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Elaborating Analogies of Time Perception

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Using a mixture of physiological evidence and analogies of time, the author describes the current version of a model of how we might view our interactions with time in music and beyond. An older model designed for analysis of complex twentieth-century acoustic works is updated to incorporate varied profiles of electroacoustic music. Recent research in auditory systems corroborates that we receive different types of information simultaneously through different channels, each taking more or less periodic sampling from different bands of frequencies – from timbre to phrase length and beyond. In order to acknowledge both the primitive structures of our complex hearing mechanisms and the different profiles of listeners, it is suggested that this multiple-sampling strategy may operate in a parallel way at a much larger scale, thereby allowing us to integrate the listener's preference for pacing, contrast and densities of activity into the sensory processing of a musical work. The article is enriched by insights from soundscape pioneer Hildegard Westerkamp relating to various aspects of the discussion, from sensory overload to ecological concerns to the natural *rallentando* of a soundwalk. Finally, a whimsical elaboration based on the analogy of time as a river is presented in order to incorporate a more organic set of characteristics into our appreciation of music and time.

1. INTRODUCTION

The subject of time and our perception of it is notably complex. Time is such an essential part of our experience of life that any explanation about the behaviour of time becomes context-dependent on our perspective (what is being studied, by whom, from what distance, in what context); our filters (cultural, aesthetic, physiological, etc.); the particular scale of rates and durations being studied, and the standards for measurement being evoked: inner sensations or planetary motion? Newtonian principles? String Theory? Evolving time?[1]

Our findings are likewise conveyable in numerous ways, each with its own influence: are we exploring time for our own understanding, or to share with others? Are we concerned with linking our findings to our community's prevailing worldview, or with inventing new viewpoints, or simply wondering how best to arrange the sounds in a new composition? This diversity of time's properties helps explain the range of analogies that have been devised: linear *vs* cyclic time, clock time, time as a river, an arrow, an onion-skin, a flame and so on. Believing that such analogies can provide the 'something-to-hold-onto' factor that a composer appreciates while working, I have been developing my own set of analogies for an appreciation of time in music which combine all the elements I find useful.[2] The current result – an almost unmanageable collage of rivers, graph paper, telescopes, gears and mixing boards – is best treated as both 'in progress' and begging 'poetic licence' but presented here in the hopes that it might provoke further reflection by composers and analysts.

1.1. Background

When I first read Stockhausen's article '... *How Time Passes* ...' (1957), I was fascinated, but could not internalise its central idea that pitch and rhythm were usefully seen as part of the same continuum; confusing those two different modes of listening seemed an error. After decades of reflection, I am now ready to adopt an even broader view than Stockhausen's, akin to a related text I read at the time, by Bielawski (1981). This describes a continuum far beyond Stockhausen's range, stretching from light waves to human history, which he divides into seven (sub-dividable) zones, three of which concern music: (2) audible sounds, (3) psychological present, and (4) compositions and performances. Such a viewpoint is compatible with another idea I have absorbed, that music can present microcosms of experienced time: portrayals of familiar and unfamiliar time-scapes – in miniature or as fragments of real-world time. These can be created through typical and atypical fluctuations of densities of fast- and slow-paced events and moods, and can also model elements of memory and future expectations that pepper our everyday experiences. Furthermore, in most cases, even when the listener is following the time-flow of a single-paced narrative, multiple processing rates are employed simultaneously.

[1]Fraser (1982: *passim*) argues coherently for the view of the evolution of time.

[2]Thanks to Landy (1994) for this term, which I am re-purposing here but in an associated context. My enthusiasm for analogies and metaphors was kindled by Mark Johnson (1999) and fuelled by the impact on my own thinking of various anthropomorphic descriptions of concepts by diverse composers, artists and the occasional musicologist such as McAdams (1987).

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The complexity increases when the musical form involves various fast- and slow-flowing currents, which may or may not appear related to each other.

From this perspective, time in music is perceived on two levels simultaneously: the clock-time duration of the composition, and the time that the composition itself represents or evokes. Instructions (whether to a computer program or to a performer) are usually carefully plotted out in relation to a fixed reference – such as the clock – in order to produce the desired proportions accurately. As some features of music are perceived directly, involving our human body clocks to encode and retrieve them, we discover that only some aspects of temporal activity are in fact reducible. Just as a theatre piece depicting two years in the space of two hours still depends on words spoken in 'real time', music depends on certain elements retaining their real-world scale to be intelligible.

Although my initial scholarly research into musical time was conducted with reference to twentieth-century acoustic music, it is the vastness of the electroacoustic repertoire which has helped broaden my views to this point; my recent conversations with Hildegard Westerkamp, who agreed to brainstorm with me about time in soundscape composition and soundwalks, also helped refine some concepts and fanciful analogies. As various aspects of my own views on time in music are available elsewhere,[3] I have chosen to focus here on some recent modifications, as they emerge specifically from reflecting on electroacoustic repertoire, compositional and listening strategies, representations and analyses, and trying to find ways to express these ideas which might resonate with people in a variety of fields and functions.

