Debris: Machine learning, archive archaeology, digital audio waste

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This article fragments and processes *Debris*, a project developed to formalise the creative recycling of digital audio byproducts. *Debris* began as an open call for electronic compositions that take as their point of departure gigabytes of audio material generated through training and calibrating *Demiurge*, an audio synthesis platform driven by machine learning. The *Debris* project led us down rabbitholes of structural analysis: what does it mean to work with digital waste, how is it qualified, and what new relationships and methodologies do this foment? To chart the fluid boundaries of *Debris* and pin down its underlying conceptualisation of sound, this article introduces a framework ranging from archaeomusicology to intertextuality, from actor-network theory to Deleuzian assemblage, from Adornian constellation to swarm intelligence to platform and network topology. This diversity of approaches traces connective frictions that may allow us to understand, from the perspective of *Debris*, what working with sound *means* under the regime of machine intelligence. How has machine intelligence fundamentally altered the already shaky diagram connecting humans, creativity and history? We advise the reader to approach the text as a multisensory experience, listening to *Debris* while navigating the circuitous theoretical alleys below.

1. INTRODUCTION

Building and training a machine-learning environment often involves producing and consuming massive amounts of surplus data. This was certainly the case with *Demiurge*, a tripartite neural network architecture developed by Marek Poliks and Roberto Alonso with a team of collaborators from Hong Kong Baptist University (Alonso and Poliks 2022). *Demiurge* combines a sound-generating generative adversarial network pair (GANs built from the unaGAN and MelGAN mel-spectrum generation and phase vocoder paradigm) with a custom transformer network that resequences their output. The *Demiurge* team calibrated and trained the system with a database of sounds recorded by violinist and researcher Roberto Alonso.

Material piled up – training data for all three networks, output of faulty test models, experimental output of hybrid models, resequenced and rearranged outputs by the transformer. Yet its waste-condition was not one-dimensional, involving instead some or all of *Demiurge*'s key characteristics: endless sound generation (waste as overflow), the introduction of waste into that process as part of the involved down- and up-scaling of the audio files (e.g., as processing artefacts – glitch as waste), waste as discarded material, and so on. Google Drive folders began to swell with audio that bore upon its surface the pre-aesthetic conditions of its manufacture (Figure 1). As artists themselves, the *Demiurge* team recognised the creative fertility implicit in this digital waste, not least because this waste itself functioned as historical documentation tracing the technical progress of the platform.

Debris offered us a subset of this vast, unedited collection of GAN-generated audio as source material for an open call for electronic music.[1] As a team already interested in the complex actor-network topology implicit in this platform's development (Alonso and Poliks 2022), *Debris* afforded *Demiurge* a new vector of documentation and creative interpenetration. As music made with AI byproducts, *Debris* represents, within a broader engagement with digital audio waste, a human-in-the-loop reworking of discarded materials 'incidentally' produced in the synthesis of something else (ibid.). So far, the following sound artists and composers have made contributions to the project: Didem Conskunseven (France/Turkey), Mariam Gviniashvili (Georgia/Norway), Kyoka (Japan/Germany), Dariush Derakhshani (Germany/Iran), David Quang-Minh Nguyen (USA), Bihe Wen (China), Stylianos Dimou (Greece) and Iván Ferrer (Mexico/Spain). *Debris* imposed no restrictions apart from the material itself; participants were granted complete freedom on their approach to sound processing and modelling techniques (Table 1).

The analysis below focuses on the processes involved in the generation of the material and the composers' engagement with it but avoids any aesthetic evaluation of the resultant works. We refer to the employed processing and sampling techniques but do not explore the narratives that emerge from the overall compositional strategies. We leave the

[1]The reader may listen to the album at https://open.spotify.com/album/2WuH1vwdlpeU3cOFCaVR48.

Organised Sound **28**(3): 392–406 © The Author(s), 2023. Published by Cambridge University Press. doi:10.1017/S1355771823000249

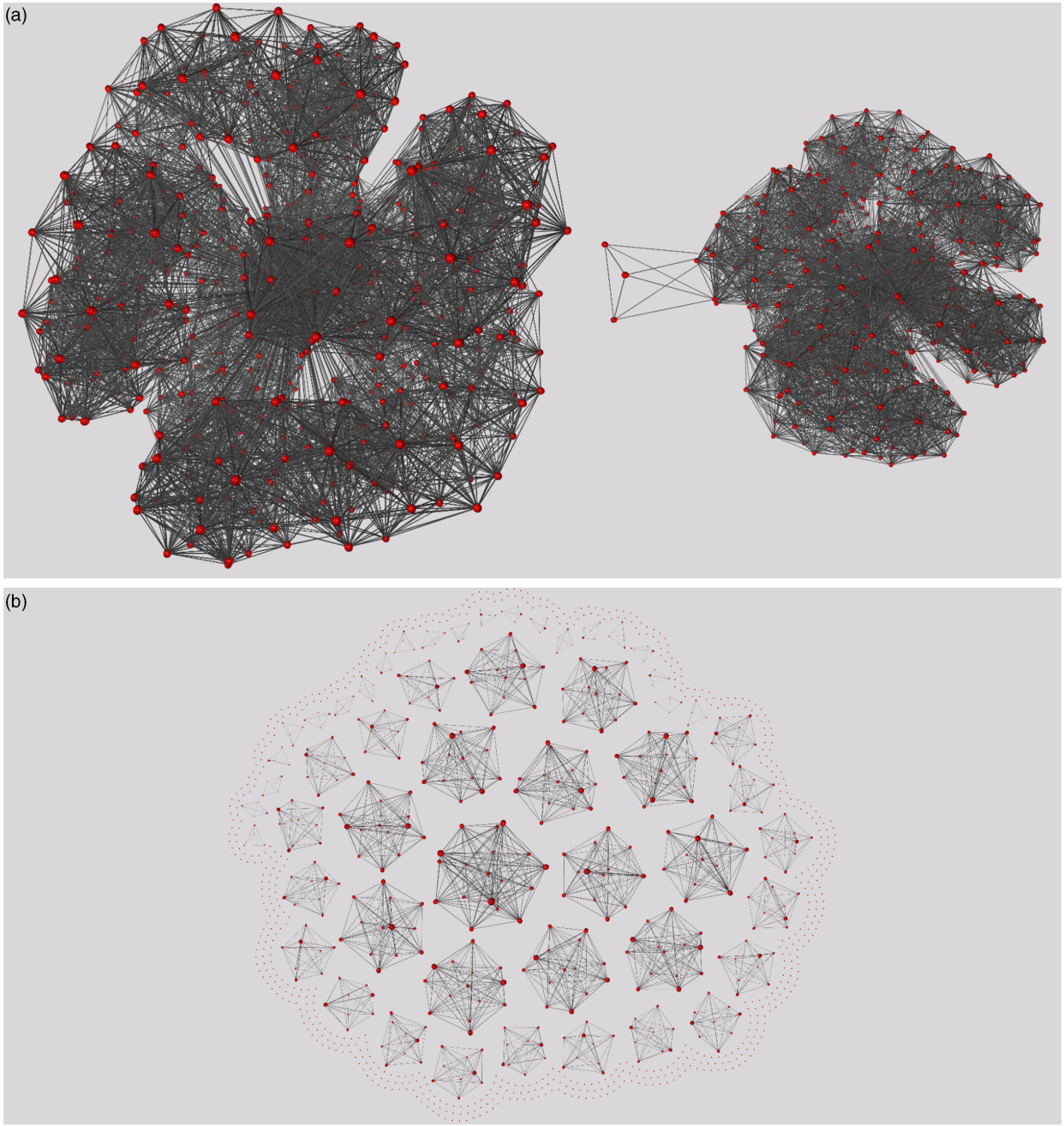

Figure 1. Abstractions of 1368614 files as distributed in *Demiurge*'s GDrive (generated via Folderstats and Graphia).

question of interpretation unanswered, as an open path for future research. In addition, we ask the readers to listen to *Debris* but to expect a paradoxical experience: given the spectral limitations of the supplied material and the international standardisation of DSP techniques in contemporary electronic music, striking similarities will emerge between the works and their structural management of sound(s). These coherences both resonate and starkly contrast with the complexity of the following conceptual framework. For us, this disparity is an expected outcome of the human-in-the-loop approach introduced in *Debris*.

