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Poking Holes: Distributed Ambivalence and Aesthetics in Sound Networks

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Amid the current pandemic (COVID-19) disembodied presence has emerged as the new norm, revealing a world increasingly entangled with the technological and conceptual paradigm of the network. In this scenario, it is crucial to reconsider core axioms of the pervasive connectionist credo, acknowledging the empty space that a network subtends, the hollowness of its lattice, the ambivalence of its membership, the weave and web of its relational embodiment. This paper enquires on how such notions map onto the music/sound domain by drawing on aesthetics for a more lucid account, while also proposing a speculative approach to tracing inner layers of these networks, through three modalities: Artificial Neural Networks, Audible Ecosystems, and Networked Music Performance.

1. Networks

> What I want is a network. What do you have to change in your whatchamacallit to do a network? (Latour 1996, 116)

Networks might not be an intrinsic property of the universe, notwithstanding they have acquired a remarkable significance in the collective imaginary; the dominant paradigm which "makes scarcely imaginable the possibility of an alternative or an outside uninflected by networks" (Jagoda 2016, 221).

Beyond the technical definitions at a mathematical level, the specifics of a myriad structural and operational variations and models, or the graphical conventions for representing it, a network is a conceptual subset of a system. The general systems theory, although initially posited in the 1930s, was formalised by Ludwig von Bertalanffy (1969), and was characterised by a move towards interrelations and interdependence. To describe a system, normally one would specify who/what interacts with whom/what, and how entities behave in their response to the other. Interaction involves reciprocal influence, which modifies behaviour, actions and reactions either directly (through communication) or indirectly (stigmergic).

When systems are governed by non-linear interactions amongst entities and through feedback processes with the environment, they are often referred to as 'complex'. These, in turn, are normally and non-exhaustively associated with the following characteristics: *autopoiesis* (self-organisation), locality of interactions, defiance of a single rule or level of explanation, emergence, sub-optimality, connectivity, iterativity, decentralisation, adaptation, amongst others. The theory regarding complex systems is not a single body of theory, and it comprises contributions from different fields such as cognitive and behavioural science, evolutionary theory, social science, computer science, mathematics, philosophy, to name but a few.

The notion of a network, which weaves together these viewpoints, has become a ubiquitous approach for the modelling of complex systems. It has been argued (Jagoda 2016) that three major and parallel developments contributed to the emergence of the network as a leading explanatory paradigm: the theoretical/mathematical framework spanning Graph Theory to modern Network Theory, the implementation of an informational architecture (the Internet), and neoliberalism and finance capitalism, which resulted in the adoption of the network as the key organisational and conceptual model, and key driver of socio-eco-

nomic development. These framings, in isolation, do not adequately elucidate the role, function or form of music networks, and deeper enquiry is required to understand how networks aid performative topo[typo]logy.

Turning to aesthetics might help overcome partial accounts, beyond rational descriptions or representations, even if the illusory search for the rhizomatic origin may remain fruitless, due to the abstracted relational assessment of intra-partial interconnection (Deleuze & Guattari, 1988).

1.1. Network Aesthetics

In this paper, aesthetics does not refer to those viewpoints predicating objective and universal laws that map perceptual analyses of the aesthetic object to notions of beauty or hedonic value. Instead, we consider the lineage originating from Dewey's art as experience (2005) and include aesthetic viewpoints based on relational and pragmatist axioms. The relational stance had originally been highlighted in systems aesthetics, when it was posited that "there are no contrived confines such as the theater proscenium or picture frame. Conceptual focus rather than material limits define the system" (Burnham 1968, 32). It has been argued that one can truly experience the network at a "level of imperceptible flux — of things unforming and reforming relationally" (Munster 2013, 3). According to Rancière, aesthetics is "a mode of articulation between ways of doing and making, their corresponding forms of visibility, and possible ways of thinking about their relationships" (Rancière 2005, 10). The political reading of aesthetics professed by Rancière or Bourriaud, however, is not entirely unquestioned, and some (Potgierter 2018) argue that the folding/collapse of art and everyday life incurs the danger of depriving life-enhancing experiences. A suitable aesthetic framework for dealing with the network must come "to terms with conflict, boredom, confusion and stagnation" (Munster & Lovink 2005) as well as intricate and nuanced notions of social complexity. The need for the acknowledgment of stagnation, contradiction, misalignment and discomfort is echoed in the notion of ambivalence, put forward by Jagoda as an alternative to moving beyond networks or opting out of them. Ambivalence in this sense is seen as extreme presence, beyond apathy, cynicism, disengagement, or hopelessness, and "it demands risking non sovereign experiences of absence, uncertainty, boredom, complexity, and disconnection without promises of instant gratification, certainty, discovery, closure, or reconnection" (Jagoda 2016, 225). Accepting ambivalence and uncertainty is thus a *sine qua non* of networked being.