2. LISTENING MODES AND CLOCK TIME

Speaking about processing sounds for her composition, Westerkamp (2019) said:

> I realised that it's actually a parallel experience to how we listen. … When we listen to anything in the world, we will process it immediately – interpret it – as we listen. … To me that processing in the studio is an equivalent, really. And that's … the reason why I'm doing it, because … what I really like to explore is how we listen.[4]

The joy of entering a listening space/time is partly that one has mentally reserved the evening – or whatever duration is anticipated – to completely lose oneself in experiencing time *without any concern for the clock.* It is only the composer who needs to deal with the clock in order to ensure that her designs will be carried out as intended.[5] However, the dichotomy between the 'real time' of clock time and 'inaccurate' or 'distorted' human perception of time is somewhat artificial, as 'clock time' – and by extension, 'calendar time' – is only accurate insofar as it approximates the solar cycle from a human perspective. Thus, perception of time is not 'erroneous' in situations when one hour seems longer than another, but simply focused on something which is not moving at the same rate. It is not 'time' but the earth's orbit around the sun which defines many aspects of our lives: day/night cycle, the annual cycle of seasons. In the everyday world, however, it becomes extremely useful to be able to express any temporal duration in clock time for the sake of coordinating with each other. For composers (and analysts), this is excruciatingly true when we are building artificial temporal structures for reproduction – although in musique concrète, oddly enough, as with improvisation, it is possible to organise sounds into interesting configurations without paying much attention to their clock-time durations. In many cases, we gauge the passing of time through our body clocks instead, which most of us have learned to 'convert' to external clock units when necessary.

2.1. The range of inputs and contexts for listening

Our auditory system appears optimised for perceiving sounds emanating from physical sound sources and processing them accordingly, so it seems useful to reflect on how we perceive time in our lives, and how we perceive sound in the natural world. We have evolved ways of processing as efficiently as possible depending on their role: speech and other forms of human vocal expression; limb movements such as walking, drumming, dancing and gesturing; more intimate body functions such as heartbeat and breathing; natural sounds from the environment; and, increasingly, an array of more artificial sounds ranging from signals, machine rhythms, and the ubiquitous internal combustion engine to traditional and newly invented instruments and playback systems.[6]

2.2. Periodicities in music and our auditory systems

Our perception of sounds emerges through a blend of data that comes in part from an array of sampling at different rates of activity (and bit depths), a knowledge

[3]Mountain 1989, 1993, 1999, 2001, 2003, 2004 and a forthcoming book *A Musician's Guide to Time.*

[4]Westerkamp has pursued the topic of listening in depth in several of her talks and writings: see her webpage (www.hildegardwesterkamp.ca) for a complete list and some online texts.

[5]There are a few exceptions where the composer has not clarified a durational 'frame'.

[6]Despite modern desires to assume that we can re-wire ourselves in a generation or two, I believe that we are protected – or shackled – by a much slower evolutionary rate, and that our brains, although 'plastic', have basic reactions not unlike our ancestors.

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of what is typically found at those rates, and the effects of each rate and combinations thereof. Some of these rates are traditionally indicated through salient periodicities in the music or by their resemblance to familiar configurations (from natural or human soundscapes, or from musical repertoire). Typically, some of the periodic elements are aligned in nested fashion, like the formants of a fundamental, as Stockhausen points out (1957: 18–19); we then may guess that they are emanating from the same sonic image. (There are of course non-periodic elements involved as well which contribute to these effects, or negate them.) Periodicities have various functions: they help minimise information load; they can provide a clock-like framework against which the more organic or fluid qualities of a musical passage can be better appreciated; and they may signal the likelihood of a particular type of sound source by a specific nested arrangement. In more complex environments ranging from soundscapes to experimental music, this last factor in particular will also help in segregating auditory streams. The direct perception of faster rates allows us to store information about temporal patterns in reference to our personal body rhythms, so the accuracy of memory and reproduction is assured (although still vulnerable to distortions through metabolic shifts).

Music with a discernable pulse and regular pulse-grouping level (which I call 'super-pulse' – see section 3) usually corresponds neatly to rhythmic limb movement, and our direct perception of those periodicities has thus been reinforced through dance, work songs, etc. since time immemorial: this is called 'entrainment'.[7] However, in other cases, such as speech – and some electroacoustic music – the nested structures which indicate the cohesion of various periodicities into a single stream operate at such fast rates that we cannot perceive any potential harmonicity in their relationship. Since the brain seems to appreciate having a large-scale reference grid, however, the listener may then experiment with other slow scanning rates, although they may be much vaguer in their regularity and more susceptible to distortion from the musical context. If we imagine our scanning rates being controllable through a kind of mixing board, with each channel assigned to a particular band of frequencies, and the gain controls indicating the amount of attention (focusing lens), then we can understand that some listeners will choose to leave the board at its default levels while eager aficionados (typical of the electroacoustic community) will prefer to try numerous configurations to discover the optimum information flow.

