Music, Discourse and Intuitive Technology

Jonathan Impett

jonathan.impett@orpheusinstituut.be

j.impett@mdx.ac.uk

ORCID 0000-0002-6525-2095

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Abstract

This paper proposes that intuitive technologies play a vital role in cognition and cultural reception. The case of music is considered in particular. The perceived temporality of contemporary technology is shown to be an artificial barrier to the acknowledgement of longer-term dynamics.

The increased role of explanatory metaphors from technology is traced across various fields of study. Processes of sense-making – conscious or otherwise – are seen as an informal, unreflected repertory of mechanisms ranging from predictive models to instrumental metaphors. It is suggested that these derive by assimilation and induction from the technological milieu within which the subject develops and operates. The acquisition of these models and metaphors is itself an imaginative process, based on experience ranging from partial expertise to fantastical extrapolation.

Keywords

Intuitive technology, Metaphor, Music, Technics, Temporality

1 Introduction

This paper sets out from two inter-related notions. First, that engagement with music happens on the basis of what we might call a *second-order intuitive technology* – a set of ideas derived from technology in the broadest sense and through mediated experience. And second, that music as a cultural experience provides a unique prism through which to re-examine our relationship with technology – both historically and, crucially, in the present. It will attempt to show that the blurred boundaries of these ideas are fundamental to their functioning. Like any idea of which haziness is an essential characteristic, they dance at the intersection of a range of possible disciplinary and theoretical approaches, each with their own terms and strategies. From these initial premises we develop a wider view of the perceived, instrumental and potential relationship between technology and culture.

There are two sets of issues underlying this exercise – motivations rather than questions: the first is specific to music, the second concerns the cognitive foundations of culture in general. The initial concern of this work is with the practices and discourses of music, but it has broader implications for the relationship of culture with

technology and for the role of metaphor and model in human thought. I want to suggest that these areas crucially inform each other because of the way music works, because of the intuitive technicity involved in its creation and apprehension. This discussion will therefore move between the general case and the specific nature of music. Technology has much to tell us about music; music has much to tell about the mechanisms of cultural production and reception, and in particular our relationship with the technologies of the virtual.

1.1 First motivation

When we speak of music as a cultural phenomenon we are actually referring to a set of practices around creation, reception, infrastructure, criticism and pedagogy, integrated into various local assemblages in increasingly dynamic ways. The discourses of music are not only a set of descriptors, parameters, value judgements or theoretical frameworks. They are also the terms in which it is imagined, created, understood and discussed; they are crucially instrumental in the cultural evolution of music and in the broader place it finds in society. The discourses of description, theory, criticism or manipulation may or may not intersect. They may be explicit or not, verbal or otherwise (and of course most *speech* is intuitive rather than reflective, a major part of it being internal rather than spoken). Ours is an extraordinary moment in the development of music; the richness and invention are overwhelming, technical and theoretical expertise in very specialised areas are highly developed, and yet the common critical and creative discourses of music do not keep pace. This situation raises significant questions: does the faux-liberty of a market cult of individualism inhibit cultural dynamics? Does it promote a state of infinite granularisation whereby art is disarmed? Does the apparent obligation on artists and academics alike to claim novelty and ownership with their every statement actually inhibit the emergence of certain kinds of knowledge?

Schools of thought frame the problem from different perspectives. Alain Badiou points to the negative impact of the mis-use of notions of difference (Badiou 2002, pp. 18-29) and calls for an affirmative aesthetics based on commonality (2006). Giorgio Agamben sees a paradox, a contradiction between the radical freedom of contemporary artists and the impact their work achieves (Agamben 1999, pp. 3-7). He suggests that among the multiplicity of languages of contemporary art, the common cultural ground is the empty space, the shared witnessing of the emergence of something from nothing (1999, pp. 62-3). Francis Fukuyama's analysis of identity politics offers a wider context: "The retreat … into ever narrower identities threatens the possibility of deliberation and collective action by the society as a whole. … But if the logic of identity politics is to divide societies into ever smaller, self-regarding groups, it is also possible to create identities that are broader and more integrative" (Fukuyama 2018, pp. 165-6).

1.2 Second motivation

Such a state has a resonant parallel in Bernard Stiegler's analysis of the current state of knowledge and its crucial relationship with technology. Having established *technics* as a mode of revealing, as essential to human knowledge, he sees a rupture in that natural relationship in the case of modern technics. However, "modern technics nevertheless remains a mode of disclosure [and] constitutes what is most properly to be thought" (Stiegler 1998, p. 10). In particular, he identifies the *temporality* of the action of technics – it no longer acts on the temporal

plane of speech – and the temporality of its evolution – it now manages its own evolution, at a rate faster than that of human culture. He refers to "a divorce, if not between culture and technics, at least between the rhythms of cultural evolution and the rhythms of technical evolution." (1998, p. 15)

The assertion that modern technics "constitutes what is most properly to be thought" will be central to the present argument. To realise its potential, however, we must take issue with the suggestion that modern technology is now advancing at such a speed that human culture cannot keep pace. We might better frame the situation as a phase difference between cultural memory and discourse, and what Stiegler terms "tertiary retention" – the inscription of memory and experience not in individual consciousness (Husserl's primary retention) or language and writing (secondary) but in the artefacts, infrastructure and practices of the modern world as a whole (2009, p. 41). Cultural and technical are bound together in this tertiary retention. The issue to address, then, is one of cultural self-image, of discourse, of acknowledging the mediated technical elements that are actually at play.

