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Mining the ambient commons: building interdisciplinary connections between environmental knowledge, AI and creative practice research

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ABSTRACT

According to Brooks [2017. "The Big Problem with Self-driving Cars Is People". *IEEE Spectrum: Technology, Engineering, and Science News*], artificial intelligence has had a variable track-record of usefulness in situations where context and environmental knowledge are responsible for shaping human interactions. In 2021, providing contextually aware training to supervised machine learning is still a non-trivial task for AI models that involve complex systems. In addition, knowledge held only across distributed members of a community, within culture, or tacitly within the wider environment of the ambient commons [McCullough 2013. *Ambient Commons: Attention in the Age of Embodied Information*. Cambridge, MA: MIT Press] evades consistent generalizable modelling – even in technical domains such as traffic flow management, atmospheric chemistry, or the prediction of election results. Yet it is precisely these interactions of context, community, culture and environment that also define how music can be created. The creative arts can themselves be thought of as a complex system. Assuming that creativity is non-generalizable, this paper assesses creative processes through a humanities-centric lens of machine learning and robotics, aiming to better understand relationships between context, environment and experimental system in artistic research. These relationships are now themselves significantly digitally mediated, requiring a change in academic discourse away from artefacts which need discrete research justification towards a more holistic, and often non-linear view of networks that require cultural situation. In doing so, issues of creative accountability [Field 2021. "Changing the Vocabulary of Creative Research: The Role of Networks, Risk, and Accountability in Transcending Technical Rationality." In *Sound Work: Composition as Critical Technical Practice*, edited by J. Impett, 303–317.Orpheus Institute Series. Leuven: Leuven University Press] and the implications of substituting "creative question" for "research question" are examined within creative research. Early twentieth century ideas related to progressivism which have instrumentalized creative practice, particularly where technology forms part of art making, are challenged by re-

KEYWORDS

Creativity; research design; AI; complex systems; musical composition; technical rationality; creative computation; change processes

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thinking change through new models. The Three Horizons change model [Sharpe 2016. "Three Horizons: A Pathways Practice for Transformation." *Ecology and Society* 21 (2): 47] originally intended to describe environmental ecosystems, is assessed as a practical tool for designing creative research.

Introduction

This paper proposes that the *process* of creative work, with particular reference to musical composition, has strong parallels with some of the more problematic methodological questions in AI research. In particular, these revolve around the definition of research processes which are not neatly compartmentalized into traditional workflows or those that can be enacted through the tools and language of scientific method.[1][2] The problems encountered in musical creativity are complex, inhabiting multiple dependencies to outside contexts and timescales, so much so that setting them in research assessment frameworks which linearize this complexity will result in seeing the total picture through a narrow window. The view through that window is often one constructed in terms of technical legitimation as that is relatively straightforward to define and one that can also be of use in certain pedagogical contexts. Whilst technical discussion is useful, it alone may not always encapsulate the rhizomatic relationship material has with context: in this space music can be both an end in its own right and a powerful means of critical exploration, linking artistic material with culture, community and external significance. Through a window of technical practice only, the richness and variety of research process that is used to establish those links is not fully revealed, or even visible as research – partly because constructing a musical work can be a multidisciplinary activity *from the outset*. It is time to re-think the ontology of creative research (particularly within institutions), especially at a time when scientific research has itself fully embraced complex systems, uncertainty, emergence and contextual relevance. These ideas form an apex in the implementation of Natural Computing (Rozenberg 2012, 534–565) and AI systems. For example, describing the technical rationality of an AI system is not likely to give any indication as to its contextual function, as the 'intelligence' itself is not procedurally visible in the code directly.[3] It is argued here that the language of music research, which in institutional forms seems to have inherited the science vocabulary from a past century, also needs updating. With appropriate methods to encapsulate multi-levelled thought and broader contextual dependencies, the importance of creative practice as a driver for advanced critical processes and human knowledge creation as a complex system in its own right, becomes clear.