A key point to my discussion involves the nature of this sampling strategy, and its function. I began to imagine it as relying on an array of pinion gears, linked to our internal clocks, which we try to mesh with the 'racks' of the musical signals to pick up a series of 'core samples' of the audio.[8] The 'samples' themselves – at least at the range of pulse and super-pulse – appear to have relatively short durations (like a square-wave duty cycle of 10 per cent perhaps?), long enough to tolerate Weber fraction deviation[9] and to notice slight deviations in the onset which, if continued, would alert the brain to the potential of a global tempo fluctuation. This interpretation is suggested by auditory research which demonstrates that when a specific period is established through sonic pulses, listeners are much less precise in identifying sonic information which falls outside the expected target zone (just as they do with unexpected registral displacements for pitch) (see, e.g., Dowling, Lung and Herrbold 1987 and Monahan and Hirsh 1990). But since we can simultaneously discriminate extremely fine fluctuations in configurations running at much faster rates, it shows that we are expecting certain types of information on certain channels. Thus, intermediary material – such as the faster sub-pulse, textural, and ornamental rates of metric music – are supplied by different channels sampling at those rates, and understood as having complementary functions. I suspect that many of those who enjoy electroacoustic music are particularly 'tuned' to the more microscopic level as a potential zone of salient information.

2.3. Expanding the framework

My proposal is that this type of multiple sampling according to roughly periodic rates may operate on virtually all levels of time – at least in the form of a structuring framework. Such a framework allows us to remember activities and experiences with reference to a time-scale, whether constant or nuanced by content. At slower levels, the sample durations themselves would presumably be longer, if they maintain a similar proportion, but those samples are themselves likely to be a composite of faster-level samples, optimised for storage/retrieval efficiency (an ongoing process in listening, where the 'now' rarely exceeds 10 seconds; see Mountain 1993: Appendix B). Listeners doubtless have preferences for different levels of activity and experience, which predispose them to particular

[7]See London (2004: 5 and *passim*) for a full explanation of entrainment in metric music.

[8]Worm gears also work well for this analogy.

[9]Nineteenth-century psychologist Ernst Weber noticed that two things – such as duration, or distance, or weight – would be sensed as being equal if the difference between them is sufficiently small, and that the 'just noticeable difference' (JND) is a constant in relation to the overall size. For many decades, the figure of 8 per cent was used as an average for temporal durations (i.e., two durations that differ by less than 8 per cent will be sensed as essentially equal in length), although there are now various studies showing discrepancies in this figure and to the entire concept, from personal acuity and overall duration bands; see for example Ungan and Yagcioglu (2014).

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configurations of sampling rates. Returning to the analogy of the mixing board, the gain controls for the various frequency bands (from microseconds to composition length and beyond) would be complemented with other controls for adjusting the precision level, aperture (sample duration) and, perhaps most importantly, clutches to enable (and disable) synchronising between specific channels. Since this often needs to be done 'on the fly', it makes sense that we learn to anticipate particular arrays of the most appropriate lenses.

2.4. Reinforcements from auditory research

Recent research in auditory perception confirms that we listen to our environment on various channels simultaneously, through a multiplicity of body systems. In metric music, for example, it is clear that we track the pulse, super-pulse and phrase lengths simultaneously, as a nested hierarchical arrangement, while simultaneously discriminating pitch and timbre with different receptors. So, although the metric structures form a kind of 'graph paper' ground which allows our efficiency-seeking brain to focus on the more irregular gestural or melodic figures, the pitches or timbre are not heard as extensions of that grid – *pace* Stockhausen. Entrainment seems to aid greatly in mental processing by passing a significant part of the incoming information directly to those body clocks that inform our limb movements. Simple global fluctuations of tempo are then easily tracked, although it helps when smaller units (e.g., sub-pulse) are articulated, as they provide a higher resolution of the fluctuation curve.

The older assumption that our bodies contain a 'master clock' which controls all the other clocks (enabling us to do things from breathing and heartbeat to physical gestures, sleeping and dancing) is now being challenged in favour of the idea of a master synchroniser, which is itself able to be substituted in some circumstances (see, e.g., Phillips 2002: 254–6 and *passim*; Reinberg and Ashkenazi 2003; McGuiness and Overy 2011). Research also indicates independent controllers for different temporal activities, including memory (Jacobs, Allen, Nguyen and Fortin 2013). In addition, it is being shown that our auditory system works in both parallel and hierarchical ways, using different channels for different purposes: three employed just for determining spatial origin (Briley, Goman and Summerfield 2016), several for scanning for activity within broad registral bands, others for scanning smaller-range frequency bands for finer frequency discrimination, etc. Phillips (2002: 255–6) further underscores that when, as is typical, more than one channel is providing the necessary information about the sound, the brain needs time to switch channels, especially if the different channels' data have to be compared.