1.3 Perceptions of technological time

The illusion of an alienating technological acceleration induces a discourse deafness, reinforced by the apparent exclusivity of expertise and a sense that inherited terms are insufficient – indeed, that they generate a false, brittle nostalgia. The proposal here is that we might consider the models of cultural perception from a technical perspective, as a way to better articulate our relationship both with technology and with our own culture. We can regard this set of issues – cultural fragmentation, the perception of technological acceleration, alienation – as the product of a mismatch between the tools of understanding and the terms of discourse. Not so much a deafness, then, as a muting, which we can perhaps release by encouraging discourse to come into resonance with understanding – and that, it is proposed here, derives importantly from technology.

Thought on the time relationship of technology with society has matured as the issue has become familiar. At one end of the spectrum lies the analysis of economic historian Carlota Perez, who sees the current apparent pace of change in the context of longer historical waves of innovation – a pattern of periods of installation and deployment, of which we are currently in the latter (Perez, 2002). Technical detail aside, many of the fundamental ideas and questions raised by modern technology have been discussed for some decades; frequent reference to the cybernetics of Norbert Wiener in contemporary discussion of machine learning is but one example (Nature: Machine Intelligence 2019). We could look back nearly a century to Lewis Mumford, whose vision of the emerging "neotechnic" order remains largely unrealized, inhibited – as he observed - by the purposes of the previous "paleotechnic" regime, the economic and social structures of the industrial revolution (Mumford 2010, p. 267).

The views of autonomists, of those who see a neo-liberal hegemony as a terminally destructive force to be replaced, bring more urgency to the debate. Bifo Berardi describes "The slow cancellation of the future" (2011, p. 18), and sees the project of modernism, of enlightenment progress, as having been thwarted: "Now that every inch of the planet has been colonized, the colonization of the temporal dimension has begun, i.e. the colonization of mind, of perception, of life. Thus begins the century with no future." (2011, p. 24). He identifies "cognitive workers" as the new norm, and refers to "the fractalization of their life and intelligence" (2011, p. 163), the value

of their labour determined by dynamical, derivative parameters that neither historical concepts of productivity nor economic science are capable of predicting. (We might note in passing that this easy use of 'fractalization' is indicative of the state that this article seeks to bring to light.) Intensity of stimulus and data and the apparent immediacy of technological engagement fully occupy cognitive space to leave no room for a notion of future, which is "a modality of perception and imagination, a feature of expectation and attention, and its modalities and features change with the evolution of culture" (2011, pp. 24-5). Virno (2015) describes the perpetual, incapacitating déjà vu inherent in high capitalism.

A paradox arises: the cult of individualism leaves no space for the formation of the individual. Radical analysis creates space for radical shift, however. Like Badiou, Berardi sees commonality as a path forwards – "the self-organization of collective knowledge". This echoes Negri's call for "the recognition of the common" in contemporary artistic production (Negri 2011, p. 121). Like Agamben, Badiou sees acknowledgement of common emptiness as fundamental to that new knowledge: "The present ignorance has to be seen as the space of a possibility. We have to start from the ignorance of the general intellect. The force of the collective intelligence is boundless" (2011, p. 163). The "re-composition of social subjectivity" is what Berardi seeks, and he offers a succinct definition: "Social composition is the cultural process of unification of the social body through the fusion of imaginary and cultural flows" (2011, p. 127).

These apparently contradictory perspectives (long historical waves or an exceptional state of crisis) gain texture and context in sociologist Hartmut Rosa's account of our "acceleration society", a state simultaneously of both unsatisfiable speed and apparent stasis, a "frenetic standstill" in which "The core of modernization, the acceleration process, has turned against the very project of modernity that originally motivated, grounded, and helped set it in motion." (Rosa 2013, p. 295). He analyses not only the modes of acceleration (technical, social, pace of life) but also the forms of inertia that inhibit this tendency, including "structural and cultural rigidity"; acceleration becomes its own impediment. The present has contracted, in both personal and cultural terms. As for the acceleration of change, so for the cult of individualism: the definition of identity is "detemporalized" and situational, such that the development of identity is ultimately thwarted (Rosa 2013, p. 288). The problem with many readings of the current techno-social environment, Rosa says, is that they bring earlier concepts of time to bear on a situation that no longer conforms in that respect; the dynamical view of time in Rosa"s work owes much to the systems theory-based sociology of Niklas Luhmann. What is needed, he concludes, is "a critical theory of acceleration that is capable of identifying acceleration-induced social pathologies without relying on the normative criteria of a now questionable philosophical anthropology or philosophy of history" (Rosa 2013, p. 298).

Technical acceleration is the material enabler of the acceleration society, but technology and social change are in a feedback loop, driving each other (Rosa 2013, pp. 106, 308). "Technical acceleration always harbors a tendency to transform the objective, the social, and (mediated through these) the subjective world, because it implicitly transforms our relations to things (i.e., to the material structures of our environment), to our fellow human beings, and to space and time" (Rosa 2013, p. 304). The *ideas* of technology must be the vehicle of this transformation, the common currency; such ideas are technologically-derived, but not technically determined.