As the project launched, so did its concurrent meta-analysis among the team. This article articulates the many threads and divergences this analysis took, from an initial interest in palimpsest and meta-documentation, to the strata of semiotic play contained therein, to contexts of sampling and remixing, to the hybrid actor-network array of its participants, and to the unrestrained proliferation of its underlying technological platform as a stack, an assemblage, a swarm. This article leverages a

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Table 1. Processing and modelling techniques

Composer	Processing and Modelling	Composer	Processing and Modelling
Didem Coskunseven	Concatenative synthesis, filtering, granular synthesis, spatialisation and reamping with analogue gear	Mariam Gviniashvili	Concatenative synthesis
Dariush Derakhshani	Granular synthesis: sound sprays, clouds, micro-montage, higher-order granulation	Kyoka	Handmade granular synthesis effects: micromontage, microsound, cloud, reverb, echo, wave interference, time, distance, frequency, howling, algorithmic techniques derived from my research on brain waves
Stylianos Dimou	Granular synthesis, physical modelling synthesis, Super-VP (Super Phase Vocoder), multi time-stretching, filtering, spatialisation, micro- and macro-montage, resynthesis of AI-generated violin samples	David Quang-Minh Nguyen	Delays and phase relationships, filtering, granulation, micro-montage, timbre spatialisation, reverb manipulation, amplitude panning
Iván Ferrer	Frippetronics, beat juggling, spatialisation in time and frequency domain, granular synthesis, stochastic synthesis, screwing, chirping, time-stretching, resampling	Bihe Wen	Resampling techniques, automated DSP parameters

plurality of frameworks – in part to avoid the reification of linked paradigms into habituated knowledge (Pernecky 2020) and in part to account for the tremendous discursive fecundity found in digital goo.

The underlying trigger for this theory-shotgun begins with the act of superposition, palimpsest and the addition of new layers so 're-worked and mixed together that it is difficult or impossible to separate them into their original constituents' (Bailey 2007: 204). New meanings emerge from de- and re-contextualised sound, transforming the contents of the original database through the attribution of new uses and associations.

2. PALIMPSEST

We define palimpsest as a process of accumulative and transformative super(im)position engendering/begetting a new object with greater structural intricacy than its constituent parts. Traces left by 'multiple, overlapping activities over variable periods of time' irregularly erase earlier ones (Lucas 2005: 37).

Over the past few decades, the concept of the palimpsest has found increasing metaphorical and analytical salience across disciplines as diverse as architecture (e.g., Aksamija, Maines and Wagoner 2017), literary studies (e.g., Dillon 2014), psychology (e.g., Maniquis 2011) and the performing arts (Hellier 2019). In this scholarship, as archaeologist Bailey points out:

> the emphasis is on the interplay between erasure and inscription … between the text and the material medium through which it is expressed, and how that interplay creates complex layered and multi-temporal entities that disrupt conventional views of temporal sequence. (Bailey 2007: 203)

The *Demiurge* team has been particularly interested in the metaphor of the palimpsest as applied to temporality. For example, Gavin Lucas's archaeology of time (Lucas 2005), which posits a vision of *archaeology* as a mode of historical and ethnographic temporalisation – a tool to understand human experience within an overlapping polyhedra of time and phenomenon. The palimpsest is also central to the concerns that have shaped 'time perspectivism' (e.g., Fletcher 1992; Hull 2005):

> (1) the palimpsest-like nature of archaeological records,
>
> (2) the analytical affordances implicit in a flexible time-resolution lens,
>
> (3) the arbitrary nature of the past/present/future distinction. (see Bailey 2007: 199)[2]

[2]For a critique of Time Perspectivism, see Gavin Lucas's *The Archaeology of Time* (Lucas 2005). Lucas bases his critique on the distinction between chronological time (i.e., time as a unilinear abstract scientific measuring tool) and real or narrative time (i.e., time as a complex non-necessarily-teleological flow).

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Debris deals with the reconsumption of material that itself bears the time-assignations of *historical technical documentation* and *historical utility*. The reconsumption of this material introduces a vision of digital sound as archeological strata, as a cumulative erasing-inscribing structure approachable from distinct and flexible time-depths.

This flexibility aligns nicely with the analytical structure of this article, that is, fragmentary (re-)readings of the same project through variously interwoven intellectual frameworks, 'a constellation of ideas, in which an object of discussion comes to be differently refracted given one's own changing position in relation to it' (Wilson 2018: 261). Under the regime of machine intelligence, a text that reflects upon itself to raise, paraphrasing Raymond Carver, the question: 'What do we talk about when we talk about sound?'

3. ARCHAEOMUSICOLOGY

We started with a vision of *Debris* as buried, historicised, palimpsested audio strata: training recordings, waste audio from prototype models, remix stems and compositions in a GDrive. A catalogue distributed in time and time-depth. The next question is obvious – what does an archaeology of *Debris* look like? As archaeomusicology (e.g., Buckley 1989; Olsen 2007), perhaps, albeit an archaeomusicology that expands its discursive obligation beyond the *ancient* – or maybe just takes its notion of *ancient* from GPUs that perform trillions of operations per second.

Debris inherits much from Berio's 1968 Sinfonia, a technologically *ancient* but pertinent work that epitomises the multilayered use of musical quotation as archaeomusicological strata. Berio pointed out how

> each language is able to reflect on itself, to think about itself. Music too is able to do so, despite the impossibility to translate it into terms of language … every musical work is a set of partial systems that interact among themselves, not merely because they are active at the same time, but because they establish a sort of organic and unstable reciprocity. (Berio 2006: 12)

Sinfonia takes Joyce's *Ulysses* as a model to expand previous work without 'attempting to hide the irony implicit in the modernizing of incomplete material' (Klein 2004b). This is not to suggest, however, that Berio's work can be reduced to a mere exercise in quotation; it is not a dry collage nor pastiche. Sinfonia unfurls itself as mosaic, as montage, as interactive Hadron collider of semantically charged references and sounds.

The Adornian concept of musical material, 'all that faces the composer in the present has inherited from the past' (Wilson 2018: 261), rises to the surface (see Paddison 2011 for a more thorough discussion). Very apropos for Berio, himself very much a composer, very much embedded in media inherited from the past – scores, orchestras and their associated histories.

Debris has some extra complexities beyond those contained by Sinfonia – at the very least, *Debris* holds its semiotics closer to the physical and mathematical manifestations of its sounds. Adorno's conceptual framework is agnostic to physics; the propagation of waves through the air or the concatenation of amplitude indices have less relevance to his analytical framework than the sediment of associated socio-musical relations. Adorno does not examine sounds as what they are but as what they become, as second nature (concept articulated in the *Theorie des Romans* by Lukacs 2006): 'the possibilities of composing already contain the sediment of history within them' (Adorno 1984: 433–9).

Yet *Debris* emerges from a world of raw quanta, from the productive barrage of training data through a black box of filters, socialised through encounters both with human curators and, meaningfully, with non-human composers only playing by the rules of multivariable calculus. *Debris* thus manifests the tensions emerging between sounds seen as facts and sounds understood as processual artefacts.

To seek a riposte from Adorno, one could look to his theory of 'gramophone specific music'. In spite of his wider critical consideration of technical reproducibility, he does create affordances for a type of 'loud-speaker music' involving the gramophone as productive and not merely reproductive technology (Adorno 1979). While *Demiurge*'s own team has doubts about musical textuality (Alonso 2018) and there are endless texts enumerating the semiotic differences between literature and music (e.g., Steiner 1981; Eco 1989; Barthes, Howard and Lavers 2013), media and sound studies have followed this thread down various through-lines (one can hardly mention the gramophone without following up with Kittler 2006).

Yet machine learning presents a special case, one not *yet* over-theorised (especially with regards to sound). Truly, *Demiurge* makes music *with* music, but unlike Berio, the music being made is one level further abstracted from its source material *as music*. One could even go so far as to argue that the sounds of *Demiurge* themselves, in that they arrive from the unwieldy multiplication of a mind-bogglingly enormous array of sonic possibilities, *have not yet entirely been socialised* – they are both proto- and post-social. Regardless of whether or not one accepts the latter point, the team will henceforth use the term musical *material* to variably refer to any datum, air pressure change, symbol, or affiliation deployed in the service of musical construction. This makes way for an

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archaeology of *Debris* through *material*, through a comprehensively multimedial intertextuality.

4. DEBRIS AS INTER- AND TRANSTEXTUALITY

As Peter Burkholder points out, 'as long as people have been making music, people have been remaking music: taking a musical idea someone already made and reworking it in some way to make something new' (Burkholder in Burns, Lacasse and Burkholder 2018: v). In turn, the intertextual analysis of reworked musical material is not new, gaining greater analytical relevance over the past few decades not only within the fields of ethnomusicology and sound studies (e.g., Lacasse 2000; Middleton 2001; Nicholson 2006; Burns, Woods and Lafrance 2015) but also within classical musicology, especially within the context of quotation (e.g., Burkholder's n.d.; Kostka, Castro and Everett 2021; Klein 2004a).