The idea of scanning at pre-set periodic rates is consistent with the idea that we want to be as efficient as possible in coping with the selection and parsing[10] of incoming audio information. At slower rates (e.g., a typical phrase rate of 10–15 secs, or a section rate of a minute or two), we seem to rely almost exclusively on a variety of elements such as familiarity of material, awareness of development techniques, and contrast between sections to contribute to a sense of experienced duration. Since these depend enormously on phenomena such as mental processing, the individual profile and attitude of the listener become so crucial that further expansion of rhythmic frameworks often seems useless. However, I believe that the influences on a given listener's mode can be disentangled to allow more investigation.

3. ADJUSTING THE MODEL FOR ELECTROACOUSTICS

My original attempts to disentangle issues surrounding rhythmic perception in music (Mountain 1993), based on studies of complex early twentieth-century acoustic works, revealed a tight correlation between the actual rate of periodicities manifest in this type of music and our perception of their functions. Specifically, I identified five main bands of periodicity with proposed clock-time boundaries:

1. Ornamental/textural:[11] 25[?]–100 ms (or 40–10 Hz).
2. Sub-pulse: 100–500 ms (10 Hz–120 bpm).
3. Pulse: 500–1500 ms (120 bpm–40 bpm).
4. 'Super-pulse': 1.5–4.5 secs (or, up to 6 secs).

5+. All other longer/slower rates – phrase levels, etc.

I speculated on further subdivision of the band '5+' to include macro-pulse (5–45 secs) and meta-pulse (0.5 to 10 mins), but the multiplication of ingredients was too daunting to predict boundaries.[12] The periodicities in the band I labelled 'super-pulse' (equivalent to a typical bar length of metric music) have a particular

[10] I use 'parsing' in its general rather than strict linguistic sense to refer to the cognitive process of grouping elements that are usefully grasped as being the ingredients of a larger element, similar to lexical analysis.

[11] 'Textural' in the sense of passages or layers in which the listener's attention is focused on the interplay of the components rather than on any individual part.

[12] It will be noticed by those familiar with Roads's (2002) time-scales that our respective approaches betray our respective foci: much of my level 1 and below (which I considered sub-rhythmic) are expanded by Roads to the four main zones of the microsound world (Micro, Sample, Subsample and Infinitesimal) while my other five delineated bands of sub-pulse, along with pulse, super-pulse and two longer ones with vaguer boundaries (macro- and meta-pulse) all fit within his levels 5 (Sound Object) and 4 (Meso).

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stability, even in the absence of metric organisation, doubtless relating to their correspondence with limb movement (the full gait of a left-right step[13]); the piquancy of rhythmic dissonance also seems exceptionally salient at this level. I suspected that it might serve as a kind of default 'fundamental' scanning rate, with any consonant faster pulses being perceived as 'formants'. The link to gait seemed to reiterate how our perception mechanisms are optimised for human sound production and reception, just as our ability to distinguish frequencies is more accurate in the range of human speech than above or below, and the correlation between the liminal threshold separating our perception of pitch from rhythm (around 16–20 Hz) correlates with our upper capacity for coordination of fingers in tapping or playing notes on a keyed instrument.

3.1. The case of the missing super-pulse

My first concern with adjusting this '5-band' model to the electroacoustics field was the vast number of acousmatic works I encountered which appear to have no major fluctuations of intensity at the super-pulse level but instead have significant activity on the much faster levels of ornamentation, timbre and fine-grained texture, often with a pulse level too. (Of course, most works have audible fluctuations at the longer durational level – even if only in the form of gradual shifts towards and away from tension or complexity.) I first speculated, facetiously, that early electroacoustic music composers and fans were less interested in the body – and it is true that some works do promote a more purely cerebral effect, in which the listener may be more 'spectator' than participant. On the other hand, I also remember being intrigued at the reactions of listeners at an electroacoustic concert who had difficulty adjusting to the pace of a soundwalk-based work, specifically *because* it moved for several minutes at a real-world speed, as underlined by the presence of the composer's footsteps. But in many other works, the bodily sensations seem more vivid than in conventional metric music, when they portray forces which might affect us physically even though they do not involve limb movement per se. For example, as sweeps of sound from one speaker to another can easily represent motion, they become potentially powerful when the frequency and amplitude contours suggest a large invasive thing, or a force that can sweep us away. When there is no beat or pulse at all, the motion can prove very unpredictable, effectively coercing the listener into a passive position subject to the whims of the represented sounds – sometimes akin to being on a roller-coaster, and appreciated or avoided for similar reasons.