Rosa responds to his own analysis of the alienation of the acceleration society with the notion of "resonance":

> Resonance is a kind of relationship to the world, formed through af←fect and e→motion, intrinsic interest, and perceived self-efficacy, in which subject and world are mutually affected and transformed. Resonance is not an echo, but a responsive relationship, requiring that both sides speak with their own voice. This is only possible where strong evaluations are affected. Resonance implies an aspect of constitutive inaccessibility. Resonant relationships require that both subject and world be sufficiently "closed" or self-consistent so as to each speak in their own voice, while also remaining open enough to be affected or reached by each other. Resonance is not an emotional state, but a mode of relation that is neutral with respect to emotional content. (Rosa 2019, p. 174)

His emphasis on mutual transformation is redolent of the concept of "strong emergence", itself a mechanism of resonance or feedback. Emergence – the arising of new structure of behaviour that was not or could not be predicted from existing conditions – can be understood as "weak" from the perspective of the observer, whose previous model cannot account for the new phenomenon, or "strong" if the new phenomenon materially affects the environment within which it occurs (Chalmers 2006). Rosa is primarily concerned with human relationships. He expands his theory to art, however, considering the motivation of the artist, the reception of viewer or listener, and the collective emotional response of audiences. While coherent in terms of the kinds of engagement that Rosa is concerned with, his explanation contains clues as to what is missing from such an account:

> … what is specific to art is that, beyond the experience of pure resonance, it is also capable of recreating, giving expression to, and thus making palpable the whole spectrum of historically and culturally possible relationships to the world. … Aesthetic resonance is thus an experimental field for adaptively transforming different models of relating to the world. (Rosa 2019, pp. 285-6)

Rosa's analysis remains entirely within an emotional domain. Unless one adopts a purely affective-mimetic view of art, this tells us little about how a subject engages with the particularity of artworks as they unfold in the receiver's imagination, little about the process of apprehension. It is a perfectly reasonable aesthetic stance to suggest that individual artworks propose new models of relating to the world, but ultimately the resonance is intrasubjective – that is, they must find resonance with other models that are either innate to the subject or induced from the world the subject inhabits.

Technology, time and the formation of individual and collective cultural identity are interwoven. Stiegler's call for "a new consideration of technicity" (Stiegler 1998, p. 17) might be best addressed by studying the reflection of technicity in the cloudy, shifting mirror of cultural perception. The models we use for discussing music are in

intense need of some analogous refocusing. While specific genres and practices have developed highly specialised technical and critical topics, the broader public sphere has relinquished the ability to engage meaningfully with the *material* of music. Music education confronts a proliferation of interests, of cultural awareness, of professional opportunities; music creators – composers, sound artists, improvisers, interpreters, songwriters – appear to inhabit independent discursive worlds; and music research tends to an irresistible bifurcation between the social and the material (Born 2010). Of course, this is to say neither that there is not excellent work done in all these areas, nor that some kind of music-critical Esperanto would be in any way desirable. And yet we must assume that in the global, networked environment that has produced such a situation, a major part of the culturally-acquired conceptual apparatus for conceiving/receiving music is held in common. Technicity is a sea of potential, of technologically-analogous principles and processes absorbed from waves of thickly mediated input from technology of all kinds. There is an important degree of technicity in the 'pre-technical' imagining of music, even in the evolution of a single sound. We hear not isolated events but processes, echoes, patterns, relationships – and our particular cognitive apparatus has to afford such hearing. The creation and apprehension of any kind of reflective music – art music, if you will – are grounded in technicity. At the same time, music might be the area of human activity where we can experiment with the reconfiguring of our relationship with technology.

2 Hypothesis

A degree of prediction is fundamental to making sense of dynamical behaviours, however unarticulated, multi-dimensional, parallel, non-symbolic and provisional it may be. In the case of music, researchers have paid most attention to aspects that can be considered innate – part of human physiology – or those that are learned through experience of music. David Huron gives a clear summary of this position:

> Whether innate or learned, expectations are typically formed through exposure to an environment. Expectations arise through a process of induction, in which generalizations are formed from a finite number of specific experiences. Since inductive inference is known to be fallible, the generalizations formed through listener experience are also fallible. That is, the principles underlying expectations are likely to be imperfect approximations of the actual principles that shape the world. (Huron 2006, p. 359)

So far so good; but this account misses a vital layer. Sense-making is also informed by an *infinite* number of *non-specific* experiences which likewise produce even more fallible, imperfect approximations of impressions and half-knowledge of how things can work in the world. These are neither innate nor learned from a specific musical environment. They are experiences, glimpses and traces of the ideas and mechanisms thrown up by technology as it evolves, each of which develops its own evolution and after-life.

Here we have to declare a working hypothesis: that the discourses of music are the surface traces and emergent products of a less explicit dynamics of imagination and apprehension - an informal repertoire of operators that we might see as predictive or sense-making. We might think of them as a population of agents competing to produce the best explanation of what we're hearing - but of course that would suggest that these operators are discreet and

that there could be a single mode of understanding, both of which ideas would be to entirely miss the point. As a second step I want to suggest that these operators largely derive from technology – technology understood in a wide sense, the bounds of which we will look at shortly. On this view, technology provides the models for the conceptual tools with which we make sense of music. We might say that, beyond the bounds of easily chunkable echoic memory and a repetitive bodily empathy - the hook and groove of vernacular music - music is inconceivable without technology.