Brooks (2017) notes that despite several decades of evolution, AI has not managed to address situations where behavioural and cultural practices are adequately accounted for in the configuration of technical systems. (Ciston 2019, 5) points out that AI systems have also become dependent on the human biases and backgrounds of people who build training data sets, as highlighted by the league for algorithmic justice. The performance of AI systems will mirror those biases when viewed in a wider cultural context. AI systems have

[1]See McLeish (2019, 29–32) for a summary of scientific method seen through the lens of the arts.
[2]Noting that *scientific method* should not necessarily be seen as prescriptive or formulaic itself.
[3]A similar situation exists in other domains of exploratory research computing where complex data determines outcomes in ways that the code itself does not prescribe.

not evolved to a state where cultural understanding, from an independent perspective of lived experience can be built or more importantly understood, respected or challenged. Providing culturally aware training data to AI systems is very much a live problem in 2021. Likewise, in creative practice, composers can face this problem on a daily basis when constructing creative work: how to balance their own artistic intention with the potential for a large spectrum of possible interpretations a diverse audience may generate, how to draw on existing cultural knowledge without simple emulation, or how to construct real and deep relevance to communities of people that will take part in the reception or performance of music – an activity that is accomplished today through a large variety of different media. As with the contextual awareness of AI, this is not by any stretch of the imagination a problem well suited to simplistic, linear research methodologies. It is therefore not surprising that it is difficult to represent the richness of such multi-levelled processes without loss of information if channelled through the ontology of science from a previous era in institutional arts research frameworks. In order to tackle this situation, it is helpful to situate the research question and the methodology (in the sense of a dynamic multi-dimensional approach which connects context to creativity in a non-reductive fashion) in a manner more appropriate to the medium itself (a complex system) rather than being framed through more generic research frameworks by default. Born and Barry (2010, 103–116) draw attention to this divide on a larger-scale, where disciplines themselves can seem positioned against each other in unproductive ways within art/science discourse. Here, artistic practice can sometimes be attached to science research as public demonstration or a communications or engagement piece (rather than making use of the arts as research in their own right) – but as the authors note, a more meaningful dialogue could be leveraged through networked, curiosity-based methods of interdisciplinary interaction. A consequence of not adopting an approach which is more appropriate to the working practices of the medium[4] is that the interdisciplinary aspects of a project could appear to an observer to be 'bolted on', rather than integral to, the creative processes within the work.

Likewise, experimental environments of a reductive kind may not themselves be of significance for real-world AI applications (beyond perhaps initial testing). In systems such as automotive safety (Borg 2021), AI needs exposure to a dataset where challenges, discontinuity, unexpected behaviours and non-rule-based situational responses are required to successfully train models. This experiential knowledge tends to exist in spaces which are today highly mediated and non-traditional in their expression (see below), and is often situational, ephemeral and shared through a network of relationships between people and the environment which they inhabit. McCullough (2013) terms this space the *ambient commons* and it is a space which creativity frequently mines in order to inform new work and to connect with audiences. The work of (Small 1998) is particularly important in this respect, as it created a space for the critical and creative exploration of community-driven relationships between people, their creative actions and surroundings. McCullough (2013, 105) points out that the ambient commons is, compared to the subset of information that can be received and manipulated on say a contemporary phone screen, a high-resolution space. The ambient commons can be seen as a summation of situation, time and ambient environmental information. It can be accessed

[4]Acknowledging that the 'medium' may be broader than one used within a single discipline.

by art or ignored by it, although it is probably not possible to entirely avoid its influence. Ambient information as a concept could imply a passivity on behalf of a human within this system: however, it is far from that today as nearly every space has the potential to become technologically mediated and actively channelled as an information resource. It is in this space also that the detailed contextual knowledge needed by AI can reside, but as in creative practice, it is present in a messy tangle of relationships amongst the tacit knowledge of the environment and the embodied knowledge of humans. This non-symbolically expressed, experiential knowledge is as vital to cultural understanding as is written communication and traditional research, yet, in both AI research and musical composition it can be problematic to represent it within the narrow channels of technical practice and *post-hoc* analysis alone. (McCullough 2013, 98) demonstrates that the ambient environment itself is becoming needlessly tagged and quantified, giving an example of an exit sign on a doorway to the outside (probably for compliance reasons) yet the architecture itself communicates this. Today, the tagging of the environment continues and is now frequently performed by humans in order to facilitate the machine readability of that environment, imposing additional layers of bias, assumption and interpretation upon the forms which exist in the ambient environment, whilst seeking to bring a sense of objective clarity to the complexity observed.