In this paper, we are interested in investigating the construct of the network, through the domains of music and sound.

2. Music & Sound Networks

There are countless expressions of the network in the context of music and sound, all affording different interpretations of the connectionist imperative. Of these, those that do not have the generation of music/sound as the ultimate output will not be considered. These could include social networks formed amongst music professionals (*e.g.,* Linkedin, Bandcamp, Instagram, etc.), supporters, fans, collectors, forum users, music communities, and so on. Moreover, we limit the discussion to those networks that are technologically assisted, thus omitting, for example, pre-digital networks of embodied culture and collective memory, as in the case of oral transmission of musical practices and knowledge. Amongst the music and sound networks that we are interested in, three can be considered as the leading paradigms.

2.1. Artificial Neural Networks

Artificial Neural Networks (ANNs) are speculative digital re-workings of processes that normally take place in the human brain; surrogates of electro-chemical interconnections of neurons and synapses, used to model learning in all domains of artificial intelligence. In the last few years, ANNs have also become a principal model for music and audio endeavours, from information retrieval (Choi et al. 2018) to digital signal processing (Purwins et al. 2019) through to generation and composition (Briot, Hadjeres & Pachet 2020). Different network architectures are normally used depending on the task (e.g., convolutional networks for classification tasks, recurrent neural networks for temporal dependencies, etc.) but in the last few years self-attention-based models (Vaswani et al. 2017) are increasingly used for most generative music tasks. The use of networks for music generation, however, extends further back before ANNs, for example as in the augmented networks-based Experiments in Musical Intelligence (EMI) (Cope 1996) or the MUSACT system (Bharucha 1993).

2.2. Audible Ecosystems

Pioneered by Agostino Di Scipio, audible ecosystems (AEs) and emergent sound structures, instead, are tightly bound to the philosophical discourses revolving around autopoiesis. AEs are, in fact, complex adaptive systems; dynamic feedback and interaction between a human agent, a digital signal processing unit

and the external environment give rise to seeming sonic self-organisation that cannot exist in isolation from the listener's cognitive processes. AEs "prompt not only a reconsideration of the way we do performance, but also an examination of our practice in a more diachronic sense: as the weave of activities and relationships through which we bring forth work" (Green 2014, 62). Under the umbrella of AEs other musical practices can be included by virtue of some common conceptual axioms. An example is the sonic practice of Onkyokei (Plourde 2008) and the so called "no-input" or "empty" instruments (Novak 2010; Moriaty 2016) pioneered by Toshimaru Nakamura and Sachiko M, respectively. These instruments presuppose no sound sources other than their own self-noise. *No-input* mixer, for example, involves looping the output of a mixer back into the input, to amplify the inner circuitry sound and shape by means of the parametric equalisation afforded by the desk itself (although throughput devices such as FX pedals might be used to enhance specific behaviours of the system).

