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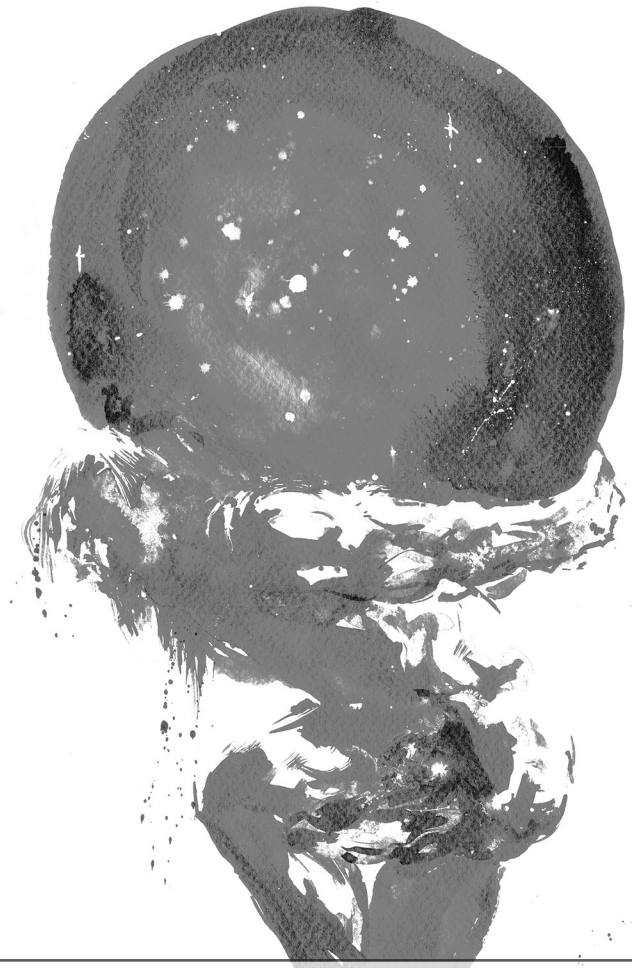

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TOWARDS TECHNOLOGICAL ECOLOGIES AS COMPOSITIONAL ENVIRONMENTS IN THE PEDAGOGY OF ACOUSTIC COMPOSITION

Abstract: Over the last few decades, the use of engraving software in acoustic composition pedagogy has become near ubiquitous. Numerous studies, such as those by Chen and O'Neill, Owlabi, and Nielsen, show that the use of both notation software and technology more broadly in composition aids both the creative process and the development of musical skills. However the paradigms of thought offered by traditional engraving software such as Sibelius and Finale arguably discourage approaches to acoustic composition beyond the quantifiable parameters it encodes visually and represents in playback, leading to the decentring of many of the musical features prevalent in contemporary art music. Using a framework informed by ecosystem-oriented analyses of creativity and Sara Ahmed's queer phenomenology of disorientation, this paper will interrogate the potential for practical applications of new technology to broaden student composers' toolkits when used in addition to notation software. As such, it draws from a range of real-world examples in order to offer educators some achievable means by which they can encourage student composers to think beyond notation software, as well a number of suggestions for future research, and furnish them with a basis from which to consider their music in terms that matter most to them.

Keywords: technology, pedagogy, notation software, affordances, disorientation, score, notation, ecosystem, ecology.

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Over the last three decades, contemporary art music and its associated institutions have undergone a process of fragmentation and renewal, opening up a startling diversity of creative approaches, external influences and artistic priorities. This change is concurrent with the rapid development and adoption of new technologies, including the internet, but also speaks to an increasing interest in performing and listening bodies, the sociological and political issues of our time, and a massive expansion of permissible aesthetic sensibilities from the production of outright noise to the reappropriation of historical models (Rutherford-Johnson 2017, 1–20). From my own observations of our cultural landscape, this is a tendency that has only accelerated in the last decade, as the increasing accessibility of new technologies and information have weakened traditional gatekeeping institutions (Bayle and Provenzano 2021, 113–14).