This hypothesis comes in two flavours – strong and weak. A strong version might have it that technology of all kinds provides the set of examples of what is possible in the world, on the basis of which we develop our personal repertoire of conceptual operators, much of which we will inevitably have in common at any given moment. A weaker version might simply propose that tracing relationships with technology-derived ideas could give us a useful way to create, understand and criticise music and musical experience. We will stick with the latter and make occasional forays into the former, because that's an approach consonant with how this phenomenon works.

Technology provides us with a sense of the possible, in terms of how things can happen in the world, of what operations or relationships are possible. Beyond the innately embodied and immediately social, we form impressions of how things might work through experience – direct, indirect, induced or invented – which is in some way technologically facilitated or mediated. This can rarely be described as expert knowledge; it is much more often partial, misconstrued, fantasy, or most commonly perhaps a kind of abstracted, plastic caricature in which behaviours, impacts and affordances play a greater part than specific materiality. In human understanding beyond the bounds of formal logic, predication recedes infinitely; making sense of the world is an imaginative, parallel, provisional process. Here we are concerned not with the affordances of specific technologies, nor with the ways in which individuals and communities consciously make use of or respond to their evolving technological environment. What interests us is rather the accumulated, aggregate, received, induced, *unreflected* perception of what technologies might make possible.

This has much in common with Hayles' (2017) notion of *unthought*, or the cognitive nonconscious. She describes a layer of cognitive processes built on the neurological substrate that develops through experience and subtends consciousness. Such experience includes human-technical interaction, and in increasingly complex and interactive ways as technology insinuates itself ever more directly into human behaviour. She describes human-technical "cognitive assemblages", characterised by flows of information and power, which "transform the contexts and conditions under which human cognition operates, ultimately affecting what it means to be human in developed societies" (2017, p. 120). The present proposal of intuitive technology goes further in two important respects. First that the mechanisms of this cognitive nonconscious are assimilated or induced largely from the technological milieu within which the subject develops and operates. Second that this process of induction which may occur as a revelation or over years, is largely imaginative – that is, that the mechanisms thus induced are generally based on received, partial, reconstructed knowledge rather than direct experience.

In this context, the bounds of what we understand as technology must clearly extend beyond computation, machines or physical objects to a wider range of human behaviours and conceptual tools. Two historically,

technically and culturally polar examples illustrate this: natural language – at the "analogue" limit of what we might consider as technology - and machine learning – the "black box" engine of current Artificial Intelligence. Arguments for regarding language as a technology have been proposed from various perspectives (Mufwene 2013, 2019). There is no inherent thingness to machine learning – the computation could in principle be distributed among a sufficiently large enough population of human "computers" (Grier 2005) - and yet it epitomizes contemporary technology. Neither require extra-human materiality. Both have what Brian Arthur sees as essential characteristics of a technology: being predicated on and enabling other technologies (Arthur 2009, p. 18). The point here is not to determine definitions; it is rather than in its operation, unreflected knowledge does also not determine definitions. It does *not* work on the basis of clearly articulated, exclusive concepts. The hazy borders, shifting frameworks and transposability of technological ideas are, I shall argue, precisely what allows them to be so cognitively and culturally instrumental.

Eric Schatzberg describes technology as "… the bastard child of uncertain parentage, the result of a twisted genealogy cutting across multiple discourses." "No scholarly discipline owns this term", he says (Schatzberg 2018, p. 14). Schatzberg unravels the various understandings of "technology" across history and among discourses. He distinguishes between "cultural" and "instrumental" views - a variation on Heidegger's "anthropological" and "instrumental" categorization (Heidegger 1977) - and looks at the ways in which notions of "technique" and "technology" have been separated at various historical moments and in different languages. The multiple ambiguities of the anglophone use of "technology" become very clear. Schatzberg's own preferred understanding of the term is appropriate for the present context: "… the set of practices humans use to transform the material world, practices involved in creating and transforming material things" (Schatzberg 2018, p. 2). This definition serves well, except that – like most – it ignores the feedback relationship with human experience and imagination, the roles of memory, understanding, projection and invention.

Writers on technology often return to the Aristotelean division of epistêmê and technê to account for a largely hierarchical relationship between thinking and doing through Western culture. This distinction has also served to maintain a social hierarchy as - at least in practical economic terms - wealth, wisdom and hence power have been assumed to have a natural association. Artists - in common with jesters, fools and saints – have sometimes been held to exist outside this dichotomy, to access another kind of knowledge. It is no coincidence that these borders dissolve together; now artists are called upon to articulate the knowledge they produce, and it is technologists who are now seen to pose new questions, to forge new paradigms not only of knowledge but of being human. Bioscience, AI, communications, the manipulation of data and media – in most cases our direct material experience of the technologies that challenge the bounds of selfness and physicality is little more than a screen, its thinness a metaphor for the permeability of the membrane between human and machine operation.

3 Technological narratives

The intention here is not to establish what is or is not technology, but rather to demonstrate the increasing tendency of disciplines to consider and present themselves in technological terms, and to suggest that looking at art through the prism of technology might provide useful terms that have contemporary resonance and instrumentality.