2.3. Networked Music Performance

Finally, we consider networked music performance (NMP). While some (Lemmon 2019) argue for a subtle distinction between telematic music (more concerned with cybernetic and technologically leveraged political themes) and NMP (musicians performing together in remote locations leveraged by modern networking technologies), we ignore this debate and, hereinafter, view NMP as pointing at both practices. NMP predominantly is seen to emerge sometime in the mid 20th century, bringing with it a diverse collection of creative and technological paradigms, description of which would far exceed the scope of this paper (c.f. Joy 2011). For a brief introduction to NMP the reader is encouraged to consult Carôt, Rebelo & Renaud (2007). NMP enjoyed a relative increase in popularity from the early 2000's, having been a marginal phenomenon for 30 years prior, mostly due to technological developments (high-speed network communication protocols, increased bandwidth affordance, etc.) in conjunction with increasing recognition of net/web art (Schroeder 2009). From the participants' perspective, in the manner of experience and action, NMP provides a certain degree of independence from three basic factors: spatial proximity, temporal synchronicity, and bodily (physical) presence. These factors afford a 'parralistic' dichotomy to emerge; both enabling and disabling through juxtaposition of intra- and supra- relationism. Involvement in a NMP demands reassessment of aspects involved in collective music making. Listening is perhaps one of the more crucial ones, as it becomes, at times, uncoupled from the perceptual experience of the body and subject to varying degrees of network latency and audio

fidelity; "listening in the network [...] can be seen as an activity and an interactivity that not only shapes our perception of a musical work but also, ultimately, performers as (listening) subjects themselves" (Schroeder 2013, 223). Sá and Tanaka describe three planes of performance, the local, the distributed, and the extended, where the extended affords a "subjective sense of presence beyond the physical performance space" (Sá and Tanaka 2019, 15). The extension into the digital world is likened to an extended notion of semantic typology, where the habitat of the performer is augmented through a digitally interfaced divide. Oneself now becomes the interface mediated through sound and perception, as one extends from the 'here' into and unto the 'there'.

2.4. Music & Sound Network Aesthetics

These three paradigms outline different accounts of the network, highlighting how heterogeneous and complex a notion it is. Comparable definitions foreground situatedness, disembodiment, and inter-subjectivity as performative companions, whilst technological dependency provide distinct avenues for hindrance and affordance, an intricate dance of unconscious agency. Adkins has proposed a connectionist frame for understanding the inter relational nature of his own artistic practice, drawing on the connectionist paradigm to understand how "networks of ideas or connectionist neural models of cognitive behaviour can be used to contextualize, understand and become a creative tool" (Adkins 2014, 51). He draws on the musical assemblage framing of Born (2010) and the nodalistic model of Gouchenour (2011), by proposing a network mediated lens to understand contemporary culture. Like system components which "derive their value solely through their assigned context" (Burnham 1968, 34), so are performers, musicians and programmers linked "together in social forms which are invariably historical." (Bourriaud 1998, 7). However, these 'components' are complex and nuanced individuals, not only endowed with decision-making skills, but also subject to bounded rationality. This is a key factor which sets these systems radically apart from static abstractions of the network. In the context of proposing a *nodalist* (Gochenour 2011) reading of network music to overcome the plethora of idiosyncratic definitions available, Renwick reminds us that "viewing network music as a set of 'selfs' organised within a coherent and cogent structure, allows one to garner a better understanding of what it means to be a participatory 'self'" (Renwick 2016, 24). Drawing on the aesthetic framing of the sublime by Iris Murdoch (1959), one's relation to the other provides the basis upon which one fully comprehends oneself.

In the wider domain of aesthetics in the arts and music it is now common to acknowledge the sense of uneasiness, discomfort (Aldama and Linderberger 2016) or failure (Cascone 2000), whilst relatively new fields of enquiry, such as experimental aesthetics, are also open to a disquieting dimension. Brincker, for example, argues for an aesthetic stance "to capture the temporally extended and complex processes that seem to characterize the broad embodied conditions of aesthetic experiences and responses" (2015, 4). The notion of *edge of action* is also formulated and identified as being of particular importance in non-artistic contexts (a distinction that evaporates under relational aesthetics lenses), and paramount in forming the experiences of beholding, co-beholding, vulnerability and appraisal. Adopting an aesthetic stance can be a useful for thinking about distributed aesthetics in network music, as it describes "the sense of being an active and physical bodily positioning and psychological attitude, and yet responding to and embedded in environment affordances" (Brincker 2015, 21).