However, *Debris* introduces new elements into the mix:

1. The source material was generated by a machine-learning environment (*Demiurge*), thereby essentially a product between noise, seed material, a generator, a discriminator, the interiority of each model, human curators and decision-makers, and the entire realm of aesthetic choices therein.[3]
2. The source material documents the *development* of the said machine-learning environment and is therefore charged both with the trace of a project at a given stage of development and with a significantly more variable scope of choice-making.
3. The source material was determined to be a waste product by its human curators according to unwritten and irrecoverable criteria.
4. The source material was deployed in *Debris* by artists with variably informed relationships to the project and the environment in general, and only in possession of the sonic domain of these charged materials.

Given these stipulations our approach to textuality is inclusive to the *technical* interior of the *Demiurge* platform.

In *Palimpsests*, Gérard Genette's five-layered model of textuality (Figure 2) proposes two domains of textuality relevant to *Debris*: *hypertextuality*, 'any relationship uniting a text B [the hypertext] to an earlier text A [the hypotext], upon which it is grafted in a manner that is not that of commentary' (Genette 1997a: 5); and *architextuality*, 'the most abstract and implicit of the transcendent categories, the relationship of inclusion linking each text to the various kinds of discourse of which it is a representative' (Macksey in Genette 1997b: xix).

The pieces of *Debris* bear hypertextual characteristics: the artists involved incorporated the database of audio either as decontextualised sound material (e.g., the minimalistic repetition of sequences found in Kyoka) or in processed forms grafted onto new sound material (e.g., the use of filtering, analogue processing, phasing and amplitude panning found in Coskunseven, Derakhshani or Nguyen).

On the other hand, the unplanned relationships that emerge between the works of the different composers/sound artists evoke elements of architextuality: in their relative disparity the works are linked by a common origin (the sonic material) and the shared abstract technical and aesthetic 'discourses' of the now globalised electronic music field – a Japanese sound artist working in Germany, a Turkish composer at the IRCAM, or an Oslo-based Georgian sound artist. This is a necessary concession to Adorno, but we are just scratching the surface of the architextual.

Inspired by Genette's work, Serge Lacasse starts with the concept of the phonogram (phono – sound/voice + gram – writing/recording) to propose what he calls a *transphonographic* system. Lacasse's system of textuality is not just more relevant to music, but is also inclusive of both the 'abstract parameters … characteristic of the allographic regime … as well as more concrete parameters … characteristic of a recording's autographic regime' (Lacasse in Burns et al. 2018: 12–13).

Transphonography goes a step beyond previous scholarship (e.g., Burkholder 2001) in its enumeration of a huge host of extramusical relations. It is easy to see parallels between *Debris* and two the transphonographic relationships from Lacasse's expanded eight-layered framework (Figure 3): *interphonography*, related to the presence of a recording's given sample in a second host recording, and *transfictionality*, the sharing of 'common characters inhabiting a (trans) fictional world' (ibid.: 14).

The *interphonographic* and *polyphonographic* domains seem simple – we are, after all, talking about sampling. Yet *Debris* contains layer upon layer of nested interphonography: from repeated blocks in Kyoka's work (self-sampling), to the unaGAN mel-spectrogram from whence it came, the melGAN phase vocoder that interpreted it, the transformer model that sequenced it, the sample bank used to train all three models, the sample bank used to seed all three models, and the originary samples themselves recorded by

[3]As explained earlier, *Demiurge*'s three-part machine-learning architecture involves audio synthesis (melGan + unaGan) and sequencing (custom Transformer). The system 'learns' to generate sounds using the adversarial neural process described in Alonso and Poliks (2022), which is not a form of concatenative synthesis.

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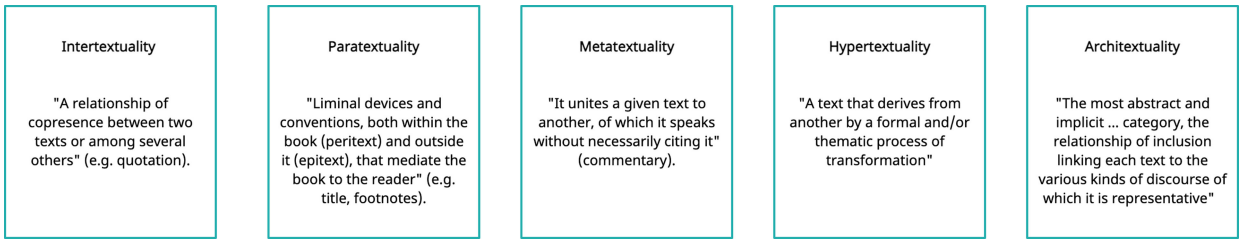

Figure 2. Gerard Genette's transtextual relationships.

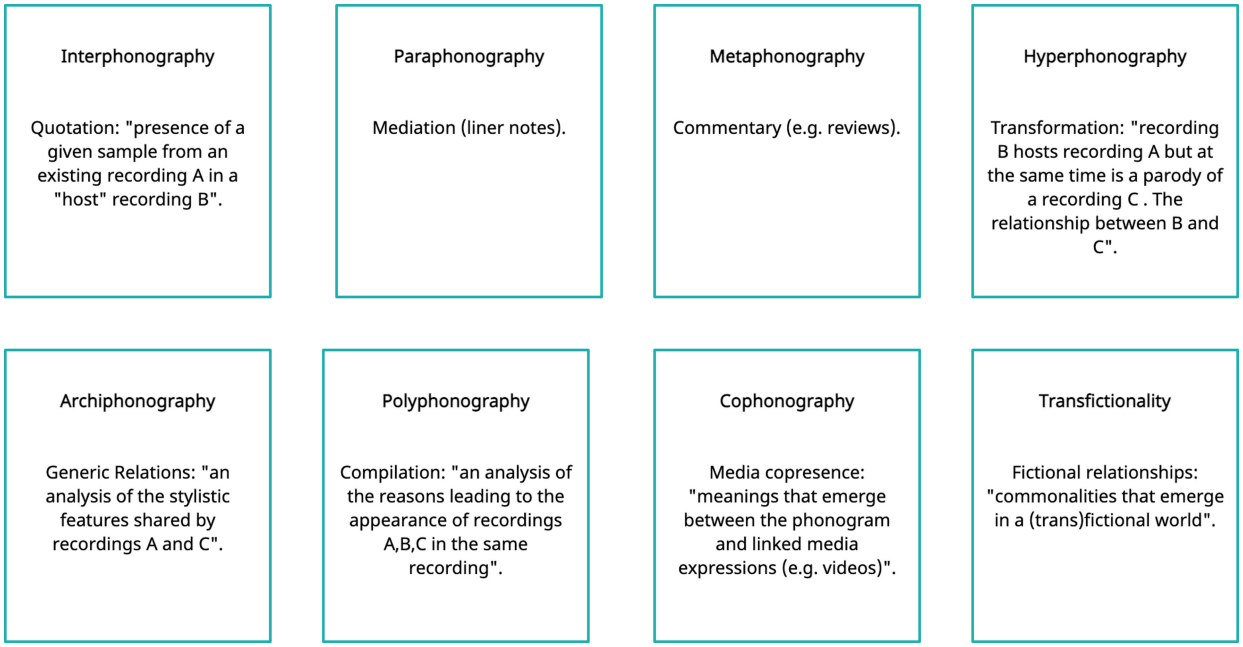

Figure 3. Serge Lacasse's transphonographic relationships.

Roberto Alonso thoroughly and barely identifiably interbred with artificial intelligence. Here emerges the real *architextual* or *transfictional* – the loose outline of an intersubjective network coming into focus as AI, ghost curator.

Yet in order to account for its presence more fully, we will first dive deeper into the *interphonographic*.

5. SAMPLING AND RESYNTHESIS

Sampling, 'the use of previously-recorded material in a new composition' (Youngblood 2019: 1) is everywhere.[4] To state its importance to hip-hop, rap and electronic music is cliché, and to underline its increasing centrality to the expanded universe of rock music is trite at best. Yet sampling is not a static practice, confined to the old-school re-pitch and re-sequence modality of the turntable, the MPC, or Ableton's *Simpler*.

In fact, the outer reaches of sampling have started to approach something more akin to resynthesis. An example of this is micro-montage (Sturm 2006), defined in part by the work of Horacio Vaggione. Micro-montage involves the highly specific, manual concatenation of an array of small microsamples – this is exemplified in *Debris* with the works of Nguyen and Derakhshani. Another example is granular synthesis, applying the principles of sampling to the micro-sound timescale through the automated generation, manipulation and concatenation of short sound fragments called grains – exemplified in the music of Conskunseven and Dimou.