Technical rationality and research logic, in AI and musical composition

In both AI and musical composition, a conceptual gap exists between the acquisition and the performance of knowledge: it is straightforward to make assumptions on how structures encoded within an AI system apply to reality if the training context has been *abstracted from reality* – it is less easy to enable a neat abstraction when the contextual environment surrounding a model is diverse, ephemeral, culturally situated or not pre-categorized by humans. Hagendorff and Wezel (2019, 2) observe that: 'intelligent software are understood in a sense in which data or data evaluations are understood to represent reality': AI's ability (or otherwise) to interact with unexpected situations are therefore limited by the nature of that representation. The notion of pragmatic validity (particularly as applied in Worren (2002, 1228)) challenges the idea that an AI system could amass sufficient contextual breadth to transcend a particularly reductive collection of use cases. Pragmatic validity is formed through the real-world, in-the-moment application of a design and not through pre-existing assumptions about 'what might work'. An AI system might consider the training data to represent reality, but pragmatic validity may not be present until the system runs in application. An AI system can not (yet) assess it's own pragmatic validity, as this would require a combination of conscious thought and lived experience, without reliance on a pre-tagged and categorized dataset. Hagendorff and Wezel (2019, 2) also note that the creative capabilities of AI today fall within the remit of producing 're-configurations, of existing art works whose characteristics have been learned by a computer and are being reproduced anew'. Importantly, this should not automatically render any output 'uncreative'; composers can themselves work in this way, but it may limit the stylistic diversity of outputs. AI systems can be trained to produce output that is *not* like existing output, but with no means of self-evaluating the outcome against the intended cultural context in which it is situated, outputs of these systems may be prone to higher

degrees of quality variation as might be assessed by a human in what they produce despite having a potentially sophisticated technical implementation.

Agre et al. (1997, 138) describes a similar situation within AI where the role of technical rationality is questioned as the bedrock of research enquiry. He writes:

> It is commonly supposed that work in technical fields proceeds through sharply defined rational, logical reasoning. Many technical people actually believe this to be the case, but in AI at least, it is not true.

Could a similar process be occurring within musical composition, itself a complex system that is highly dependent on context? Musical composition as research has become bound up in technical rationality as a proxy for methodological accountability in institutional research contexts. In my view, Agre is not arguing that AI is irrational or un-methodological, more so that accountability must *transcend* technical rationality. It could also be observed that current descriptions of what logical and rational might be – in the arts and sciences – are starting to look too narrow in the face of complex systems which depend on real-world environments for their articulation. The mismatch between medium and methodology comes where the logical and rational are sought through a reductive process – often configured as a search for a singular truth, where instead, the richness of information present in the ambient commons requires dynamic and multi-layered enquiry processes which are capable of accessing and assessing multiple truths. Agre et al. (1997, 150) suggests with regard to AI, that 'it would have been impossible to simply cast off that whole network of cultural forms, any more than I could simply decide to stop being American and start being Thai, or to become transcendentally stateless and cultureless.'

This situation again is of relevance to how musical composition is situated in a research context: each human involved in the process of artistic creation and reception will inhabit different and highly nuanced cultural contexts. Those relationships emerge from the *total system* of performance reception and creation just as much as they are encoded in an artwork.[5] Because of this, considerable care needs to be taken in assessing the cultural impact of music in research assessment metrics. The quantity of dissemination to public contexts should not be confused with how music is of relevance to the cultures it interacts with. The scale of the latter can be hard to measure (certainly over short timespans) as music is not simply about the supply of research goods to a market - as noted below, it is through relationships where value is created.[6]

Agre (1997, 150) concludes, 'Whereas industrial computer programming is organized primarily around specifications that govern the input-output behaviour of the various modules of a system, research programming in AI is self-consciously virtuosic and experimental.' The relationship between programming as design and experimental practice is important here, as similar research tensions are embedded within the practice of musical composition where process, structure, and form have equal creative relevance to experiment and emergence.[7,8] The contemporary understanding of AI as a multilayered,

[5]Traditionally discussed in as part of *reception theory* in music – for example, in Nattiez (1990).
[6]Although in participatory contexts such as community music, healthcare, the time-to-influence particular communities is notably shorter than it might be for other forms which rely on reception for their primary articulation.
[7]Depending on the artistic intention.
[8]For an extended discussion on the relationship between music and technical practice, see Impett (2021).

contextually situated system and not as a linear methodology provides a strong steer that we have traditionally approached the assessment of creative musical research in a way that is incompatible with how it operates. Trying to force musical composition through research assessments to enshrine technical practice in order to eventually describe outcomes in symbolic/linguistic form, will miss part of the richness of the rhizomatic network of connections that deliver the totality of a musical experience. Note however that this is not an argument presented against the need for understanding usefulness of technical practice, or being technically skilled, as technical practice is as necessary in underpinning the design and realization of music[9] as coding is ultimately necessary for the *performance* of AI systems: rather, its use as a proxy for quality in creative research assessment. It would be problematic to assess the research worth of an AI on code alone, without application within the medium and the context in which it is intended to function.