A view of language as technology is predicated on an understanding of thought and language as having separate origins, however inter-dependent they become, as put forward by Vygotsky (1962). Clark suggests considering language-empowered thought as computation, a view that "implicates our linguistic capacities in some highly productive transformations of our overall computational powers" (Clark 1998, p. 182). His description of language as an enabling, co-evolving technology is very relevant to our discussion: "Public language … is a species of external artefact whose current adaptive value is partially constituted by its role in re-shaping the kinds of computational space that our biological brains must negotiate in order to solve certain types of problems, or to carry out certain complex projects" (Clark 1998, p. 162). The language of inner thought is provisional, incomplete, fragmentary - neither the well-formed communication of public speech nor a systematic reflection of deeper levels of cognition: "Viewed as a complementary cognitive artefact, language can genuinely extend our cognitive horizons – and without the impossible burden of re-capitulating the detailed contents of non-linguistic thought" (Clark 1998, p. 179).

A more explicit understanding of language as technology emerges with the development of computational interaction based on natural language (Dascal 2002). Dascal's summary establishes his view of the processes very clearly:

> Just as "environmental" properties of language (e.g., sequential ordering) can give rise to resources (e.g., narrative structure) and thence to tools (e.g., explanatory strategies), so too a tool (e.g., a successful metaphor created in order to understand a new concept) can become a resource (a frozen metaphor) and then recede into the "environmental" background (e.g., by becoming incorporated into the semantic system as a lexical polysemy). (Dascal 2002, p. 35)

Mufwene (2013, 2019) takes the argument further. He sees language as an emergent, adaptive technology – a technology in that it embodies the three properties identified by Arthur (2008, p. 28).

This abbreviated narrative shows three threads of development of the use of "technology" as a term – threads as intertwined as thought and language themselves: its expanding role in theories of cognition, a broadening understanding of what constitutes technology, and an increasing propensity to exploit the metaphorical ambiguity of "technology". Informally, we might observe a diminishing inclination to see such use as "mechanistic", or to be concerned with what is "literally" technology.

We see a similar trajectory in views of writing as technology; the materiality of writing has long invited such an interpretation. We could describe it as an enactive technology: each instantiation is the product of the concept of

the potential of writing modulated by the affordances of the particular "writing machine", whether stylus and clay slab or keyboard and computer. This is a situation stable enough within any given place and moment that in the general case it requires little reflection. From Nietzsche's reflection on his use of the typewriter to Kittler (1999) and Hayles (2002), the feedback between modes of inscription and the evolution of language is a topic of wide investigation. The impact of literacy on non-literate societies has also been widely studied since the early work of Ong (2002) and Goody and Watt (Goody and Watt 1963; Goody 1986). What is often ignored is the fact that, for the most part, our own modern, Western society is itself semi-literate in thought and action. Transitional phenomena are instructive; Goody and Watt showed how in a scribe culture, modes of understanding and reasoning are transformed also for those who do not have direct access to literacy. The kinds of conceptual operation afforded by literacy allow, for example, senses of history and philosophical thought to emerge from what was previously subsumed by myth (Goody and Watt 1963). Goody resonantly described writing as "the technology of the intellect" (Goody 1977, p. 10; 1987, p. 59).

Technological perspectives have subsequently informed every aspect of thinking about writing. Eaglestone accounts for developments in contemporary fiction in technological terms, but significantly he expands his understanding of technology to include the novel itself. This is an important step in the present discussion. Not only the technologically-enabled or -conceived activity but also the forms of thought they afford must be considered as technology:

> Writing is a "machine" to supplement both the fallible and limited nature of our memory (it stores information over time) and our bodies over space (it carries information over distances). So it's not so much that we humans made technology: technology also made us. As we write, so writing makes us. It is technology that allows us history, as a recorded past and so a present, and so, perhaps a future. So to think about technology, and changes in technology, is to think about the very core of what we, as a species, are and about how we are changing. As we change technology, we change ourselves. And all novels, because they are a form of technology, implicitly or explicitly, do this. (Eaglestone 2013, p. 86)

From Frampton's (2019) study of classical Greek and Roman practices to Kirschenbaum's (2016) history of word processing, writing is now seen as an inherently technological activity. Haas (1996) develops Ingold's suggestion that writing should be seen as corporeal to the same extent as it is technological: "… the person who has developed the skill of using a pen to write, is harnessing and creating a type of technology within themselves" (Ingold 2000, p. 403). This has echoes of Simon's observation that the natural state of any artefact is that of interface (Simon 1996, p. 6). He speaks of inner and outer environments, of the artefact as "the thin interface between the natural laws within it and the natural laws without" (Simon 1996, p. 113). The fluidity of technological metaphors allows them to adapt to describe the "natural laws" of a phenomenon in the production of a percept and associated expectations. Expertise – the application of artificial laws - would reduce the space for such negotiation.

Similar tendencies can be traced in other disciplines, as they explore new narratives that emphasise a fundamental bi-directional relationship with technology. Particularly telling are those dealing with the "pure" branches of mathematics and science. Frank et al. (2008) show that the language of numbers in particular can be usefully considered a technology, by comparing the linguistic-mathematical operations of differing language cultures. Hansson argues for the "technology-dependence" of mathematics – from notches on a stick to computers – and the inseparability of its operations from notation: "We need notation not only to remember numbers but also to keep track of the successive steps of a computation, derivation, or proof" (Hansson 2020, p. 126). The use of computers to keep track of their own computation presents an epistemological challenge to the "non-empirical" nature of mathematics. He extends this technological view of mathematics to draw a distinction between the agency, intention and input-output of mathematical operations and the study of physics. "Computation is essentially a technological, not a natural, process", he concludes, calling for a new investigation of the mathematics-technology relationship (Hansson 2020, p. 133). The complementary view – that mathematics is the essence of technology – is widespread in the field of critical mathematics education. This is very relevant to our current concerns in two respects: that technology is crucially a social phenomenon, and that common experience of technology affords models for an intuitive relationship with more abstract concepts. Skovmose, for instance, refers to the "mathematics-based technological imagination" (Skovmose 2016, p. 8).