Relational viewpoints on aesthetics and socio-political discourses are not uncommon in the context of NMP (Schroeder 2013; Vorster 2015) and AEs (Di Scipio 2011; 2015). In the music and sound ANNs domain, on the other hand, discussions of aesthetic nature are seemingly unrelated to the concerns and themes developed in philosophy of art. There are, of course, discussions around machine aesthetics (Rutsky 1999) or machine art (Taylor 2014; Broeckmann 2016), but in creative AI for music and sound, these discourses are limited. Normally, they relate only to the application of ANNs for the aesthetics judgment/evaluation of music artefacts/output, according to rules distilled from the human experience of music. Usually these are heavily skewed towards information-based accounts of perceptual features, and often implemented as one-factor explanations (Kalonaris, Gifford and Brown 2019). Alternatively, they may be focused on the integration of aesthetic evaluation into seemingly creative generative systems (using more or less the same rules, *e.g.,* in the optimisation process in the generation of machine music), or towards human aesthetic evaluation of the music artefacts produced by ANNs. What is missing, to date, is a holistic, multi-disciplinary discussion on the aesthetics of music/sound neural networks.

3. Objective

Normally, the network is perceived as ontologically ambivalent: allegedly an objective entity (e.g., physical or virtual cables and connections, routers, performers, artifacts, environments, digital neural layers, etc.) as well as a meta-

phor to understand emergent qualities of other entities. The three music and sound networks seen above all "share an anti-reductionist view of what count as actors and agency. Action is afforded by socio-material circumstances or, indeed, dispersed among collectives of human and non-human entities co-operating via associations or networks" (Krogh 2018, 548). The inclusion of non-sentient entities in the workings of the network is explicitly stated and programmatically specified in AEs. In ANNs, too, most agents apart from the programmer(s) who developed and runs the code or the listener(s), will be inanimate (*e.g.,* nodes and edges forming neural "layers", CPU, GPU, circuitry, software, etc.). As for NMP, it also comprises a wide array of agents/actors, both sentient and not (*e.g.,* LAN, Wi-Fi, computers, musicians, instruments, and so forth), with the environment (whether seen at situated or not) breathing performative agency in itself (e.g., latency, packet loss, inter-spacial resonance). This extended notion of network is characterised by non-free, traceable, empirically recorded point-to-point connections which leave empty most of what is not connected, needing the passage of other circulating entities in order to be traced back. How fulcral is this idea of trace? Arguably, "nothing, either in the elements or in the system, is anywhere simply present or absent. There are only, everywhere, differences and traces of traces" (Derrida 1981, 26).

How, then, does one go about tracing? Would doing so afford us novel insights on the relational nature of the system itself? Would poking holes in the network's lattice reveal different views of its ontological complexity and ambivalence?

4. Tracing: Part One

Arguably, tracing the displacement of data, information and/or sound along edges and between nodes, can be associated with the notion of flow. Networked flow has been used to investigate creative networks, such as NMP, in Gaggioli et al (2013), and it is based on the systems model of creativity developed by Mihaly Csikszentmihalyi (2014) which outlines a triumvirate of society (field), culture (domain) and person (individual). Network flow in creative domains is predicated upon six conditions (i.e., shared objectives/emotions, transition from one state to a future one, collective intention/strategy for exiting liminality, belief in transforming intention into action through group involvement, interactions between the group and the outside, and creation of narratives for making sense of the emergent concepts/ideas/artifacts) and then further hypothesised to be a process of six successive stages. This notion of flow involves the adoption of sequential/linear accounts of processes which might instead not be reducible to phenomenological timelines.