[4]The following website explores sampling connections between 832,000 songs and 267,000 artists: www.whosampled.com. Sampling has ignited significant policy-changing intellectual property, originality and copyright discussions (e.g., the definition of a *de minimis* instantiation was first put forward in the 1971 revision of the 1909 copyright law, a revision intended to protect the use of sounds in a fixed/tangible medium).

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Machine learning elevates the question of sampling-as-synthesis to yet another level, as exemplified by *Demiurge*:

1. unaGAN samples audio at the level of the mel-spectrogram, a medium-resolution image that represents audio frequency data. Its generator and discriminator models are trained against noise, 'real' recordings and a mind-boggling volume of digital waste thrown at the discriminator from the generator as it approaches sonic plausibility.
2. melGAN samples audio at both the level of PCM audio and the level of mel-spectrograms (Figure 4). Its goal is to deliver phase vocoder models and translators between these two modes of representation.
3. The sequencer/transformer samples audio at the level of the mel frequency central coefficient (MFCC) – a low-resolution image that represents frequency data against benchmarks determined by the capabilities of the human ear (Figure 5). These models are trained against databases of entire pieces of music, ripping structural information from them and using it to sequence new music by sampling the output of unaGAN/melGAN pairs.

Every constituent component here can be considered either sample or sampler, as they represent either fully realised audio data imbued with both functional and aesthetic significance, or the very means through which that significance is afforded. Machine-learning proposes an interesting question – what distinguishes the technological *sampler* (the MPC, the looper pedal, the neural network) from the DJ or the composer doing the *sampling*?

Thomas Schumacher, taking ideas from Walter Benjamin, posits that the former by its very nature effaces the singular existence of the latter, explaining that 'in the case of sampling technology in musical production, the abolition of the aura signals the insertion of different subjects into the creative process' (Schumacher in Forman and Neal 2012: 450). The *one-who-samples* diffracts into a list of names that, as legal markers ('universals of legal discourse'), exist only insofar as they commodify the objects with which they work (Schumacher 1995: 265). Or, following Bakhtin, the *one-who-samples* is fully subordinated to the sample itself, an object that contains within it the inflected voice of its antecedent other (Bakhtin 1989). From there, it follows that this inflected voice is further subordinated to social regimes and larger and more diffuse networks of people and ideas – the notion of appropriation, which has played a crucial role in postmodern art and its theorisation (e.g., Evans 2009).

As the deconstruction-machine 'goes brrr', the result is a web of agencies not at all dissimilar in its interwovenness to the internal contents of the *Demiurge* synthesis engine. In that regard, we have discussed elsewhere our vision of *Demiurge* as an eco-process related to Di Scipian ecosystemic models as a distributed 'network of sound-producing agents' (Alonso and Poliks 2022).

6. REMIX

Debris is a form of *détourage*, transplantation, re-grafting, decontextualisation and re-semantisation of *Demiurge*'s byproducts. If God is a DJ, so is *Debris*.

Sound artist and DJ Paul D. Miller defines his role as that of the 'cybernetic inheritor of the improvisational tradition of jazz' and a 'custodian of aural history', and stresses how 'DJ culture … is all about recombinant potential. It has a central feature, an eugenics of the imagination. Each and every source sample is fragmented and bereft of prior meaning … like a future without a past. The samples are given meaning only when re-presented in the assemblage of the mix' (Miller in Cox and Warner 2017: 498–500).

In Miller's work, sound – taken as an isolated object of reproduction – becomes a 'collective memory bank' (ibid.). Samples are synecdoches and the assembly process is a 'social construction of memory'. The mix speaks from the 'bricolage of a place where the self exists as a deployed network of personae' (ibid.: 500).

Miller argues that electronic art, adopting Lucy Lippard's notion of a 'dematerialized art object' (Lippard 2001), highlights a transition from mimetic to semiotic representation, DJing representing a 'neurolinguistic relationship of human beings to their … alienated life elements' that create a 'syncretic flow of sound as externalized memory' and 'become epiphenomena whose central purpose is to act as a mnemonic device' (Miller in Cox and Warner 2017: 502).

Debris is an exploration of the recombinant potential of musical material, specifically waste material, articulated as an 'interactive space of semantically charged references and sounds'. Yet what of waste? What emblematises the creative recycling of digital trash better than the bargain-bin hunter, the hoarder of long-forgotten 78s and the hauntology junkie deploying old souls on the dance floor? (Is it too early to speak of the hauntology of *Demiurge*'s earliest una-GAN Models, digitally ancient, dripping with aliased low-bitrate MP3 quality and oddly transcoded transients?)

As we problematise the *one-who-samples*, the remix artist, the DJ, as all separable from a vector field of human and non-human forces, we witness a ceaseless dovetailing of creative impulses (network topology ↔ hybrid synthesis engine ↔ humans-in-the-loop ↔ hybrid synthesis engine ↔ network topology) – an amoebic memory bank, a rhizomatic bargain bin. The

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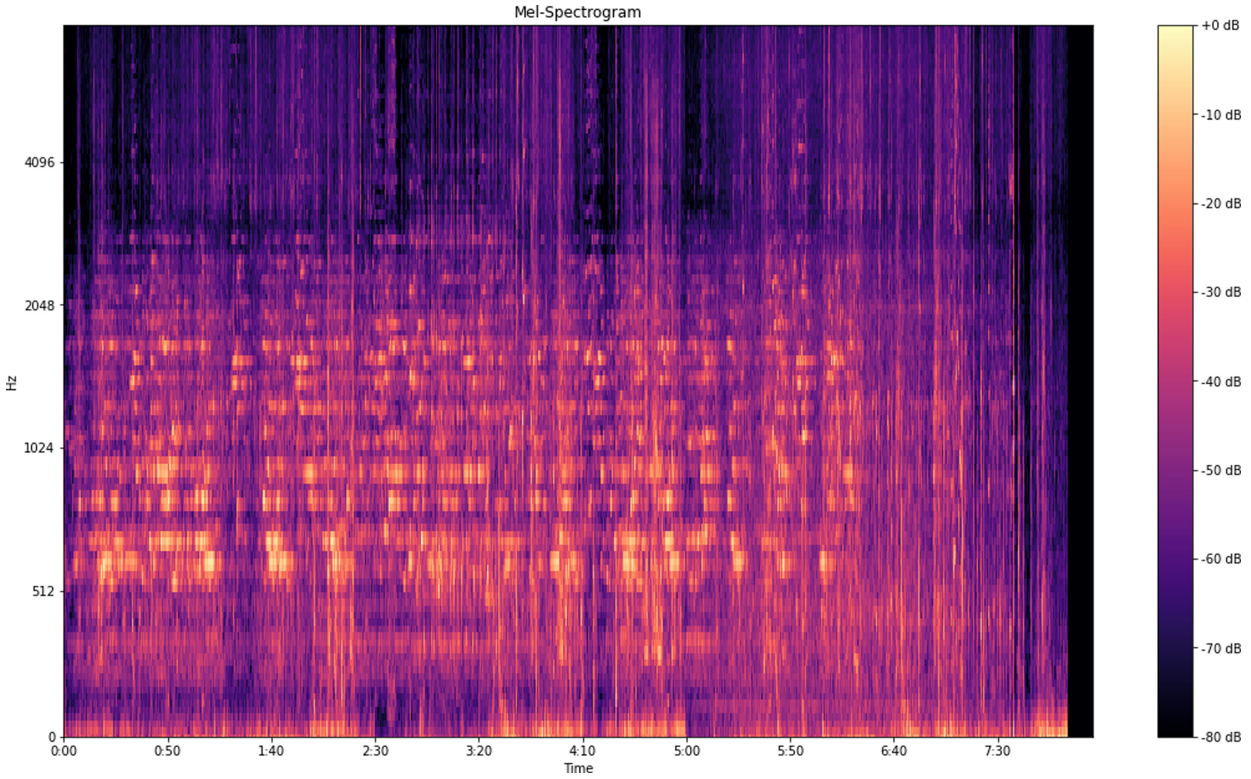

Figure 4. Mel-spectrogram (lossy resampled representations of audio data used in *Demiurge*).