Another factor in the 'disappearance' of the super-pulse might parallel our changes of transport: even though our ancestors may have travelled in chariots or in boats as well as walking and running, the rhythmic pace of the drawing animal, the oars, or the slap of the waves would still be audible. I was also intrigued to learn from Westerkamp (2019) that a typical occurrence in a soundwalk is for the participants to (collectively) slow down almost to a standstill when they become engrossed in the sounds around them. Presumably this silencing of their self-generated super-pulse is a natural effect stemming from a desire to (a) minimise confusion in identifying spatial location, (b) minimise interference from the audio signal of one's own footsteps, and (c) minimise entrainment to the walking rhythm in favour of allowing the body clocks to seek new patterns.

Other reasons for this avoidance of the super-pulse in early electroacoustic music may include an interest in portraying non-human entities – both natural and mechanical – or adhering to the prevalent new music aesthetics which rejected traditional forms and rhythmic organisation. Another set of influences emerge from a simple desire to focus on the microscopic, due to the sheer delight in having the option to shape a sound with no limitations of performer ability, thus substituting for vibrato, articulation, etc. There may be a wish to compensate for the loss of reverberant court halls and cathedrals, or – nowadays – trying to combat the noisy environmental soundscapes by effectively sculpting it with even higher densities of activity in chosen frequency bands. With any such deliberate attention to the microscopic, it then it seems intuitive to avoid the nearly adjacent super-pulse band to compensate for potential information overload, and move towards longer durations for the next level of significant features.

3.2. Familiar irregularities

Our body's natural responses to sound are of course not limited to walking, drumming and dancing. In speech, we appreciate vocal character at the timbral level, moving towards meaning at the level of phonemes, words, sentences and phrases. Some languages have different properties, and some contexts have different lengths of phrase and depth of meaning (compare poetry, prose, recipes, reports) – and thus it is in music. Then we have the more amorphous, but more universal, vocal utterances: sighs, screams, shouts, groans. These are much more variable in their temporal duration (including pitch/timbre contours), and can therefore be invoked recognisably even when stretched slightly beyond the humanly possible, or

[13]The full left-right cycle may easily incorporate irregularities of the two sections, as in a limp, a hop, or a 'left-slide-right' of triple dance steps.

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timbrally realistic. Closely related to these are body gestures, also highly variable in their real-world temporal contours. Audio gestures of this sort are familiar not only from works such as Henry's *Variations pour une porte et un soupir* but also traceable in Schaeffer-inspired studies such as the under-explored *Unités Sémiotiques Temporelles* research (see, e.g., Favory et al. 2002) and complemented by research in areas such as embodied music cognition (see, e.g., Godøy 2006, and Godøy and Leman 2010: *passim*). The electroacoustic music repertoire is of course full of speech-related sounds, so listeners grow adept at recognising speech even when fairly far away from its natural rhythms. More commonly, we become sensitive to the amount of information we can gain from a few seconds of speech: distinguishing ambiguities of meaning, attributes of authority, mood and degree of personal distance and sincerity. Increasingly, research into speech is probing areas of high relevance to the type of listening in electroacoustics, especially in the timbral-ornamental bands and the multiple manifestations of gesture in music.[14]

A different approach to composition, doubtless invoked by ancient story-tellers and re-surfacing in electroacoustic works as well as with certain other twentieth-century composers (e.g., Crumb, Thoresen), involves high realism in reproducing other natural sounds such as water and bird calls which have no need of pulse or super-pulse regularity to be recognised. In such cases, not only do we have a sense of physicality through that recognition, but we may well be induced into the kind of relaxed deep breathing that often accompanies visits into natural surroundings where one stops to listen (less cautiously than our hunting/hunted ancestors). As breathing cycles can be varied at will when we are not active, between the 'normal' 12–18 breaths per minute to the very slow of 2–3 per minute or less, the incorporation of such rates can be sensed quite easily in the macrorhythms of some pulse-less music.

Westerkamp (2019) discussed how her work often maintains a link between natural and processed sounds:

> The processing that I do is very much in the tradition of musique concrète … abstracting the recorded sound into an unrecognizable sound … but always in connection with a sound that I've recorded and that lends itself to processing … and then invariably its original will also appear somewhere in the piece. By processing a recorded sound, you get to know its inner qualities, its characteristics and sonic details. And so, when I'm processing a sound – say, the sound of the cricket in my piece *Cricket Voice*, where I slowed it down (and that's more or less all I did there) I began to understand its inner rhythm. Slowing it down by a number of octaves, a pulse almost like a heartbeat emerged … and that completely determined how I was going to use it in the piece. I could actually hear the individual grains of the scraping sound … when you then listen back to the original, you have a completely new and deepened understanding of it. And that's really why I do this type of processing.