> Our lifeworld is formed through techniques and practices as well as categories and discourses emerging from mathematics in action. Technology is not something "additional" which we can put aside, as if it was a simple tool, like a hammer. We live in a technologically structured environment, a techno-nature. Our life-world is situated in this techno-nature, and we cannot even imagine what it would mean to eliminate technology from our environment. Just try to do the subtraction piece by piece. We remove the computer, the credit card, the TV set, the phone. And we continue by removing medicine, newspapers, cars, bridges, streets, shoes. We have no idea about what kind of life-world such a continued subtraction would bring us into. In this sense our life-world is submerged in techno-nature. Mathematical constructs make integral part of both techno-nature and life-world. (Skovmose 2016, p. 13).

Yasukawa sees mathematics as experienced in the world as an "invisible technology" in Postmans' (1993) sense, as he explores the potential of technological concepts in mathematics teaching. He asks whether Porter's (1995) concept of a "technology of distance" might also apply, but concludes the mathematical models that are so prevalent in our world should rather be understood as components of a complex system, and that any resulting social distances are the product "firstly and more significantly by the boundaries of the 'system' agreed upon by the technical/economic interest groups …. … it is not the lack of mathematical knowledge which makes technological decisions impenetrable for the general public. It is the way in which problems/projects are conceived within a client/patron relationship which has little visible accountability to the society at large" (Yasukawa 1998, p. 4).

The vicissitudes of the perceived relationship between science and technology through history have been plotted by Forman across theory, professions and institutions, leading to the emergence of the contemporary notion of technoscience (Forman 2007). Ihde points to the implied ontological primacy of technology in Heidegger's writing, in an elegant and apposite formulation: "Thus, hidden behind modern physics is the spirit of technology, technology in its ontological sense as world-taken-as-standing-reserve" (Ihde 2010, p. 36). The understanding of science as a practice and hence fundamentally materially-informed has long roots – in the writings of Giulio Preti, for example: "Technology is not just the practical application of science, something exterior it produces, quite other to itself. Technology is already a fundamental element of the truth of science" (Preti 1975, p. 440) (1958). It should be noted that in the same essay, Preti anticipates Clarke's third law: that any sufficiently advanced technology is indistinguishable from magic. There is no paradox, no absurdity here; there is a nonlinear continuum between expertise and blind faith. If the cosmological revolutions of Copernicus and Galileo were fundamentally technological, then we might usefully understand the previous cosmological picture – as a view of how things work – as equally technological.

Châtelet explores the science-technology relationship in material detail. He shows how the tools of measurement, calculation and representation find traction with the spatial nature of cognition. He shows how spatial and visual representation – particularly the technology of the diagram – derive from physical models. He cites Maxwell's explanation of his equations as an example:

> Maxwell's equations interlacing electrical and magnetic fields like two helices in space-time are the culmination of a meditation on the screw as a special mechanism' capable of articulating length and width:
>
> *Now it seems natural to suppose that all the direct effects of any cause which is itself of a longitudinal character, must be themselves longitudinal, and that the direct effects of a rotatory cause must be themselves rotatory. A motion of translation along an axis cannot produce a rotation about that axis unless it meets with some special mechanism, like that of a screw, which connects a motion in a given direction along the axis with a rotation in a given direction round it; and a motion of rotation, though it may produce tension along the axis, cannot of itself produce a current in one direction along the axis rather than the other* (Maxwell 1890, p. 503).
>
> The screw that endows the length with perforation power through a flick of the wrist is part of a whole set of diagrams and metaphors intended by Maxwell to promote a new physico-geometric self-evidence. We should speak of a technology of the metaphor that possesses an autonomous logic and precedes formalization. (Châtelet 2000, p. 177)

The distinctions between science and technoscience – as the sophistication of technology – are debatable. Nordmann et al. (2011) present a very sophisticated rationalisation of their distinction – one that, however, effectively reifies an earlier pure/applied polarisation in a situation that is more 'chicken-or-egg' than ever. Their

logic may be impeccable, but I would suggest that in the public imagination the two are indivisible – that science is increasingly understood informally in technological terms, as technology, as acknowledged by Channell (2017, p. 1). Davies et al. (2019) urge scientists not to see the sharing of their thought as dissemination, as addressing a deficit of understanding, but as meaning-making, as story-telling, as part of culture more widely.