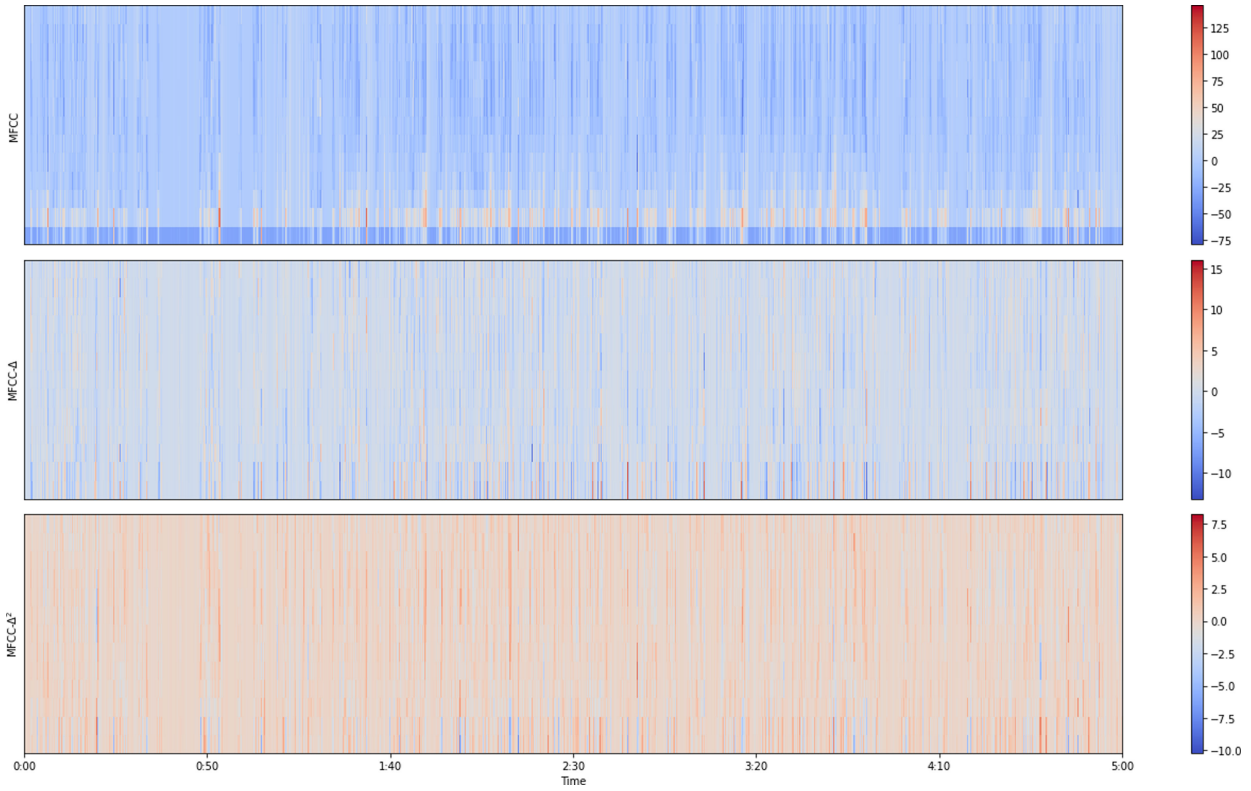

Figure 5. MFCC (lossy resampled representations of audio data used in *Demiurge*).

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works included in *Debris* give voice to different recombinant layers of that evolving sound-incarnated memory, transforming *Demiurge* into a distributed mnemonic device.

Forward into the vector field.

7. MEDIATION

As Hennion puts it:

> music does something other than what the humans gathered around it would like it to do, something other than what they have programmed. This is why they listen to it; it is not their double, nor the mirror of their vanity. 'Made' the way it is, it has its own capacity to act. It forges identities and sensibilities; it does not obey them. (Hennion 2016: 294)

Music is made out of a heterogeneous tissue that generates resistances and cumulative effects, what Georgina Born defines as a 'non-organic and non-linear constellation of mediations' (Born and Barry 2018: 448). Machine learning, with its vector field of fragmented agencies, samples and samplers, invites additional complexity onto the scene. Taking a closer look requires a theory of mediation with which to disentangle this array of forces.

There are three tidy historical reference points for this theory:

1. A return to Adorno, this time filtered through contemporary researchers such as Tia DeNora (i.e., DeNora 2000) or Georgina Born (i.e., Born 2015).
2. Actor-network/mediant musicology, stemming from Bruno Latour's research but also linked to the work of Antoine Hennion (2003), Annemarie Mol and John Law (i.e., Law 1999).
3. Assemblage theories that take the Deleuzian universe as a point of departure, exemplified by the work of de Landa (2006), among others.

All three reference points establish different models for a similar motion – subordinating a thing (music) to its constituent vector field of mediations (e.g., embodied practices, material devices, locations, social practices) taking place at different levels (background to foreground) and through divergent processes (e.g., momentary, processual, evanescent). According to Hennion:

> by seeing the musical thing as something that emerges, a presence, yet without having an object sitting there in front of us that one can isolate, mediation breaks this sterile dualism [the traditional vision of musical works as autonomous entities (essentialism) or as a reflection of alien determinations]. (Hennion 2016: 294)

Music is everyone's favourite trans-substance.

The *Demiurge* team argues that machine learning-driven music might be a slightly more interesting object for etheric abstraction. After all, there are tangible mediators involved: layers, nodes, weights, backpropagation functions, generators and discriminators – with relationships that are not just complex but *fundamentally inscrutable*. Black boxes do exist, not just by virtue of deconstruction into ever-smaller force relationships, but also in practice due to the hidden, highly randomised and unpreserved internal machinations of any simple neural network. *Debris* takes this a step further, by not just presenting but also in fact *highlighting* the products and source materials of models at varying stages of development. Indeed, this remains on display all the way into the 'end' products – take for example the route inclusion of unmodified GAN sounds in Ferrer's *Debris* rework.

Technologically mediated approaches do 'not only provide for new affordances, and evolve in relation to the intermingling of functions and counter-functions, but can also, in their emergence, reveal things that have been there all along, but which were difficult or impossible to perceive without them' (Bratton 2015: 21). We claim that the significance granted in *Demiurge* to things that 'make their making' (Hennion 2016: 296), a move from instrumental to situated action, is a common trait to all music creation.

The waste products of machine learning systems can, in some cases, bear out more closely the hidden technical interiorites of said systems than 'final' products subject to heavy end-user curation. We have hinted at this already when we discussed sampling – *Debris* presents, with one degree of mediation, a subset of 'samples' deployed by *Demiurge*'s various 'sampling functions' at various stages of the development journey (training, seeding). Yet it goes a step further by deploying the output of 'failed' or 'incomplete' models, through which a listener could re-architect some of the core principles through which these black boxes work their magic. The easiest example of this is in the 'incomplete' synthesis of sustained pitch material, which at its earliest stages clearly sounds like concatenated microsamples looping at some division of the audible fundamental frequency. Yet a better example might be in the earliest models of violin bow sounds (unpitched material), through which a listener can easily apprehend the phenomenon of vocoded, filtered noise (and can, with patience, actually start to make out what that filter might look like).

Debris is, in part, its own mediation theory of *Demiurge*.

A normal analysis would stop there and spin its wheels, after all – that is textbook *archaeomusicology*: sound as *semina rerum*, substrata, polytextual documentation of *Demiurge*. In turn, *Debris*'s packaging of this archeomusicological material is classic palimpsest – the addition of new participant nodes that expand

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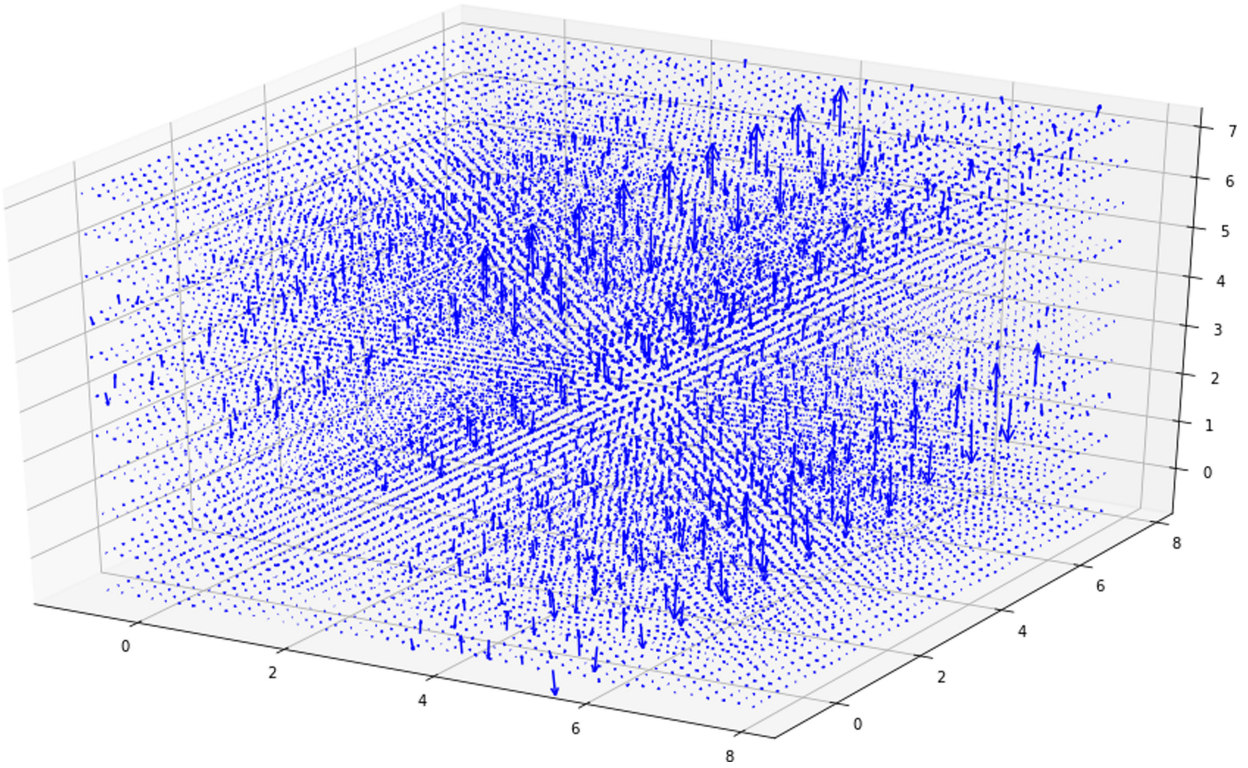