We discussed the natural rhythms not only of the sounds themselves but also of their occurrence in circadian cycles. She confirmed that '[t]he cricket makes a continuous sound, so you can use it that way … but the raven calls on the West Coast, they're occasional sounds. So in *Beneath the Forest Floor*, they come in only occasionally. I want to be respectful of those original rhythms in the natural world' (Westerkamp 2019).[15] What I find intriguing about this particular treatment of time – retaining a sense of real-world proportion of events while 'unpacking' the microscopic – is that it incorporates the idea of a set of adjusted lenses rather than a simplistic 'compression' of elements.

Electroacoustics provides an ideal set of tools to accentuate and exaggerate any and all of these different models: body rhythms, speech, realistic and imaginary soundscapes, abstract patterns and aural illusions. Naturally, our perception of time passing in each one of these will depend on a combination of the ways in which we tend to process all those things: if we hear speech-like sounds we might expect certain lengths of phrases and certain types of character and meaning; if we hear something reminiscent of birds and water we may switch to a more relaxed appreciation of the sounds; if we hear unfamiliar textures evolving slowly we may switch to 'abstract' with a focus on longer durations. If those abstract textures start growing louder and faster, we may feel more absorbed and even overwhelmed by their energy. And if everything suddenly switches to another mode, we might have a marked emotional response to the contrast.

4. INFORMATION OVERLOAD

Westerkamp talked extensively about the soundwalks she has been involved with, and the way in which participants 'forget about time' during their experience. The organisers at the Vancouver Soundwalk Collective have determined that a one-hour event

[14]Research clusters have managed to improve this exchange dramatically when conditions are favourable, such as in Montreal, where funded centres such as CIRMMT (Centre for Interdisciplinary Research in Music Media and Technology) and BRAMS (International Laboratory for Brain, Music, and Sound Research) help host and promote interdisciplinary conferences, talks and projects to complement the work of individual scholars and their teams, involving numerous specialists and practitioners in music (including electroacoustics and *musique mixte*) and auditory and cognate research.

[15]This idea of 'respect' is of course related to the ecological approach that characterises the original soundscape composition stance – a concept that becomes increasingly difficult to convey to people who are living almost exclusively in the aggressively noisy environments of human design.

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(followed by an essential discussion session which allows people to appreciate both the commonalities and the differences of their listening experience) seems ideal for giving the group time to 'settle in' to full listening mode, without exceeding the likely potential of undue fatigue from the unusual concentration on aural information. Westerkamp acknowledges her own tendency to become easily overwhelmed by sonic information in the studio, the concert hall, and the environment. This is of course a natural state for anyone who listens intently to sounds, but seems more readily acknowledged by those researching auditory processing than by many composers, who seem to feel that we should be able to handle everything.

Our whole auditory system has evolved to minimise overload: the constant searching for patterns and recognisable soundprints permits a continual discarding of all extraneous noises. The problem comes from having a palette of sounds and behaviours so varied and full (as in many electroacoustic pieces and increasingly in our environments) that the determination of what is extraneous becomes challenging – and challenges cost processing time, leading to reduced acuity in temporal judgements. It is interesting to note the variety of strategies we use, such as our ability to re-adjust the timeline of sonic events in order to conform to our preferred interpretation: experiments of 'click migration' (discussed in Kaminska and Mayer 1993) showed that participants mentally 'moved' an interrupting noise-burst to the start or end of a musical sub-phrase, rather than accept that it was temporally interfering with the melodic line. This indicates that our hearing of simultaneous things can be re-organised to accommodate more plausible scenarios. One wonders how often this phenomenon occurs in electroacoustic music contexts.

5. SHIFTING BOUNDARIES OF TEMPORAL DESIGN

Many composers have thought about music as being specifically an art of time: involving its shaping, manipulating, patterning, distorting, etc. Those who do not are nonetheless preoccupied with temporal aspects: duration, scale, tempo, proportion, speed, motion, envelope shaping, articulation, etc. 'Temporal design' usually implies the conceptualisation of the entire work as a single duration (the length of the piece) filled with sonic material in certain orders and relationships according to aesthetic choices. Such choices might involve the choosing of a particular set of rules (e.g., Brownian motion, serialised fields), complementing or interweaving with another aspect of the artwork (such as film or dance) or a more idiosyncratic arrangement of densities and moods in certain proportions. The idea of thinking of the duration of the piece as a single unit is very convenient (even when it refers to an imprecise duration), yet it is more appropriately viewed as merely one duration in a multiple, possibly hierarchical, set of time-frames.