Artistic responses: the interaction of contextual knowledge, humans and technical systems

Artists themselves are making use of precisely these multilayered dynamics between environment, context, technological system and human behaviour as the subject matter for their work.

Emanuel Gollob's robotics installation *Doing nothing with AI* (Gollob 2021) involves what he describes as the 'spectator' within a very different relationship to technology to that explored in many interactive installations. Rather than encourage the observer to be a participant with whom the installation interacts, *Doing Nothing with AI* works to actively influence the behaviour of the spectator. A colourful robotic sculpture performs using a GAN system and ECG input in such a way to encourage the observer to do nothing at all whilst taking in the display. Gollob's installation magnifies the idea of the human-in-the-loop AI (Zanzotto 2019) from a situation where a human is defining the behaviour of an AI system through contributing data to a position where the AI system is directly learning how to influence human actions to achieve the desired behaviour. The process of musical composition research with technology can itself exhibit this relationship: it is not always technology that is in the service of *realizing* human artistic objectives (with the human as gatekeeper and bystander), instead, the imprint of technology as a medium can itself strongly influence the creative choices made by humans. Gollob's work highlights the attention deficits created by contemporary digital lifestyles, foregrounding the idea that creativity and a space to think or do nothing, are linked qualities. Ironically, it is this area which AI itself has most difficulty: could it be possible to make an AI system *do nothing*, and what then would the result be? It is likely that such an activity would need to call on extensive cultural and contextual knowledge and a non-reductive approach to the definition of artistic ideas for the starting points of a creative process to emerge.

Lauren Lee McCarthy's installation *Someone* takes an alternative view on the relationship between humans and technical systems, by substituting a human (addressed in the installation as 'someone') into places where technical systems are today encountered. The

[9]In connection with the creativity of the musician.

environment chosen is one of home automation, typically today serviced and connected through a commercial AI voice enabled assistant. Participants within the installation take on that role instead, seeing on a monitor the inhabitants of specially prepared 'smart homes'. McCarthy (2021) writes:

> By substituting humans for AI, the role of virtual assistant is re-contextualized. Inhabitants call out for 'Someone', invoking visitors as intelligence, complicating the dynamic between audience and performer. Installed simultaneously in multiple homes across the country, we're challenged to consider the scale of the work, and the even more expansive, networked systems that structure society.

Whilst McCarthy's installation exposes the information boundaries of AI interaction with daily life in homes where it has been deployed, visitors may also be wondering who is automating what and at what expense? In both installations above, the cultural relationship between AI and human is challenged through art and turned into artistic strengths, recognizing the deficiencies of AI in terms of contextual knowledge. Both installations highlight the role creative thinking plays in acquiring knowledge and allow reflection on the simultaneous location of corporate business potential within that space.

Given this situation, what are the frameworks which might help better describe the research activity of creative practice? This paper proposes some starting points for further discussion. Three alternative viewpoints are offered: firstly through thinking of creativity as a complex *change process*, secondly through opening up the idea of the research question to account for creative starting points expressed through the working medium and not translated through symbolic or linguistic forms, and thirdly by replacing *post-hoc* justification with an expanded notion of creative accountability.