However, our collective approach to the pedagogy of composition in higher education, and in particular the software we almost by default expect our students to engage with, no longer offers the means to produce what it is now possible to conceive of, and this has ramifications for both the creative outputs of our students and our own ability to help them meet their aims. In acoustic music in particular, this is most evident in our reliance on notation software that, as I will show through the first half of the paper, perpetuates an increasingly unsustainable underlying ideological framework.

The near ubiquity of music notion software as a compositional environment, both in pedagogical practice and professional life, attests to its usefulness across every aspect of the compositional process, from sketching to the production and distribution of parts. By offering a reconceptualization of notation software as a compositional environment that can be replaced, expanded, or subverted, this paper draws from theories of queer phenomenology and ecosystem-oriented conceptualizations of creativity to offer some tentative suggestions as to how we might begin to recenter some of the aspects of contemporary creative practice that it sidelines.

From a pedagogical perspective, numerous studies suggest that, particularly in primary and secondary educational settings, the use of both notation software and technology more broadly aids both the creative process and the development of traditional musical skills (Kang and Yoo 2021; Chen and O'Neill 2020; Gall and Breeze 2005; Nielsen 2013, 58–61). Gaining familiarity with notation software from an early age can significantly increase productivity as students in

higher education develop portfolios, and aids in fast and efficient exchanges of developing musical ideas from student to mentor. Further, the ability to instantly audition passages of music allows students and pedagogues alike to offer an immediate reflective or creative response without the need for a painstaking and often uncertain engagement of the musical imagination with the matter at hand (Watson 2006, 121–23; Dorfman 2017, 403).

In my own experience teaching composers in the context of higher education, a notated score produced with either Sibelius or MuseScore is by far the most common means by which students present me their work at every stage, from opening musical materials to the finished piece. Since the physical location of my current teaching position is hundreds of miles away, it is particularly convenient to be able to peruse an electronically transmitted PDF without requiring students to tediously scan or photograph handwritten work.

An ability to use the software efficiently also puts students in good stead for a prospective career in composition, where the process is expected to be fast and iterative, and the sharing of work-in-progress with ensembles and other stakeholders across great distances is rapidly becoming the norm (see, for example, Brown and Dillon 2016, 92–93). In film and television scoring in particular, where notated music will not necessarily be performed by live musicians at any point in the production process, engraving software is adjoined with digital audio workstations, where MIDI data can be rendered more convincing through the use of increasingly high quality sample libraries together with the DAW's flexibility in allowing its users to draw in subtle expression information (Davis 2010, 84).

Given the clear benefits of this significant technological development throughout a modern composer's education and profession, I often wonder if my own suspicions of it as a pedagogue, as a composer, and as a technologist are more reflective of my own artistic priorities than they are necessarily problems in need of a solution. Nonetheless, even my brief appraisal here proffers several questions that, if we are to take seriously the proliferation of changes in contemporary classical practice, ought to give us pause as to the nature of notation software as a compositional environment with all that that implies. How does the structure and design of such an environment shape our compositional decision-making processes? How might we give students the conceptual and technological tools to subvert them? When we listen to a MIDI rendering of a notated score

through engraving software, what is it exactly we are listening *to*, and how does that inform our understanding of the musical materials in play? How might this environment be amended, re-formulated or structured otherwise to better meet the increasing plurality of artistic priorities both in contemporary classical composition and beyond its borders?

Ecosystems thinking: technology and beyond

This latter question leans towards a more ecosystem-oriented creative practice, as outlined by Keller and Lazzarini (2017, 61), where musical decisions emerge from a tangle of interacting agencies. In this model, creative decision-making is both active and distributed, exhibiting a strong material dimension missing from "anthropocentric and disembodied acoustic-instrumental paradigms" (Ibid.). The wider paradigm of ecological thought in the social sciences from which this stems seeks to overcome the traditional dualism between human concerns and actions from which they are perceived to stand apart (Fox and Alldred 2017, 42). Here, environments, creative or otherwise, are constructed not only from immediate material circumstances, but also from the social forces, broader material conditions, communities of other people, organisations and institutions, and so on, that give rise to them, much of which is beyond the scope of this paper to explore.