Figure 6. Ghosts in a vector field.

the system's paranodal spaces (Mejias 2007) and that present new 'elements', at different 'levels', through divergent 'processes'.

Yet not all forces are equal here. If you squint, something larger is beginning to emerge – against which *Debris* and *Demiurge* merely trace the outline of a cloaked, *transfictional* entity.

8. STACKS AND PLATFORMS

Vector fields are not necessarily neutral: they are host to organising principles (ideologies), they exhibit tendencies (wants and needs), they generate and proliferate and they accumulate into larger-scale objects (Figure 6).

Theorist Benjamin Bratton expands the metaphor of the *stack* from computer science into the realm of political theory. His work reframes unfolding socio-technical and geopolitical relations into a transnational 'multilayered structure of software, hardware, and network "stacks" that arranges different technologies vertically within a modular, interdependent order' (Bratton 2015: 4).

Bratton argues that 'this accidental megastructure is not the result of some master plan, revolutionary event, or constitutional order. It is the cumulative residue of contradictions and oppositions that arose to address other more local problems of computing systems design' (ibid.: 9). Bratton's Stack erupted, accidentally, from planetary-scale networks – traumatising the nation-state-based geopolitical order and reframing politics as technopolitics inclusive to non-human, computational agents and processes.

While *Debris* in no way approaches Bratton's Stack in terms of scale, it borrows handily from Bratton's concept of verticality. Stacks pile vertically, 'at once, drawing many actors into a common infrastructure ... [distributing] forms of autonomy to the edges of its networks while also standardising conditions of communication between them' (ibid.: 46). *Debris* pulls many actors, not least the composers involved, together into a stack assembled vertically from *Demiurge*'s archive, itself accumulated vertically from what Bratton would call a platform:

> not only a technical architecture; [platforms] are also an institutional form. [Platforms] centralize (like states), scaffolding the terms of participation according to rigid but universal protocols, even as they decentralize (like markets), coordinating economies not through the superimposition of fixed plans but through interoperable and emergent interaction. (Bratton 2014)

Bratton points out how platforms do not respond to premeditated plans; they set 'the stage for action to unfold through ordered emergence' (Bratton 2015: 47). Bratton explains how platforms are standardised structures that, while allowing users to reprogram their

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elements, represent a paradoxical type of 'formal politics': a strict 'autocracy of means' that somehow inculcates 'an emergent heterogeneity of self-directed uses', that is, a 'liberty of ends' (ibid.). The composers of *Debris* leverage the digital audio waste of the *Demiurge* platform into a 'heterogeneity of self-directed uses'. Inversive geometry, a point becoming a circle.

Stacks and platforms allow us to organise *Demiurge*'s transphonographic vector field onto structures ripe with time-depth, with causality and recursive processes, with wild proliferation at the fringes. *Debris* emerges from *Demiurge*, which in turn emerges from the platform of machine learning as an emerging technology – each verticality itself both a budding fringe and a fruiting expression of the formal principles beneath it. The plurality of similar fringes (e.g., the *Hydra project* – an installation leveraging other components of the *Demiurge* ecosystem) embolddens the team's assertion that *Demiurge* is an outcome-agnostic platform.

While platforms are centralising systems accessible to human and non-human users that 'consolidate heterogeneous actors and events into more orderly alliances', they are 'not necessarily situated in a true central position to those alliances' (Bratton 2015: 48). That is very much the case with *Debris* and *Demiurge*; it becomes difficult to account for central actors across such a distributed network.

Both projects represent an 'empty diagram through which users mediate new and archived information' (ibid.), and while their structuring elements are partially replaceable (e.g., the involved agents), they retain an essential shape (i.e., orderly alliances) throughout the endless transformative processes that their instantiations enact. Yet beyond the governing principles of the platform, this diagram is constructed from – waste reconsidered as surplus, as reproductive material, as epigenetic trauma. Made from waste and to waste it shall return – the generic platform of 'machine learning' is itself a veritable mountain of broken Github repo links, open source Python sketches with missing dependencies, incorrect or outdated Stack Overflow answers, no-longer-useful research papers, poorly or incompletely named GDrive folders of training data, buggy WandB API calls, heat-leaking transistors, outdated GPUs, suspicious Cloud computing services budding and bankrupting. The rapidity with which machine learning as a platform scales has accelerated *time itself* as an axis of waste.

The challenge to orthodoxy represented by *Debris* may have less to do with its content per se than with its relationship to the platonic concept of the artwork. The *Demiurge* team argues that creative *platforms* (inclusive to hardware, software, human gristle) have replaced the artwork as the de facto paradigm for creative production under the regime of machine learning. Platforms contain everything that is relevant about the concept of the artwork (a reference point, a copyright relationship) without outdated 'nation-state' paradigms (centrality, defined borders, singular authors), and affording juicy extras (reconsumption and proliferation paradigms, human and non-human collaborators, substructural analysis of vertical layers, ghostly apparitions of non-human computational-ideological *oligarchs* exhibiting influences behind the scenes, endless abundance and endless obsolescence).

9. *DEBRIS* AS SWARM

Our analyses so far have avoided the contributing composers of *Debris* to an almost extreme extent. This is intentional; it seemed like an awfully conventional place to start a thoroughly unconventional analysis.

We have identified stacks, platforms – vertical and modular accumulations of rules, technical principles and propagative forces – characterised in part by free proliferation at the edges. Furthermore, we have identified a 'liberty of ends' described earlier, namely a proliferation of material boiling at the surfaces of the stack, a profusion of surplus waste that clots into new structures. What does it mean to participate at this level, what relationships develop among the composers of *Debris*, between them and the stack itself, between them and the deep subterranean caverns of platform technologies?

The stack is modular, reliant on emergent processes, buzzing with abstract and hard-to-disentangle communication protocols. Surface layers more resemble *swarms* than architectonic blocks of information and action. Parrika relates some of the discourse over the dawn of AI research to insect-like structures and communications:

> 1. there is no need for planning;
>
> 2. no need for central representation;
>
> 3. our traditional ways of modeling the world for the actors are impractical and unnecessary;
>
> 4. we should pay more close attention to biology and evolution;
>
> 5. one should focus on building real, concrete solutions, not merely theoretical models. (Parrika 2010: xi)

The swarm has found increasing cachet among the theory community, especially with regard to social organisation in the age of AI; for example, Eugene Thacker and Alexander Galloway. Much energy has been spent articulating the 'dumbness' (ibid.) of constituent swarm components, but Mackenzie Wark's research on sub- or para-communicational protocols (xencommunication, exocommunication) dimensionalises these layers of activity:

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> At moments of particularly fragile traffic around such a network, there are appeals to another kind of communication which can either legitimate these paltry linkages or at least cast them in some sort of perspective. If regular communication sometimes seems impossible, then it doesn't seem all that ridiculous to imagine it possible to communicate with the impossible, with the infinite, with the great outdoors—the totality. (Wark in Galloway, Thacker and Wark 2014: 161)

Revolutionary discourse, criminal underclasses and rebellion can foment within the fringes of a stack. Take, for example, the extreme modification of *Debris*'s source material to the point of unrecognisability in Gviniashvili's reworking. Waste assembles into zit-like growths with cancerous logics.

