state) *Heisenberg picture*.

[51] There is a sense in which it is this uncertainty that logically renders time irreversible. Whether or not this is a valid argument at all would have to be discussed in the context of philosophy of physics, e.g. S. F. Savitt, ed., Time's Arrows Today. Recent physical and philosophical work on the direction of time. Cambridge: Cambridge University Press, 1995.

which governs ordinary experience, including temporal experience". Intuition is challenged, in "moments of rapture" – necessary consequences of "our reveries of the real, the rational, the practical, which are full of surprises"[52]. Thereby time turns out to be a category that is indifferent to the distinction between cultural and physical, and yet, as we may say now, is exposed to its own incommensurability.

The liminal nature of algorithms is a central issue for understanding the specificity of time in algorithmic music. It is their temporal ambiguity, being half in and half out of time, that makes these 'unfoldable formalisations' such remarkable means and subjects of investigation. From some distance it seems clear why algorithmic music is an intriguing case here: it inhabits mathematical, cultural, aesthetic, and physical spheres. Because it is concerned with sound, which is an ongoing affair, a consideration of time cannot be avoided as easily as in other subject matters. Implicitly or explicitly philosophically, it thinks simultaneously through programming, process, and sound. And rather than taking it for granted, as a self-evident resource, as capital perhaps, that can be invested in the production of surplus-time, implicitly or not, algorithmic music reasons about time.

[52] A. Gell, The Anthropology of Time: Cultural Constructions of Temporal Maps and Images. Oxford; Providence: Berg Publishers Ltd, 1992, p. 314.