A narrower, more immediate application of ecological thinking, shortly to be outlined, forms the framework for much of the forthcoming. It is nonetheless necessary for my purposes to maintain a fuzzy border between the technology-specific and the broader implications of collapsing the distance between the material and social inherent to ecological thinking. Particularly in the latter parts of the paper, which deal more broadly with the educational environment of our discipline, I step beyond the technological towards our role as pedagogues as part of our students' compositional environments.

The ecosystems approach has recently been incorporated into the study of human-computer interaction and combined more forcefully with the new materialist philosophies, such as that of Karen Barad, where agencies emerge from intra-acting assemblages of bodies, devices, and social forces (Frauenberger 2019). In either case, a composer's toolkit becomes a habitat

from which the creative process arises out of the material resources (thought broadly) immediately available to them, and which have been in turn shaped by others (Keller and Lazzarini 2017, 62–63). Although Keller and Lazzarini's main focus is participatory music, the 'others' referred to could just as easily be the communities, developers, and historical forces that have shaped and continue to shape technological environments for creativity in more-or-less silent and seemingly passive ways.

Affordances in notation software

Notation software presents a highly complex array of options and tools primarily geared toward the creation of traditional scores in Western music notation. Its complexity accounts for the impossibility of thoroughly systematising the inconsistent norms and sensibilities that have accrued over hundreds of years of notational practice developed across a wide variety of contexts. The software draws both on our prior knowledge and our concomitant expectations, but also reinforces and develops them in technologically influenced directions (Grier 2021, 5–7). As such, it presents a highly structured environment that allows for some things and not others and that strongly resists some artistic decisions but eases the path to others. Like any workspace, virtual or real, that presents a variety of well-defined objects with predetermined connections between them, software environments of all kinds invite and encourage particular modes of physical and conceptual interaction that, after the concept by philosopher James Gibson, human-computer interaction and user experience analysts call affordances (Mooney 2011, 142–44).

In brief, affordances are a conceptualisation of the possibilities of action that can be made by a particular creature in a particular environment (for a critical overview, see Scarantino 2003). Since Don Norman's (2002, 87–92) application of the notion to design and his emphasis on their perceptibility in the design of designed objects, affordances have become a significant element of human-computer interaction, particularly as applied to the analysis of software user interfaces (Hartson 2003). Affordances coalesce into hierarchies, which might require more or less competence to access, or might be more or less "buried" in complex user interfaces (Mooney 2011, 148). In the context of creative software,

such hierarchies can have a direct impact on our artistic decision-making processes.

As James Mooney (2011, 145–46) has suggested, hierarchies of affordances tend to plasticize with familiarity and experience. In his framework for analysing affordances in a musical context, he points to the inability of a user to take a particular action in a particular software environment, which might either be due to its affordances being inaccessible "due to a lack of training, skills or experience," or else as a result of "the wrong tool being used." Without necessarily contesting this observation, I would add that composers' artistic priorities change as they come into contact with the practicalities and conceptual frameworks afforded by the tools before them. Even, or perhaps especially, among highly experienced practitioners, the pathways, resistances, and correspondences laid out by new working environments form an important part of an artistic exploration and the practice that emerges from it (D'Errico 2022, 102). In other words, while the relationality and perceptibility of affordances gives us useful purchase for analysing design decisions, I will later argue that encounters with the unfamiliar, disorientating and ungrounding can lead to the most critical creative moments: that is, when creative agencies emerge *between* a composer and their tools.

Stilled motion: sketching with notation software

Most of the hierarchies established by notation software are intuitively known to acoustic composers, and there are many musical idioms for which its guiding structure makes at least some sense. MuseScore and Sibelius, two of the more popular options among young composers, both present similar workflows in the opening steps of beginning a new piece. Users are taken through a setup pathway, where they can select from a vast array of instrumentation presets that generally conform to standard notational models for the particularities of the instrument in question. Selecting a violin, for example, will add a 5-line staff with a treble clef; selecting a woodblock will add a 1-line staff with an unpitched percussion clef, so on and so forth.