Gaggioli et al proceed to analyse flow by employing Social Network Analysis (SNA), a common tool used to model complex interactions between human actors. SNA often uses mapping and visualisation techniques to investigate network properties. It is based on the foundations laid by Graph and Network Theory, and is focused on connections between nodes (what have so far been referred to as entities) and edges (the links between nodes). SNA is mostly interested in the properties regarding connections, distributions and segmentation/clustering. This strategy has been often flagged for being rather partial and for offering an impoverished and flattened representation of the complex dynamics emerging from social networks. For example, it has been said that SNA-based approaches seem to ignore that "networks engage and are engaged by current political, economic and social relations." (Munster & Lovink 2005). The political, and by politics we mean "the experience and configuration of space, time, and social relations" (Jagoda 2016, 19), aspect of social networks has been revealed more explicitly during the COVID-19 pandemic, which has forced global adoption of remote connectedness as the modus operandi for shared experiences, whilst restricting physical inter-situatedness. Creative networks such as AEs and NMP are also imminently social, and not politically agnostic: the former, for example, are contingent on reconfigurations of relations between the audience/listeners, the sound designer/composer, and the environment as it exists in the collective socio-political imaginary. The latter (NMP) has further dependencies relating to quality of service, equipment, and monetary resources. As for ANNs, they, too, are nowadays dependent on vast amounts of data and GPU affordance, which has led to explicit centralisations of power towards big tech, with obvious political and ethical implications.

Besides these considerations of a political nature, there are more fundamental issues in the endorsement of graphical methods for the tracing and "re-assembling" the network; these representations can induce what has been termed network *anesthesia* (Munster 2013), a perceptual numbness that prevents us to experience the network in its complexity, which is reduced to "a problem of managing the quantity of connections among elements" (Munster 2013, 5). Furthermore, they are prone to ignore "experiences of stagnation within network formations and for coupling these networked experiences with a network's potential to transform and mutate into something not yet fully codified" (Munster & Lovink 2005). While graphical representations of networks often portray a network that never sleeps, by projecting static snapshots of a complex phenomenon in perpetual becoming, our experience of being in the network at times speaks of something rather different: information bottlenecks, retroactive flow, stagnation, wait times, lag, disconnection, data corruption, packet-loss, etc.

Similar arguments can be made when considering ANNs, notoriously impervious to scrutiny. Due to the increased affordances in GPU computing power, ANNs can be modelled to comprise deep architectural structures, with hundreds of layers and millions of parameters. This makes it difficult to understand or grasp what is actually happening inside them (*i.e.,* the "black box" paradigm). Graph-based representations are normally used for the visualisation and interpretation of the training datasets used for ANNs, by means of techniques such as 2D projections of highly dimensional data, correlation network graphs, or data-derived flowcharts such as decision trees. As for the inner workings of the ANNs, whose response functions are, in the majority of cases, non-linear and non-monotonic, attempts are being made on this front, which will be discussed in Section 5.3.

While graphical representations can help tracing (some of) the connections in a sound network, they remain a partial tool which cannot fully account for the complexity involved and accrued by the creative nature of this setting. We thus turn our inquiry to investigating how probing the latent space of a sound network might be a feasible proxy for tracing.

5. Tracing: Part Two

When discussing the difference between "traditional" interactive music systems and AEs, Di Scipio describes it as "a shift from creating wanted sounds via interactive means, towards creating wanted interactions having audible traces" (Di Scipio 2003, 271).

Network music or sound is then "heard as the empirical epiphenomenon of that network of interactions" (Di Scipio, 2005, 385) and this is arguably equally true for any of the paradigms seen earlier (ANNs, AEs, NMP). Since sound is the interface, what is heard is, then, the trace, the network itself: the "sound bears traces of the structural coupling it is born of" (Di Scipio 2003, 275). While this is true at a philosophical and sonic level, it leaves the mapping of complex interweaving of heterogeneous interactions which takes place in networked music and sound unquestioned and unscrutinised, except for the final output. On one hand "we are listening at the same time to the process and to the sound" (Meric & Solomos 2014, 12). On the other hand, it would also be valuable to have access to intermediate levels of the process, more explicitly. To this end, we propose some speculative methods, with in view to develop these more formally in the near future.