In *Debris* the 'members [representing self-aware points in a multi-dimensional problem space] ... have [no] knowledge about [its] global behavior ... nor ... global information about the environment' but their resultant interactions generate complex collective behaviours (Al-Rifaie, Bishop and Caines 2012: 323). Some of the most representative instances of socially interactive behaviours between insects or animals (e.g., bird flocking or ant foraging) involve two key elements: 1) 'self-interaction', happening between agents, and 2) 'exo-interaction' defining their relationship to the environment or 'available space.'

While a swarm burbling at the fringes of the stack (Figure 7) can develop its own, exogenous logic, ideology, behavioral quirks, the swarm remains beholden to platform gravity. *Debris*'s swarms resemble autopoietic machines:

> a machine organized (defined as a unity) as a network of processes of production (transformation and destruction) of components which: (i) through their inter-actions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and (ii) constitute it (the machine) as a concrete unity in space in which they (the components) exist by specifying the topological domain of its realization as such a network. (Maturana and Varela 1980: 135)

At the same time, the swarm can disassemble into tricksters, into exo-communicating factions, into musical compositions that presented without context could, in fact, bear absolutely *zilch* from these 5–7,000 words to the ears of their audience.

10. META-ANALYSIS, POST-ANALYSIS

A moment of meta-archaeological reflection reveals that Deleuze and Guattari's work is everywhere here.

> Deleuze and Guattari's concept of the *assemblage* resembles a swarm – a unity comprised of 'a symbiosis, a "sympathy" [... of] alliances, alloys', subject to 'contagions, epidemics, the wind'. (Deleuze and Parnet 2002: 69)

Further, Guattari's analytical approach to the *assemblage* is split, synchronic-diachronic:

> synchronic: the components that constitute an assemblage at a given moment and polarize it towards such and such a behavior;
>
> diachronic: marking out of the generation and transformation of assemblages. (Guattari 2016: 195)

In *Swarm* (synchronic) versus *platform* (diachronic) analytical logics both logics necessarily intersect, and the consequent meta-analysis explores the 'links between assemblages that sketch out rhizomatic openings' (ibid.), the fungal budding from platforms, stacks and swarms – fungal growth is a nice metaphor given its natural relationship to waste material.

- Synchronic, swarmic logic: each of the electronic music works that comprise *Debris* is an arena to explore emergent behaviors or arborescent lineages linked to specific creative configurations.
- Diachronic, platformic logic: examining the new generation and modification of assemblages.

Through this lens, *Debris* points backward through *Demiurge* towards what Guattari defines, referring to the work of Georges Aperghis, as 'focal points of creativity' or a 'chaosmic line' – an apparent foundational 'chaos that deploys not only lines of discursivity, of echoes ... but also of referential links, affects, an existential dimension that is non-discursive, that gives itself not in a paradigmatic sense, but as [the] texture of another order' (Guattari 2013a: 33). Peaty soil.

To push the meta-analysis even further, Guattari leads us back to Adorno, arguably prefiguring Deleuze and Guattari's assemblage: Adorno describes a 'juxtaposed rather than integrated cluster of changing elements that resist reduction to a common denominator, essential core, or generative first principle' (Jay 1984: 14–15), and which 'posits a relation on the basis of observable proximity [while having] a certain ... arbitrary quality' (Leppert 2002: 64).

Information and art theorist Anna Munster has no interest in systematic network analyses. Instead, she beholds networks as unmappable processes, that is,

> an aesthesia of networks – or more plainly, network experience – joins the heterogeneity of humans and nonhumans into arrays that tend to both repetition and difference. We find ourselves both loosely concatenated with other humans and with informatic machines, enmeshed in an architecture that depends on the auto- and allopoietic production of massively redundant crisscrossing routes and pathways (Munster 2013: 7).

Munster focuses on the experience of networks *as networking*, as 'processes, proto-formations, and

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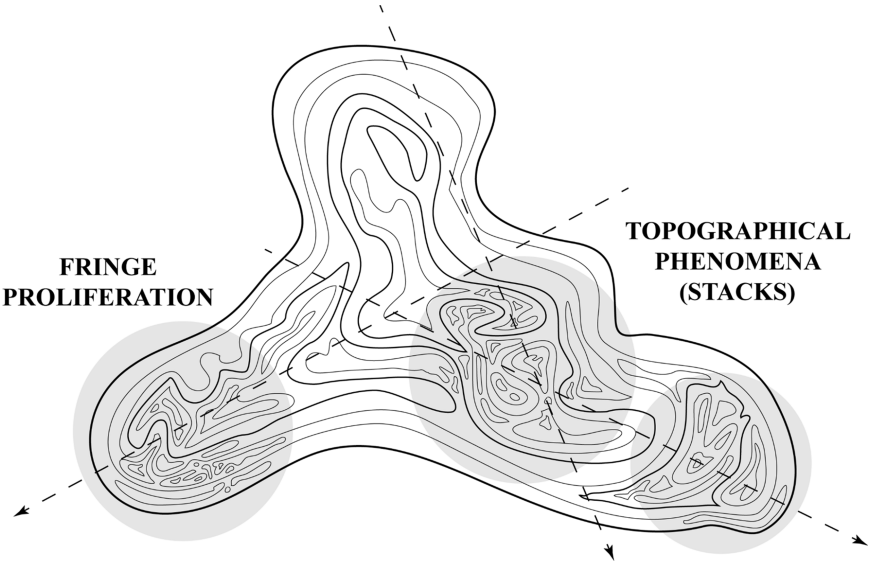

Figure 7. A 2D representation of a techno-ideological platform.

imperceptible human/machine currents that conjoin social, info-technical, and aesthetic elements in novel ways' (ibid.: 9). Munster claims that 'creation and invention the arts occur as the imperceptible is encountered and differentially actualises through novel assemblages' – exo-interaction, exocommunication, free propagation at the fringe, swarm.

Palimpsest, archive, platform, swarm, assemblage – all organisational models and metaphors for network topologies, topologies that challenge the conventional link-node approach of conventional networks and graphs, topologies likely more descriptive of how contemporary creative processes actually unfold.

11. THE GREAT HEAP

By refactoring this analysis through so many different frameworks, this paper has in the process accumulated yet another hive of propagative forces at the fringe of the *Demiurge* platform: waste-consumption, waste-recycling, waste-generation.

Piles of surplus material quivering with reproductive momentum annihilate every incoming object and computation into the fragmented, free-able, living, dying, decomposing *heap* shared and accumulated across innumerable stacks of process. Discrete output yields to indiscrete platform. Artist yields to hybrid, modular, fungible component-assembly, to *material* as a partially associated, partially contextualised, overwritable, volatile, incomplete and corrupted list of pointers to memory-locations. Archaeology yields to digital forensics. Textuality glitches out and dies from the non-contiguous allocation of its references. The *great heap eats history* and turns it into toxic sludge. To work with this stuff means dissociating, however knowingly or voluntarily, into its complex virtual-physical plane: catalogued, however incompletely, reproduced with, however thoroughly, discarded, however indifferently.

We now ask the reader to listen again to *Debris* and reintroduce the durational element, the aesthesis, into what might have become a static discussion of a simple project, returning to the network itself after a circuitous reconsumption of the network, returning to *time*, axis of waste, axis of abundance.

REFERENCES

Adorno, T. W. 1979. *Gesammelte Schriften Band 15 (Komposition für den Film Der Getreue Korrepetitor)*. Frankfurt: Suhrkamp Verlag.

Adorno, T. W. 1984. *Gesammelte Schriften Band 19*. Musikalische Schriften VI. Frankfurt: Suhrkamp Verlag.

Aksamija, N., Maines, C. and Wagoner, P. 2017. *Palimpsests: Buildings, Sites, Time*. Turnhout, Belgium: Brepols.

Alonso, R. 2018. *Death and (Re)birth of J. S. Bach*. London: Routledge.

Alonso, R. and Poliks, M. 2022. Demiurge: A Music of Babel. *Leonardo* **55**(5): 503–7.

Al-Rifaie, M. M., Bishop, J. M. and Caines, S. 2012. Creativity and Autonomy in Swarm Intelligence Systems. *Cognitive Computation* **4**(3): 320–31. https://doi.org/10.1007/s12559-012-9130-y

Bailey, G. 2007. Time Perspectives, Palimpsests and the Archaeology of Time. *Journal of Anthropological Archaeology* **26**(2): 198–223. https://doi.org/10.1016/j.jaa.2006.08.002

Bakhtin, M. M. 1989. *The Dialogic Imagination*. Austin: University of Texas Press.