In the context of describing forms of art as forms of philosophy, Alva Noë observes that: "Art is not a technological practice any more than choreography is a way of dancing. But art presupposes technology and can be understood only against that background. One of the striking things about technology - this is not a novel idea, but it deserves to be repeated - is that technologies are natural for us" (Noë 2015, p.18). Music has always used technology to explain its workings: from the millennium-long use of the monochord as a teaching device for both practice and theory, through the use of the keyboard as a music computer – a mapping device for figure and tonal harmony – to the language of electronic dance music which relates directly to software such as *Ableton Live* (loop, chop, drop, sample, remix – the terms of music-making on a smartphone). Conventional accounts of the enabling technologies of production only serve to separate the "music" from its real-world environment. Wide discussion of the paradigm-shifting impact of printing or the internet tends to focus on distribution, dissemination or access. Studies of the intuitive empathy for musical instruments go some way – "air guitar" may have achieved virtuosic heights, but the tendency is there for all of us – and recent developments in critical organology recognise the dynamic conceptual inter-relationship between instruments and composer (Dolen 2013) or performer (De Souza 2017). But the broader technological environment is no less materially relevant; we could sketch a new history of Western art music in such terms:

It is no coincidence that mensural notation (quantised rhythm) is introduced in France in the same decade as the first escapement clocks – an entirely new mode of understanding time affording an equally new way of conceiving of music (Desmond, 2018). The perfectly balanced movement of polyphonic forms in an early sixteenth-century universe does not read the same way in the human-centric musical world of the late seventeenth. Tonal harmony is as technological as two-dimensional perspective: Rameau's theory emerges in the early eighteenth century, at a moment of standardisation of the new natural sciences. Through that century the concept of composition as a poetic art develops: Bach leaves us no sketches; Beethoven used his notebooks like we use the cloud – anything might be useful to be returned to. Advances in paper production transformed the relationship with one's own work. Haydn returned from London having witnessed the industrial revolution in full swing. He and Mozart wrote for mechanical clocks in the manner of the automata of Vaucanson: amusing evocations of the ultimate power of man over machine. Beethoven, despite having less exposure to industry, imagined a future of steam-cannon and steamships without ever having seen them. The power of unstoppable machines with an energy beyond human disciplining is clearly audible, however – a new component in the technicity of the age. The infinite repetition of the scherzo of the Seventh Symphony can only be halted by being brutally stopped in its tracks. At the end of the nineteenth century, the music of Mahler assumes a form of phonographic listening in composer and listener alike – an awareness of the possibility of recording sound - despite his never having recorded. At the same time, in the milieu that also produced the logical empiricism influenced by thinkers such as Frege and Mach, Schönberg was developing a way out of the impasse of tonal composition based on a symbolic reading of the situation – his twelve-tone music. Already, at the beginning of the twentieth century, we have the twin pillars of later music

technology – sampling and synthesis (and arguably sequencing) – and key components of the technicity with which we relate to, say the film music of Hans Zimmer or the compositions of John Adams. As we enter our own era of a more self-conscious technicity, the examples become more explicit: the tape recorder artefacts that are one of the roots of minimalism, the timbre manipulation of the spectralist composers, the clocks and clouds, broken machines and fractals of Ligeti, or the highly networked, cross-referenced, knowing mixing of DJ/producers. The technicity of music is no longer discreetly hidden; it moves not only centre-stage but centre-engagement – the practice of live coding is but one limit-case.

One challenge, then, is to bring this contemporary engagement to bear on music which is not so explicit in its technicity. A musical discourse capable of addressing the great breadth of current art-musical culture – a culture that incorporates its own past – needs a degree of style-independence. Our understanding of this music can only be in our here and now. The creation and apprehension of music are both acts of imagination, acts predicated on a set of possible behaviours and relationships that in any given moment will remain largely unarticulated. But beyond whatever we are born with, these derive from technology in Ihde's sense as "world-taken-as-standing-reserve". The inherent abstraction and transposability of contemporary technological discourse might offer useful terms – terms that illuminate new relationships and resonances across musical cultures and history.

4 What kind of theory?

We can see the cultural process of technological discourse-evolution concentrated in a single example from William Gibson – an author whose very success embodies the notion of intuitive technology:

> I was actually able to write Neuromancer because I didn't know anything about computers. I knew literally nothing. What I did was deconstruct the poetics of the language of people who were already working in the field. I'd stand in the hotel bar at the Seattle science fiction convention listening to these guys who were the first computer programmers I ever saw talk about their work. I had no idea what they were talking about, but that was the first time that I ever heard the word "interface" used as a verb. And I swooned. Wow, that's a verb. Seriously, poetically that was wonderful. (Gibson, 2020)

Recent research in cognition, material culture and speculative anthropology acknowledges the vital role of technology in being human and becoming a socialized individual. However, in substantiating their specific points, writers naturally look to clear examples and thus obscure the wider picture. That cognition is extended and distributed through material and social structures is a canonical component of any version of the extended mind hypothesis. Edwin Hutchins describes the process:

> By interacting with particular kinds of cultural things, we can produce complex cognitive accomplishments while employing simple cognitive processes. Once we have learned to interact with these things, we may learn to imagine both the things and our interaction with them. Then we can organize our thinking using internal resources in ways that previously required interaction with external cultural things. In this perspective, interaction with the material and social world come first, and imagination of those interactions come later. (Hutchins 2010, p. 101)

"Once we have learned to interact with these things" is what I would like to take issue with here, or at least to wonder how direct or aware this learning might be. Much of the excellent research looking at the relationship between people and technologies focuses on direct, engaged experience. Whether Malafouris (2013) talking about the potter or McCullough (1997) about the nature of digital craftsmanship, the emphasis is on the development of skill, the acquisition of expertise. But most people are not potters or programmers. In the general case, awareness of technology is the product of a combination of the circumstantial and the anecdotal. It is second-hand and mediated.