5.1. Tracing AEs

Conditioned upon the design and practical constraints, one could insert peripheral, intermediate sonic outputs in the lattice of the sound network. If allowed to feed out into the environment, these "traces" would naturally and recursively contribute back to the overall sonic construction, rendering the concept of "output" irrelevant at large. However, one could instead route the inner layers to hard disk or memory, to be used at a later stage and separately from the performance. Figure 1, for example, is a possible implementation based on the diagram in (Di Scipio 2003).

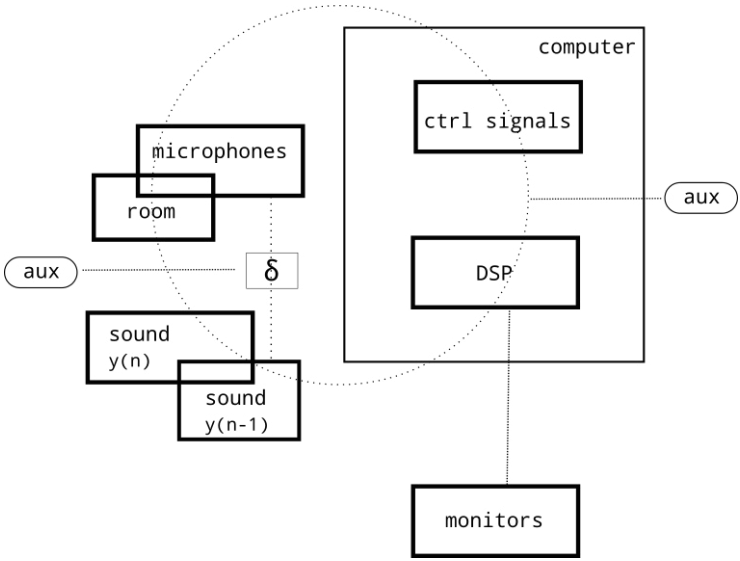

Fig. 1. Probing AEs with auxiliary outputs which can be written to file, memory, or used (in case of parametric output) for subsequent auditory or visual display, for example.

5.2. Tracing NMP

In (Gabrielli & Squartini 2016) a formal taxonomy for NMP is offered, based on eight structural features. Of these, topology is particularly important for the current discussion on probing, and can be characterised according to centralised/decentralised and synchronous/asynchronous axes (Weinberg 2003), with variations contingent upon having symmetric/asymmetric, weighted/unweighted connections. As an experiment, we consider a fully connected, unweighted and interdependent star topology where each node can only listen to the adjacent node. The direction is one way, therefore players in a node pair do not have knowledge of each other's sound; what each node

interacts with is (eventually and after the sound has "travelled" through the star at least once) but a trace of the global (supra-local) sonic network. The latter remains, however, inaccessible to the individual player.

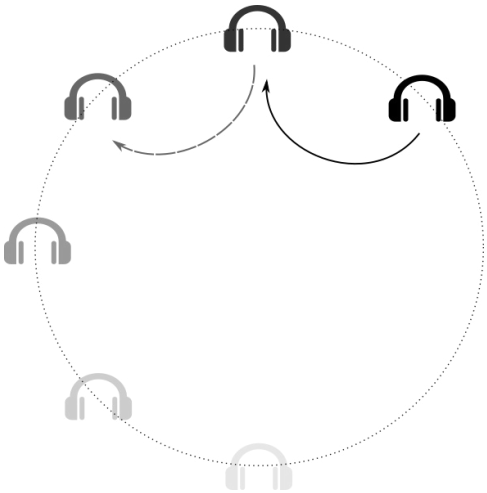

Fig. 2. Diagram of *Traces*: the global sonic output is obtained/experienced as indirect inference of the sequential propagation of one-way pairwise sound interactions.