These issues are themselves actively exposed in the contemporary discourse of AI-driven computer creativity. From a wider perspective, Sautoy (2019, 98) notes 'DeepMind's goal is to 'solve intelligence..and then solve everything else' … But how far can this technology go? … Can it create art? Write music?'. Technology can create art and write music. The question we should be asking is how can computational creativity develop relevance to the external context in which it finds itself, create for specific people and communities, respond to societal and personal issues, and finally, evaluate its own pragmatic value. Problematically, art and computation have become somewhat polarized in popular media: for example, where 'inspiration' or a sense of unbounded expressive freedom is associated with Art delivered by humans, and calculation, accuracy, and even trust being attributed to the Computation delivered by machines. In reality, these polarities do not exist: biology can be computational, humans can choose to follow narrow, systematic and restricted paths to realizing creative work, some of which might then sound entirely natural and unbounded. Composers have themselves been using structures, systems, algorithms, procedures as part of their daily work for centuries (see McLean and Dean (2018)). These exist on a spectrum between the types of processes that occur in an intuitive, interactive context and compositional strategies which can fully be expressed through pre-defined models. A musician may also choose to blend these strategies. The fact that some of these processes along this continuum are not expressed in direct linguistic or symbolic terms can render them less visible to

outside observation: it does not mean they are not there or that their effects cannot be heard in the resulting music.

Contextually aware research workflows

Musical composition as an activity is often described as an iterative process (Bogunović 2019, 94) where a stimulus occurs, work is developed, revised and the cycle iterates, rather than as a flow along a linear chain of events from concept to realization. This model is useful as it distances creativity from a simplistic test/experiment workflow: initial propositions are under constant revisions in order to generate new materials and rarely is there only one available path of response to a creative proposition. Notably, a cyclical process of shaping knowledge has become embedded in educational philosophy, such in the work of Keith Swanwick (Swanwick 1988) where re-visiting and developing concepts from different angles over time is seen as key to effective learning, rather than pursuing a series of linear blocks of education where each concept is considered finalized after it has been encountered.

Although cyclical definitions of creativity are effective in communicating the dynamic malleability of creative activity, musical composition does not have to be solely an iterative trial of 'what works' either – composers can pre-plan their creative work around goals which they wish to achieve as well as being responsive to emerging materials as they develop and they are free to adopt a working process which best reflects their artistic aims. The cyclical process above, cannot fully express the relationship between initial goals and an endpoint of the artistic enquiry at the same time as accounting for a process which is itself open to change over time.[10] This tension is also to be found in accounting for creative processes within institutional research frameworks: the malleability of how creative enquiry is designed and enacted is not necessarily comparable with the process of developing a research design that is fit to investigate a reductive set of research objectives over an entire project. Such a situation might seem problematic, as creative practice provides few tools by which progress can be measured relative to inputs and outputs. Perhaps a change is needed in how creative methodology is viewed: not as a single process, but as an ecosystem where, over time and due to complex interactions, new behaviours emerge. Chance, rules, context, systems, the starting materials and a vision for the future all work to shape the resulting art, and all of these factors interact with the context of the wider environment.

In the area of futures methodologies, some non-traditional parallels with musical composition along these lines can be observed. Change processes, originally used to describe complex environmental change of whole ecosystems, have been mapped out by Sharpe (2016). Instead of a rigid set of starting conditions which must be followed in order to arrive at an end result, the *three horizons model* articulates change as the result of the identification of core behaviours that enable the present (first horizon) to gradually move towards a future situation, one which eventually comes to be regarded as being new (the third horizon). The three horizons model does not demand the instant replacement of old behaviours and instead gives successful attributes of the first horizon a trajectory for onwards development alongside new ideas that may be

[10]Composition might be never finished as a process, and deciding where to stop is certainly a challenge for this author.

injected into the system. Broadly, those new ideas and behaviours form the second horizon, and the extent and timescale by which they replace first horizon behaviours depend not only on the ideas themselves, but on the surrounding context in which they are implemented. The strength of this model is that it acknowledges the role of context and environment as a factor which shapes the transition between original and desired behaviours. So it is with composition: as musical materials are worked on from their initial starting points, a contextually situated evolution of those materials occurs. Lastly, the three horizons model does not hold rigid endpoint definitions, rather, the situation arrived at in the third horizon will be itself a product of the interaction of the legacy of the first horizon with the new information and behaviour introduced in the second. The third horizon may or may not align with the ideas introduced in the second, but it will represent a new state. Such a system embodies an ecological approach to change, where both change agents and the relationships these agents hold to the environment, and to other agents, determines the outcomes. Within these general shifts over time to new forms and behaviours, intricate supporting processes are enacted in order to deliver them.