When thinking about all the temporal qualities of a composition, the listener's attitude towards time in general becomes an unavoidable element in the reception of the work. For this reason alone, I prefer to consider the larger scale, beyond the piece, as a kind of extension of its temporal design. We know from experience that the order of pieces on a programme will influence their reception to all but the most resilient listeners, because the contrast between pieces is potentially very close to the contrast within a single work, for which the influence of Section A on Section B has already been calculated by the composer (although we may say, like Drever (2019), for whom?). Even though the experienced concert-goers usually move into a particular listening mode to experience atypical configurations of time, they are influenced by their habits, character, attitudes and environment. Thus, the effect of one piece's temporal organisation impacting the next can be extended far beyond the concert-time, and extended from music to everything (or vice versa). For example, thinking about time as cyclic or linear depends partly on one's perspective (as a circle can seem a straight path when it is large enough in diameter and the viewer is focused more on the path than the surroundings). Similarly, there is a potential difference between a listener who studies historical periods and one who studies virus mutations; one who is 90 years old and one who is 15; one who has a steady job and one who works freelance. One can easily imagine that a listener in a boring predictable job might welcome an evening of listening to an unpredictable sequence of events, or that a freelancer might appreciate something orderly, but it is also probable that their schedules will influence their abilities to track rapid changes or to sustain interest in an almost-still atmosphere. Electroacoustic music is as susceptible to these influences as more traditional forms, although its fans may be characterised by an unusual tolerance for the degree and speed of change at all levels and parameters.

Many composers still think about their works in a more fixed way, assuming that a certain perspective will give the maximum benefit even if it is acknowledged that other interpretations are possible. Westerkamp reminded me of this error of imagining a single listener profile while explaining her approach to soundscape composition. I had conjectured that she was presenting an imaginary soundscape with a realistic character and was leading people through it. However, she rephrased it in a way that seemed much more fitting:

> I would say a piece is usually about places or sometimes about situations that ideally lead the listener into their own aural imagination, rather than talking about an imaginary place.... There's a very strong concrete element in my pieces, and it's often the basis from which

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> listeners can actually go into the imagination and can connect. It guides them into the listening, and then from there, they ideally can keep on listening and imagining, and then their listening will not stop. The piece will stop, but their listening will not stop. That's where the similarity to the soundwalk comes in. (Westerkamp 2019)

Even restricting ourselves to a single model listener, the notion of temporal design is imprecise, as it may be subject to change in mental representation or focus on repeated listenings as well as to changes resulting from different performances or different listening contexts. The listener may choose – deliberately or subconsciously – to listen to a composition as an unfolding of a single temporal design, or on the contrary to immerse themselves in the sounds and their transformations and interruptions with little attention to previous or upcoming sonic events. Certain conditions can help induce the immersion effect: high-fidelity speakers, isolated environment, high density of sonic activity, etc. Analysts prove their usefulness by suggesting which strategy (or mixture of strategies) might be the most appropriate for any given work or part thereof.

The electroacoustic composer's typical attention to microscopic activity often seems to fit within these immersive conditions. Although one might argue that a listener is 'immersed' in music when entraining at the pulse, sub-pulse, or super-pulse level, that seems to me a different type of linking, whereby the mind is much freer to track the larger-scale patterns and designs. Focusing at very fast rates of activity heightens the potential of information overload, as the brain does not have the time to 'zoom out' without losing focus of the close-up. It thus suggests an aesthetic choice in favour of immersion on the part of the composer. What changes in our perception if we stroll around the room while listening to an immersive-style piece, thereby providing another tracking level?

6. AESTHETICS OF TIME TRACKING

We are also aware of time through memory and anticipation, relating to an entire section, piece or repertoire of the composer – or anything else in the listener's memory. This is quite a different aspect from the direct experience of grains and pulses of sounds, but equally influenced by our habits and preferences. So, just as we can experience time as a projection of different time-frames – some clearly nested within others – we may have preferences for particular combinations of focal areas that seem pleasing or natural (e.g., harmonic or logarithmic) in their proportions and relations to each other, just as we may have preferences for inharmonic tones, or for irregular metres, or non-Western scales. Additionally, if music can act as a microcosm of experienced time in our lives, then it seems possible that it can model such nested durations. We can expand the image of channels of audio information at different rates to the way we track time in our everyday lives: minutes, days, seasons, years, lifetimes, etc. Being involved in a task where components are completed every 5–10 minutes will presumably give a different perspective to those with deadlines every few months, for example. Some people prefer to focus on one activity – whether doing or watching – while others prefer to be in a constant multitasking mode or in environments with different rates of activity. At a physical level also, some prefer limb movement – dancing, rambling – while some prefer rest – reading a novel, studying stars. Such choices must be reflected in one's preferences for music's temporal organisation as well, regardless of the genre.

Remembering and anticipating past and future times correlate to the 'snapshot' effect of listening on certain channels. When I think back to last week, last year, last decade, it is rarely a scanning of a lengthy duration but more like a set of nested video clips of certain key events – contextualised within a calendar that stretches back into the past, with my memory setting up markers of key milestones and snapshots of their environment. I also have a complementary timeline which is marked with milestones of music which struck me as unusual – mostly because of their treatment of time: Stravinsky, Hendrix, Reich, Crumb, Messiaen, Nancarrow, Xenakis, Hassell, Southam, Westerkamp, Scheidt, Truax, Ferreyra, Dhomont and so on. The order in which I heard these coloured my future ideas about how time could unfold in music.