Malafouris provides a concise summary of the material culture approach: "… a cognitive process is not simply what happens inside a brain; a cognitive process can be what happens in the interaction between a brain and a thing" (Malafouris 2013, p. 67). A thing? I would suggest that much more often it's what happens in the interaction with the *idea* of a thing. And not only can this idea be wrong, it is crucial to cultural evolution that it is *free* to be wrong, misconstrued, reconstrued. This is not a weakness; it is the plasticity of received, mediated technological concepts together with an aggregate partial consensus that gives them their cultural power.

The invention of specific technologies arises generally not from zero, but as a new interpretation of existing material or intellectual affordances, their adaptation and combination. The cultural assimilation of technological concepts is also interpretative; the general case is not that of technical-theoretical expertise. Images of the nano-world or the wide cosmos inform our thought; tangential encounters with the internet transform how we relate to things, to people, to knowledge. And yet few of us have more than a fleeting acquaintance with how these technologies work. Expert and informal understanding are fundamentally interlinked, therefore, but their domains of operation remain distinct. We could describe this situation in terms of Giddens' notion of "double hermeneutic", adapting his canonical definition of its functioning within the social sciences: "Technologists depend upon existing concepts and technologies to generate new technologies; and culture regularly appropriates mechanisms and concepts of technology within its behaviour, thus potentially changing their character" (adapted from Giddens 1987, pp. 30-31).

Are we ascribing some kind of intuitive theory here? Certainly not one rooted in embodied experience such as those observed in the cases of physics and psychology. Perhaps a second-order intuitive theory. Gerstenberg and Tenenbaum (2017) identify four characteristics of intuitive theories: prediction, inference, counter-factual inference and explanation. Crucially, they also suggest that cognitive processes can be understood as causal inferences operating *over* these structures. The present hypothesis scores 2.5 out of 4 on their measure, but much

of the history of the aesthetics of music – from Schopenhauer to Jankélèvitch (2003) – is rooted in precisely this freedom from explanation. The missing 1.5 is not a lack, it is the space that allows the imagination to work, that affords the elasticity and plasticity that are the strengths of intuitive technology; it is very different from the pragmatic know-how of technological literacy (National Research Council, 2002).

Each musical experience becomes a machine for constrained, guided experiments with thinking – a virtual world, if you like. A virtual world in which we can experience, test, explore the implications of the processes of the possible that we have absorbed from technology-derived experience – largely indirect, unreflected experience. For Don Ihde (2009), it is the lack of embodiment that allows us to suspend disbelief in the context of virtual realities. In the case of music we explore and reconcile these possibilities through embodiment.

Musical works have much in common with the virtual or digital objects we now seek to understand and with our new world of augmented materiality. They exist in a unique state of materiality/immateriality: while they are intensely bound to direct experience, to technologies, techniques and materials, this physicality can exist in multiple and very different instantiations, they can be manipulated, engaged with and acted upon as cultural abstractions. In cultural terms, music is the area of human activity in which we deal with the virtual, with the constructive relationship between materiality, human affect and abstract structures or formal systems. Rather than reducing music to a mechanistic interpretation, such a view recognises that the affective-intellectual-cultural power of music is predicated on multiple, parallel, plastic, largely non-reflected, interacting and provisional sense-making processes that crucially derive from being in the world – a partially shared, evolving world largely formed by human technologies.

5 Conclusion

We have seen above an increasing tendency to view different aspects of human behaviour - of understanding, communication, culture and knowledge production – through the prism of technology. Such accounts might be regarded as metaphorical, but the degree of their neurological veracity is immaterial to the present argument; as metaphor they have significant traction in our current cultural climate. Lakoff and Johnson argued that metaphor is the fundamental mechanism of our conceptual system (1980). They point to the partial nature of metaphor (1980, p. 41). Here we acknowledge that the technological model in question is already – unreflectedly – a partial metaphorical construct. Hence the suggestion that this is a *second-order* intuitive technology.

That Gibson heard ‘interface’ as a verb is significant. We are dealing here with behaviours or operators, not objects. Of the techno-operators that surround us, the most characteristic of our age is mapping – the abstraction and re-application of data, a form of mediated transduction. Mapping stands in a reflexive relationship with the very idea of metaphor. To reprise Châtelet “We should speak of a technology of the metaphor that possesses an autonomous logic and precedes formalization” (Châtelet 2000, p. 177).

It is not only in our techno-aware world that technology provides the most resonant source of metaphors. Beyond our own bodies and their exchanges with embodied others, technology in its internalised and imagined forms provides the prime repertoire of conceptual models. If technological accounts of the development of knowledge and expertise are so convincing currently, perhaps they can be equally useful in encouraging a more widely shared, engaged discourse around those same areas. Why does this not already happen? We can identify two inhibiting factors (to use Rosa's term). First, the cultivation of an impression of exclusive, alienating discourse in respect of fields where high levels of expertise are important. Second, the persistence of no-longer relevant discourse, whether in terms of machines or art. In both respects we see the twin barriers to progress identified earlier: the cultivation of fragmentation and individualism, and the maintenance of a hegemonic discourse.

The contention here is that the problem identified by Stiegler comes with its own solution: that we might leverage the metaphorical power of non-expert understandings of technology – with all their adaptive, imaginative flexibility – to enhance engagement with the crucial issues that technology itself has raised. This might encourage the development of more relevant discourse in areas that have need – in art, in music – and with it the re-empowerment of their critical potential. Music remains a unique and essential laboratory for exploring and understanding our own present and future relationships with technology.

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