An example of this experimental probing is Traces[1], a triptych of improvised pieces that were recorded so that each player had an independent booth and was able to listen only to the player to their left (see Figure 2). Thus, the information that each player received was some sort of propagated inference about what the totality of the music could have been at any given point in time, given what could be heard from a single adjacent player: a chain of blind interactions which, nevertheless, carried traces of the global sound network. Because of the independent multitrack recording procedure, Traces could be also broken down into separate duets, to offer a defragmented view of the sound total. The simultaneously inter- and dis- connected duets afford the listener to reflect on supra-local sound network's becoming.

1. ΣK, 2021. "Traces". Accessed April 4, 2021. https://skalo.bandcamp.com/album/traces

5.3. Tracing ANNs

Efforts on the front of Explainable AI (XAI) have been informed by social (e.g., trust, understanding) and commercial (e.g., regulatory compliance, adoption & acceptance, risk reduction) motivations. Many interpretability techniques are being used (Samek et al. 2019) but, while these offer insight as to how the input and output of ANNs models are related, they say little in terms of explanatory power on the internal mechanisms. It is, however, possible to inspect specific

layers of the network and to obtain feature visualisations (Nguyen, Yosinski & Clune 2019), for example. As for music and sound ANNs, to date, little has been done. Similarly to what proposed above for AEs and NMP, one could envisage probing inner layers' sound output for ANNs. Figure 3, for example, shows the attention maps for the same input to an attention-based model used for counterpoint generation (Kalonaris, McLachlan & Aljanaki 2020), for two different layers.

As one can see, different layers respond differently, potentially providing useful probes if used to generate intermediate music/sound outputs. The exploration of inner representations of the network in the sound domain is almost exclusively done in the context of Variational Autoencoders (VAEs) (Roberts et al. 2019), but we contend that it would be a valuable strategy for other neural network architectures, too.

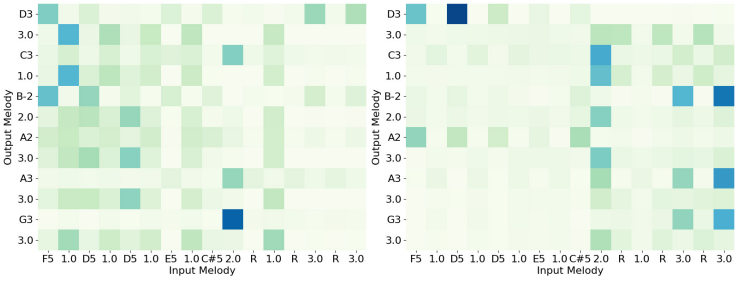

Fig. 3. Attention maps for layer 2 (left) and 4 (right) of the 8th attention head in a *Transformer* model used in a two-voice counterpoint generation task.

6. Conclusion

We set to investigate and re-contextualise our experience of sound and music networks by adopting viewpoints normally argued for in the sociological branch of network science and in postmodern aesthetic stances foregrounding relational and dialogical approaches.

We argued for the importance/potential of providing practical ways for "tracing" or "probing" the network of interactions, in NMP, AEs and ANNs alike. Despite discussions in this realm on a philosophical level, there is at times a lack of pragmatism when it comes to suggesting how to implement these notions so that an external observer/listener (e.g., the audience) can have a window into the theoretical underpinnings and make sense of them. Conversely, we hope to have provided a more philosophical, aesthetic framework for the use of AI in music and sound: this is a field which is seemingly lacking an integrated way to

think about the aesthetics of the (neural) network, beyond the perceptual analysis or hedonic value of the sound object that these systems produce or evaluate.

The construct of the network is as complex as the phenomena it stands for and it defies single levels of explanation or representation. More importantly, it requires us to radically accept uncertainty and ambivalence as part of our experience of it, with far reaching implications in philosophical and socio-political spheres. Our enquiry focused on the sound and music domain but, while much remains to be experimented with, we hope that insight at this level might be beneficial for a more holistic experience and understanding of the network at large.

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