I would argue that such a model is also appropriate for investigating creative practice workflow, particularly where musical creativity can itself be considered a distributed system (Clarke and Doffman 2017). Innovation can be understood to be rooted in change and the transference of ideas from one domain to another. Creative processes can themselves be change processes: composers would not necessarily present their initial first sketches to the public,[11] as their musical materials undergo development and refinement as part of researching the creative questions (see below) which underpin the work. No single traditional linear methodology can account for such a process and is equally unlikely that any one reductive technical rationality will cover the complexities that result from the cumulative emergent behaviour resulting from change in such a system. Unlike the creative cycle described above, the three horizons model has purpose and goals (rather than just a never-ending cycle) but recognizes that the outcomes will be a mediation between the emergent behaviours of the system and the surrounding environment. Steering an appropriate course between these domains is itself part of the regular workflow of a music composer.

Computation as human partner for creative discovery

So far, this article has considered that there is a relationship between issues in AI research methodology and musical composition and has exposed some common problems in how those methodologies are expressed in traditional terms. It is useful to consider at this point how this relationship changes when computation is brought into close proximity with all aspects of a human creative process, or where human work is conceived as being digital from the outset, and in situations where technology is not a realization aid but an essential part of a creative ecosystem. Situating artistic computing outside of the domain of the tool and as integral to creative processes, has the effect of situating computing further away from calculation and closer to contemporary ideas within natural computation, in an arrangement where computation is exposed to the

[11]Noting that they are of course free to do so if that is a artistic requirement.

complexities of the surrounding environment directly and not solely to a reductive subset of it. If computers were simply a realization aid, such an ecosystem would not be able to exchange value amongst its component parts. When computation is used to challenge human thought or to explore un-explored creative possibilities, the relationships between computation and creativity strengthen.

When computing is thoroughly integrated with artistic creation, either through computationally assisted creativity (relying on human intelligence to select outputs and fashion code according to artistic intention) or through AI systems such as Generative Adversarial Networks (GANs),[12] through technology designed by the artist to deliver the artistic qualities inherent only to technological systems, the computer forms part of the context in which it is artistically situated and is no longer an adjunct to that context from another, non-artistic world. In this space, traditional assumptions as to what is 'human' or 'artificial' intelligence may cease to matter: the intelligence becomes that of the totality of the creative system however, the implementation crosses technological or biological boundaries. This is perhaps the point at which technical rationality breaks down: that AI system can only function within its artistic context. As such, it is difficult to identify the research component of such a system as either being entirely Art or entirely Science, occupying a fused space between these polarities. It is this domain in which much art operates today, rather than one of computer application to art.

Likewise, it has been traditionally easy to view technology as an aid or service to the human world. Such a view has taken on new form (Bastani 2019) as a consideration of how this relationship could continue with re-framing for contemporary world issues. However, the encapsulation of technology as a service rather than as an artistic partner, may serve to crystallize perceived divides between art and science if technological progress continues to be the sole driver for innovation funding in these applications. The idea of a development path for technology which resides within an envelope of addressing societal need in an integrated arts/science context need not engender a debate regarding technologically dystopian futures, but rather, holds the key to how AI might encompass concepts of art (and the humanities) in such a way that can be drawn on tacit environmental knowledge. Like art, AI needs context for relevance; something that can be explored and developed through creativity.

Context, workflow and accountability

In Field (2021), I introduced the idea of *creative accountability* and the *creative question* as concepts which might help lift research discourse in creative practice away from *post-hoc* accounts of processes expressed through technical rationality towards the idea of research that formally takes place through the medium in which artistic challenges are themselves situated. In short, creative questions are the challenges within creative practice which require critical investigation through a creative workflow. Creative questions are the what-if questions of creative practice: what if certain types of materials are combined with others, what-if new performance techniques can inform how music is crafted, what-if a technological process presents unexpected results that the human

[12]See Miller (2019, 87–99) for commentary in a creative context.

had not previously imagined were possible, to name three from a vast universe of possibilities. Importantly, such questions are investigated through practice and directly in the medium in which they were expressed, rather than through theoretical work conducted in the abstract.[13] Notably, creative questions do not generate answers in a traditional sense, and yet, due to the process of enquiry that has occurred to investigate them, they provide rather more than a simplistic response to a stimulus. For me, a creative question is the start of the research journey in creative work. They supplement, rather than supplant traditional research questions where these are appropriate to the work being undertaken. They also support a workflow where systematic and rigorous research can be conducted to a malleable and exploratory agenda where this is required. Adopting creative questions as a supplement to traditional research questions recognizes that artistic as opposed to linguistic communication, can offer significant opportunities for research challenge and curious enquiry, and that responses to those challenges may occur in non-linguistic domains. In music, sounds and structures can themselves pose detailed what-if questions, which need critical exploration to address. Creative questions allow for embodied practices to have a role in the exploratory methodology, as they will have direct impact on the medium of communication (sound and music itself) rather than requiring secondary translation into words. Creative questions can of course be written about and accounted for in a traditional textual sense, opening space for broader interdisciplinary enquiry without *post-hoc* justification.