If one works their way through this setup process to completion, they can also select the opening time signature, key signature, and tempo marker, all of which are customisable within the constraints of standard notation, or they can

exit to the canvas early, where the software assumes an implicit time signature of 4/4 and a tempo of 120 or 60, a default also prevalent in DAWs and presumed from the off to represent the naturalised "neutral" space of clock time, a concept to which I will return. Already, we are presented with a workflow that makes intuitive sense to its originally intended userbase, engravers of pre-existing works where these parameters are usually certain in advance (see Rothman 2013). In making default decisions for us, closing off the setup pathway early does not allow for the sense of fuzzy indecision conducive to creative working processes.

This kind of fixing down, in fact, continues at every level throughout an engagement with notation software because, to the software, the musical materials placed on the staff are necessarily already in a fundamental sense complete. There is no way, for example, to sketch out a rhythm without making a series of decisions, temporary or otherwise, as to its overall metricity, beam groupings, and in the case of pitched instruments, specific notes, or else have them effectively made for us. Even incomplete measures or groups are filled out with rests unless and until they are explicitly removed. Of course, these temporary parameters can be earmarked to be revisited later, but the more frequently softly determined ideas are encoded, the more difficult it is to keep track of what has been decided with intention and what is merely a consequence of the software's inclination to solidify musical materials in particular ways at every moment of indecision.

In this way, rudimentary sketches gain a sense of completion, object-ness or fossilization. As such, notation software encourages ways of thinking about the constituent materials of unfinished pieces that turn sketches, moments in an ongoing process replete with liquid, contingent, and plastic substances into objects in which "all movement is stilled" (Ingold 2021, 126). In other words, the software does not meaningfully afford contingency and indecision without actively and carefully tending to it on a meta level (for example, by colouring placeholder pitches in light grey, or labelling passages based on levels of incompletion).

From a pedagogical perspective, this is often at the crux of opening exchanges with respect to newly sketched material. Trying to pinpoint *where* we are in the sketching process and reanimate it when it is not yet clear to either of us also inevitably fixes some aspects that had originally been undecided. That being said, I have also noticed among some of my students a tendency to defer dynamics and

articulations to the later phases of their compositional process, and I suspect this, too, is as a consequence of workflow. By nature of the software design, rhythm and pitch *must* be encoded together, but dynamics are an implicit mezzo-forte until decided otherwise. When they are decided, dynamics are magnetically attached to pre-existing materials as a secondary horizontal layer. To decide to *decide* interrupts the pitch-rhythm workflow, which moves the cursor along after each note entry.

Notation software and the reinforcement of parametric reification

In general, the software strongly resists the entry of dynamic markings without concomitant rhythms, encouraging composers to defer decisions on dynamics at gesture and phrase-level until later in the process. This deferral mechanism invites ways of thinking about musical materials that can have a distancing effect. Here, pitch and rhythm are parametrically abstracted and foregrounded as the ontological root of a musical idea, as though all else is mere decoration. Further, each parameter is presented as an ontologically separate aspect of a given musical material, rather than a lens through which to momentarily view an otherwise more holistic conception.

Our acceptance and even enforcement, as educators, of notation software as the main space in which the creative work takes place echoes a general tendency of reification in music education, where the categories of analysis we intentionally or otherwise introduce become mistaken for an inherent reality of the object of scrutiny (van der Schyff 2015). As Dylan van der Schyff has pointed out, this can lead to "a rather fixed boundary between some notion of what the music is on one hand, and the environments in which it is created and experienced on the other" (2015, 4).

Both parametric reification and the separation between music and environment are, of course, much older than notation software itself, and it is the beyond the scope of this paper to fully explore its origins. I should stress, too, that it is not necessarily an unproductive approach in every case, but rather one that we have in the past been too eager to take as given, and an all too tempting solution to the problem of that which is less quantifiable and less given to presumptions of certainty as to what exactly we are producing or analysing.