Barthes, R., Howard, R. and Lavers, A. 2013. *Mythologies*. New York: Hill & Wang.

https://doi.org/10.1017/S1355771823000249 Published online by Cambridge University Press

Berio, L. 2006. *Remembering the Future*. Cambridge, MA: Harvard University Press.
Born, G. 2015. *Music, Sound, and Space: Transformations of Public and Private Experience*. Cambridge: Cambridge University Press.
Born, G. and Barry, A. 2018. Music, Mediation Theories and Actor-Network Theory. *Contemporary Music Review* **37**: 443–87.
Burns, L., Woods, A. and Lafrance, M. (2015). The Genealogy of a Song: Lady Gaga's Musical Intertexts on *The Fame Monster* (2009). *Twentieth-Century Music* **12**(1): 3–35.
Burkholder, J. 2001. Borrowing. *Grove Music Online*.www.oxfordmusiconline.com/grovemusic/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000052918 (accessed 23 April 2022).
Burkholder, J. n.d. An Annotated Bibliography. *Musical Borrowing and Reworking*. www.chmtl.indiana.edu/borrowing/index.html (accessed 13 October 2022).
Bratton, B. 2014. The Black Stack. *e-flux Journal*, 53. www.e-flux.com/journal/53/59883/the-black-stack/ (accessed 13 October 2022).
Bratton, B. 2015. *The Stack: On Software and Sovereignty*. Cambridge, MA: MIT Press.
Buckley, A. 1989. Music Archaeology: Its Contribution to 'Cultural' Musicology and 'Historical' Ethnomusicology. *Archaeologia Musicalis* **3**: 109–13.
Burns, L., Lacasse, S. and Burkholder, J. P. 2018. *The Pop Palimpsest: Intertextuality in Recorded Popular Music*. Ann Arbor, MI: Michigan University Press.
Cox, C. and Warner, D. 2017. *Audio Culture: Readings in Modern Music*. New York: Bloomsbury Academic.
Deleuze, G. and Parnet, C. 2002. *Dialogues II*. New York: Columbia University Press.
de Landa, M. 2006. *A New Philosophy of Society: Assemblage Theory and Social Complexity*. London: Continuum.
DeNora, T. 2000. *Music's Social Powers: Soundtrack, Self and Embodiment in Everyday Life*. Cambridge: Cambridge University Press.
Dillon, S. 2014. *The Palimpsest: Literature, Criticism, Theory*. London: Bloomsbury.
Eco, U. 1989. *Open Work*. Cambridge, MA: Harvard University Press.
Evans, D. (ed.) 2009. *Appropriation*. Cambridge, MA: MIT Press.
Fletcher, R. 1992. Time Perspectivism, Annales, and the Potential of Archaeology. In A. Knapp (ed.) *Archaeology, Annales, and Ethnohistory*. Cambridge: Cambridge University Press.
Forman, M. and Neal, M. A. 2012. *That's the Joint!: The hip-Hop Studies Reader*. New York: Routledge.
Galloway, A. R., Thacker, E. and Wark, M. K. 2014. *Excommunication: Three Inquiries in Media and Mediation*. Chicago: University of Chicago Press.
Genette, G. 1997a. *Palimpsests: Literature in the Second Degree*. Lincoln, NE: University of Nebraska Press.
Genette, G. 1997b. *Paratexts: Thresholds of Interpretation*. Cambridge: Cambridge University Press.
Guattari, F. 2013a. L'hétérogenèse dans la création musicale (Heterogeneity in Musical Creation). *Chimères* **79**(1), 33–6. https://doi.org/10.3917/chime.079.0033
Guattari, F. 2016. *Lines of Flight: For Another World of Possibilities*. London: Bloomsbury Academic.
Hellier, R. 2019. *Performing Palimpsest Bodies: Postmemory Theatre Experiments in Mexico*. Bristol: Intellect Books.
Hennion, A. 2003. Music and Mediation: Towards a New Sociology of Music. In M. Clayton, T. Herber, and R. Middleton (eds.) *The Cultural Study of Music: A Critical Introduction*. London: Routledge.
Hennion, A. 2016. From ANT to Pragmatism: A Journey with Bruno Latour at the CSI. *New Literary History* **47** (2/3): 289–308.
Hull, K. L. 2005. Process, Perception, and Practice: Time Perspectivism in Yosemite Native Demography. *Journal of Anthropological Archaeology* **24**(4): 354–77. https://doi.org/10.1016/j.jaa.2005.06.003
Jay, M. 1984. *Adorno*. Cambridge, MA: Harvard University Press.
Kittler, F. A. 2006. *Gramophone, Film, Typewriter*. Palo Alto, CA: Stanford University Press.
Klein, M. 2004a. *Intertextuality in Western Art Music*. Bloomington, IN: Indiana University Press.
Klein, S. W. 2004b. James Joyce and Avant-Garde Music. *The Contemporary Book Company Music Centre Ireland*. www.cmc.ie/features/james-joyce-and-avant-garde-music (accessed 13 October 2022).
Kostka, V., Castro, P. F. and Everett, W.A. 2021. *Intertexuality in Music: Dialogic Composition*. London: Routledge.
Lacasse, S. 2000. Intertextuality and Hypertextuality in Recorded Popular Music. In *The Musical Work: Reality or Invention?* Liverpool: Liverpool Unversity Press. 35–58. https://doi.org/10.5949/liverpool/9780853238256.003.0003
Law, J. 1999. After ANT: Complexity, Naming, and Topology. *The Sociological Review* **47**(1_suppl), 1–14. https://doi.org/10.1111/j.1467-954X.1999.tb03479.x
Leppert, R. 2002. Introduction. In *Essays on Music: Theodor W. Adorno*. Berkeley, CA: University of California Press. 1–84.
Lippard, L. R. 2001. *Six Years: The Dematerialization of the Art Object from 1966 to 1972: A Cross-Reference Book of Information on Some Esthetic Boundaries*. Berkeley, CA: University of California Press.
Lucas, G. 2005. *The Archaeology of Time*. London: Routledge.
Lukacs, G. 2006. *The Theory of the Novel: A Historico-Philosophical Essay on the Forms of Great Epic Literature*. London: The Merlin Press.
Maniquis, R. M. 2011. De Quincey, Varieties of the Palimpsest, and the Unconscious. *Romanticism* **17**(3): 309–18. https://doi.org/10.3366/rom.2011.0044
Maturana, H. R. and Varela, F. J. 1980. *Autopoiesis and Cognition: The Realization of the Living*. Dordrecht, The Netherland: D. Reidel Pub. Co.

Mejias, U. A. 2007. Networked Proximity: ICTs and the Mediation of Nearness. PhD dissertation, Columbia University.

Middleton, R. (ed.) 2001. *Reading Pop: Approaches to Textual Analysis in Popular Music*. Oxford: Oxford University Press.

Munster, A. 2013. *An Aesthesia of Networks: Conjunctive Experience in Art and Technology*. Cambridge, MA: MIT Press.

Nicholson, S. W. 2006. Beyond Quotation: Intertextuality in Popular Music Since 1990. PhD diss., University of Rochester.

Olsen, D. A. 2007. The Complementarity and Interdisciplinarity of Archaeomusicology: An Introduction to the Field and this Volume. *World of Music* **49**(2): 11–15. www.jstor.org/stable/41699761

Paddison, M. 2011. *Adorno's Aesthetics of Music*. Cambridge: Cambridge University Press.

Parrika, J. 2010. *Insect Media*. Minneapolis, MN: University of Minnesota Press.

Pernecky, T. 2020. *Postdisciplinary Knowledge*. London: Routledge.

Schumacher, T. G. 1995. 'This is a Sampling Sport': 1 Digital Sampling, Rap Music and the Law in Cultural Production. *Media, Culture & Society* **17**(2): 253–73. https://doi.org/10.1177/016344395017002006

Steiner, P. 1981. In Defense of Semiotics: The Dual Asymmetry of Cultural Signs. *New Literary History* **12**(3): 415–35. https://doi.org/10.2307/469022

Sturm, B. L. 2006. Adaptive Concatenative Sound Synthesis and Its Application to Micromontage Compositor. *Computer Music Journal* **30**(4): 46–66. doi: 10.1162/comj.2006.30.4.46

Wilson, S. 2018. Notes on Adorno's 'Musical Material' during the New Materialisms. *Music and Letters* **99**(2): 260–75. https://doi.org/10.1093/ml/gcy002

Youngblood, M. 2019. Conformity Bias in the Cultural Transmission of Music Sampling Traditions. *Royal Society Open Science*, **6**: 191149. https://doi.org/10.1098/rsos.191149