7. ELABORATING THE ANALOGIES

The analogy of 'time as a river' has provided me with considerable food for thought. My current favourite version is to imagine that we are somehow inside a wide and deep river (downstream = into the future) with numerous currents and eddies. Everything else on earth is also in this river, but travelling at different speeds, evolving at their own rates. Our perception of time is therefore dependent on what direction we are facing, what is in our vision, where we are focussing, and how often we change focus. Some travel in the central part (the mainstream!) where there is less variation, and the water less turbulent. But many of us enjoy the little eddies, the rapids, the murky pools and the sandy shallows – where our vision will be influenced not only by the objects and beings we observe but also by the filtering effects and reflections of the water and its banks. The mainstream is the place where one can most easily learn the correspondence between the feel of time and the clock, and, by focusing on the flow of that stream, ignore the fluctuations. The rest of us, however, delight in contemplating the motion of other things and beings around us, and are

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unconcerned with its correlation with the 'average' speed of the river.

At this point, my analogies become complex. Tenney's ideas of 'focus' and 'scale' (Tenney 1988: *passim*) suggested images of telescopes and microscopes illustrating our ability (as listeners) to zoom in on different parameters. From compositional and analytical graphs I absorbed the notion of graph paper representing metric structures, subsequently updated to a series of rack and pinion gears representing our attention focusing periodically in rapid or slower succession. Then there are the spiralling paths which can portray the compatibility of linear and cyclic views of time, and the idea of the river to embed the concept of time's flow.

The river analogy is easy to populate with many things which share a general direction but with different characteristics of movement, growth and decay, and degrees of clarity and murkiness. In trying to flesh out the details of my analogy of gears, I imagined the gear teeth being able to lengthen or retract, indicating the depth of focus at any one time. As I thought it more accurate to incorporate organic flexibility into that image, my first idea (given the shape of gear teeth) was that each would be more like an elephant leg, slowly and gracefully compressing at the knees when in motion. However, for coherence, it seemed best to substitute smaller organisms such as octopi, jellyfish and other fluidly moving creatures of the sea. So, for the moment, I have settled on an image of humans as sea creatures, each type with its own array of expanding and contracting appendages – tendrils, telescoping eyes, antennae, etc. – with which we constantly sense and measure our environment. We try to match our measuring systems to the particular temporal behaviour of the objects around us – and are attracted to explore those objects whose features seem likely to be revealed to our particular array of probes.

This complex image still neglects one of the main temporal effects of music, which is the ability to trigger mental reflections of other times. Such effects can be very local – such as the recurrence of a motive heard earlier in the composition – or extremely distant – such as an allusion to an experience from a different place and time. Local aspects are much more likely shared by many listeners, as they are keyed into the design, while distant references may be strong, personal and unpredictable. Depending on the intensity of such 'flashbacks', the listener may well lose track of the currents of time represented in the music. In fact, strong and unexpected contrast of musical material can provoke a parallel event; the irony is that as we are well aware of the infinite possibilities available in electroacoustic music, we are less likely to be surprised at contrast of any type.

The idea of perception in music being influenced by our habits of time perception in general seems so likely that I find it useful, as composer and analyst, to continue with analogies of listeners as sensored organisms with arrays of adjustable temporal probes often left in fixed arrays out of habit. The music we listen to has focal points which would benefit from the meshing of our arrays with its own events and their particular temporal arrangement. If we imagine Stockhausen's continuum extending into the days and years behind and (theoretically) in front of us, then we can imagine the positioning of our markers against a global timeframe, where the date of creation of a piece and the personal date of first listening form part of the background grid of time – little video-clips of the environment of the time, which we replay in our imaginations.

The difficulties lie in combining these last images with my little sea creatures. Perhaps the compositions could be little capsules floating by that hold representations of flowing rivers with things in them; perhaps the allusions to other times appear as bubbles which severely distort the image of the more steadily flowing currents in the foreground. Maybe the octopi like to tap their tendrils along the bottom in entrainment fashion. But as the collage is still unwieldly, I leave it to the imagination of the readers to fill in – or substitute. I have described only the visual part, but sonic characters can be assigned by the imaginer to any or all components of the river systems and imagined as the audio tracks of the video-clips, with the possibility of mentally focusing in on any particular rate of time or specific object. Such analogies can act not only as a stimulus for the creative mind, but also as a pivot between disciplines and cultures, as they are not language-specific, and help willing players to refine the more amorphous details of multifaceted and puzzling concepts such as time, and music, and why we do not listen to our soundscapes.

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