Notation software and the displacement of embodied musical imaginations

To return for a moment to questions of pulse, clock time and the notation of rhythm, our ability to audition our work through this software has led, over time, to an interesting displacement. We accept that, although increasingly sophisticated, notation software playback is an imperfect simulation. We know intuitively, for example, that many the subtleties of expression, timbre, and orchestration are not well conveyed, but we can and do also reason that it is a useful tool for checking voice leading, getting an experiential impression of form, and many other things besides (Watson 2006, 138–39).

Where rhythm is concerned, however, the allure of quantifiability, of the computer playback's perfect accuracy insofar as the limits of our perception is concerned, increasingly wins out over the embodied musical imagination in our understanding of what precisely is before us. As a consequence, the high modernist ontology of the score that Franklin Cox (2004) has identified as an encoding of an ideal performance is strengthened by the rather undignified assumption that a computer is the more capable parser of complex rhythmic information than the embodied human imagination. In this way, the bodies of performer and composer alike are pushed to the background in view of a flawed appeal to the objectivity of floating-point arithmetic.

Alternative ontologies of the score

As Floris Schuiling (2019, 437) has remarked, the visuality of music notation is not "antithetical to the social and creative processes that characterize music-making," but rather a means of "embodied engagement." The vestiges of high modernism mentioned above have led scholars suspicious of the work concept to nonetheless identify notation along lines entirely congruent with it to reach an opposite conclusion. That is, as a wholly failed or compromised attempt at encoding an ideal performance (Schuiling 2019, 429) as opposed to a successful one. From this perspective, the problem is in what it does not or cannot articulate

in comparison to sounding music or the process of making it. Both of these views center the idea that the score is an (im)perfect encoding of a finished product, rather than as an instigator of process and a compositional environment its own right.

The ontological shift necessary to overcome this, I contend, has been somewhat hampered by our reliance as acoustic composers on notation software that violently orders our creative space in its insistence on completeness, in its tendency toward high modernist impulses, in its reification of musical parameters, and in its resistance to unorthodoxy and idiosyncrasy. It is not my intention here to set out a legislative program for pedagogues to adopt, or to presume any of the forthcoming suggestions are going to align sufficiently with the aims of our students to be useful in every case. Rather, I propose that we begin to shift away from the default presumption that notation software serves our students well as a complete compositional environment best suited to their aims. One of the most straightforward ways to begin expanding the creative environment is to suggest more playful, tactile and embodied approaches to working with musical materials that can overcome the limits of notation software without necessarily insisting on a wholesale move beyond it.

Re-embodying the compositional environment

Simply printing out a score and cutting it into small fragments can foreground previously unnoticed relationships, offer new ways of thinking about form and the passage of time, and allow for the very rapid "prototyping" of different visual and chronological arrangements. Pulling the process into a more straightforwardly physical space also illuminates possibilities for drawing our bodies into the compositional process itself. Sticking for the moment with notating as a compositional act, examples include Claudia Molitor's *Voice Box.* Here, the composer re-notates ostensibly the same material in highly unorthodox physical situations, including while trampolining, with her foot, with the pen on the end of a two-meter rod, and so on (Thompson-Bell 2017). The resultant scores viscerally trace out these processes in ways that are immediately invoked in the imaginations of performers and viewers, extending the compositional

act through her own proprioception to theirs. From a pedagogical perspective, Molitor's work starkly demonstrates to composers the impact their environment (physical or virtual) has on what it is possible or impossible to produce (Thompson-Bell 2017, 2). What is more, Molitor is dealing with a compositional toolset that *makes itself felt;* it drives and shapes the work in negotiation with the composer rather than in spite of her.