At this point, it would be useful to imagine what would happen if a computer composition system using a generative adversarial network was unable to *post-hoc* justify how it arrived at making certain internal harmonies within a new piece it had made? Imagine that a generative adaptive network is loaded with a training set of data drawn from the new music of the last two centuries and a wide diaspora of cultures. Amongst any apparently emulative musical diversions, a new set of harmonies which have never been used (by humans) in the combination in which they are presented are generated. The system has made a unique contribution to knowledge in doing so. However, the actual code for this system in and of itself contains no structural representations of harmony, style, cultural relationships or anything else which defines this musical work. Yet, new and previously un-heard output results from a combination of challenge brought about by the adversarial part of the network, and the existing knowledge gathered by humans. That new situation does not follow a logical line of historical development to previous work, and it did not arise because the system had been taught by a previous master of the art. It also did not arise because those possibilities had been encoded in the form of any humanly readable rules, so accounting for those in a technical rational sense may (wrongly) indicate that there is no research process present. The situation where a unique contribution to knowledge occurred however did arise from a *creative question* posed by the collision of existing materials (the training data) and the investigative process (the GAN). The musical output from the system, in this case, is the only place where knowledge has formed from the underpinning research process. Looking to the algorithm alone for innovation may only reveal standard, well-known computational processes. So it is with musical creativity in research: looking for

[13]Acknowledging that some creative practice may not be possible without theoretical work to underpin it.

innovation in the wrong places (in *post-hoc* justification rather than practice) may not shine a light on the true value of the research which has taken place within the medium. The idea of a creative question is proposed here to re-centre creative research discourse and is a tool to clarify, contextualize and explore the significance of research that can only be expressed through the media of creative practice. Creative questions are not simply the applied counterpart to theoretical questions: whilst they may embody within themselves a theoretical component, they do not have to be a linear enactment of it. I wish to introduce the idea of creative accountability as a way of expressing research rigour combined with artistic vision.

Creative accountability (see Field 2021 for a full discussion) is a particular type of research integrity, or honesty to medium being worked with. It seeks to expose the *why* behind a creative process, rather than offering a technical justification of what has already occurred. It is a necessary notion, as shown in the fictional AI example above, as it may not be possible to locate *where* new knowledge is found or encoded within a particular symbolic structure, particularly if it is present as a property of emergence resulting from bringing together structures and creative enquiry processes. Creativity can function in this way and subjects both the structure and process of creative work to critical scrutiny (the accountability of the artistic vision) as the artwork develops. Emergent knowledge in this case arises from the medium acting as the catalyst for or essential property of the investigation. The idea of creative accountability closely mirrors what artists can refer to as their vision, personal voice or contribution to the medium: however it is not to be confused with how this vision is implemented or the styles through which it is expressed. Such aspects of creative work may be extremely diverse, yet creative accountability as a notion points to the integrity of creative development processes within a particular medium that have allowed for complex emergence and planned development to coexist in an artistically curated manner. There may be no single low-level point in this system where knowledge can be said to exist, instead, it may be present rhizomatically as a Deleuzian assemblage (Assis 2018, 75) through all contexts that represent a creative work.

Conclusion

This article reflects my personal experience of musical composition, and the disconnection I have experienced trying to map how I work as a researcher in music into more widely understood generalized research frameworks. It is however possible equally that some modification of how creative practice research is described is now necessary and over-due, as natural computing and AI expose many parallels with issues in creative practice, particularly when creativity is viewed as a complex system in its own right. This article attempts to offer some starting points to re-frame the discussion, and does not seek to find additional polarities between arts/science approaches or to create value judgements between these domains. As such, I regard musical composition as an inherently interdisciplinary process from the outset.

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Notes on contributor

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