Embodied approaches to composition need not necessarily involve intense physicality. As a means of foregrounding his own memory as an active force in the compositional process, Morton Feldman worked by copying pages written the previous day from memory, introducing distortions and changes that reflected the idiosyncratic, embodied specificities of his own musical recollections (Volans 2010). Similar acts of transcription harness technological mechanisms, the ear of an alien *other,* as a means of approaching musical materials from otherwise inaccessible perspectives. Cassandra Miller's approach draws on performances of pre-existing music as source material, feeding it through audio-to-MIDI transcription software that hears fundamentally differently to us. Melodyne, normally used for pitch correction in popular music production, picks pitches out of the grain of a voice and spluttering transients, hears overdetermined glissandi in a quiver, and metricizes rhythm with what she has called "fetishistic accuracy" (Miller 2018, 36). This disorientation between the ear of the software, on this occasion used for purposes well outside its designer's intentions, and the ear of Miller as a listener forms the basis of creative engagement from a starting point of unpredictability governed by not-quite-knowable others. That is, the traces of a performing body in the source material, and Melodyne's strange rendering of those traces into the substance of her compositional process (Tilden and Miller 2024).

Productive ungrounding: disorientation and reorientation

What all of these approaches have in common is that they exhibit various different kinds of productive ungrounding that necessarily invite vulnerability to differing degrees (Biggs and Bardzell 2024, para. 1). I use the term "ungrounding" here in reference to Sara Ahmed's (2006, 171) queer phenomenology of disorientation, which takes as its starting point the idea that moments of

disorientation leaned into, without the promise of self-correction, can lead to "new ways of making sense." These are often difficult experiences and, as Ahmed suggests, offer us the potential for "joy and excitement in the horror" (Ahmed 2006, 4).

With the ethics of pedagogy in mind, my evocation of it here is both in recognition of the complexities of asking students to step far beyond familiar territory, and of the possibility that the creative and pedagogical forces are in the ungrounding *itself*, rather than in judgements as to how it is responded to artistically. In embracing ungrounding, we ask our students to have, as Biggs and Bardzell (2024, para. 1) suggest, the "willingness and bravery to go into an unfamiliar and oftentimes cognitively and emotionally confusing and troubling space," and to stray from the habits they associate strongly with what it means to compose. We ought to do so with respect to what they themselves seek to achieve, and to present such as a space as an avenue for creative development in which failure is an acceptable and worthy outcome. Following Patricia Alessandrini (2022, 45) our emphasis on professionalism, such as the presentation of a "professional-level score and parts," can generate risk-aversion that can hamper artistic development. What might an overemphasis on score presentation, for example, have done to Molitor's *Voice Box*?

Career-oriented approaches to pedagogy at tertiary levels have completely understandable motives. Performers are often loath to receive needlessly illegible scores and imperfectly presented prototypes, and our long-term success can often depend on the buy-in and goodwill generated in our interactions with them at those very early stages, where they might, for example, be concertising or workshopping student pieces at the behest of a university department. Nonetheless, as Alessandrini (2022, 45) has suggested, encouraging students to keep lines of communication open, to foster the process as a collaborative partnership as opposed to a value adding supply chain, facilitates an expansion of the compositional environment concomitant with the more immediate disorientations I am about to set out.

In the first chapter of *Queer Phenomenology,* Sara Ahmed examines the materiality of the objects around a philosopher's desk as orienting devices that constantly slip into the background; that which is "posited as given," directs bodies "in some ways and not others." (Ahmed 2006, 27). Through the refrain of the philosopher's writing table in the domestic family home as the place

from which the philosopher's world unfolds (Ahmed 2006, 28), Ahmed argues an orientation towards the writing table can erase the very material forces that enable it, such as the domestic work that distracts and cares for children or supplies sustenance. In other words, the background is not simply incidental, but an active part of orientation: "some things are relegated to the background in order to sustain a certain direction" (Ahmed 2006, 31).

Many of the same materialities are undoubtedly hidden by the same functions as we orientate ourselves towards notation software, too, but I propose that they hide much else besides. Following Ahmed (2006, 30–31), we can evoke Husserl's thoughts of what is yonder from the perspective of his writing desk, and we can ask, in a general sense, what is yonder for the composer: where the composer's mind might "drift," for example, to instrumentalists or to the spaces in which they might perform, away from the here and now of staves, stems, and beams.

What is most material, most pertinent to making music in the immediate sense must recede and be relegated to a distraction in order to sustain our orientation toward the notation software. To do this so effectively, its own materiality must also be concealed; lines of code, interface designs, the hardware on which it runs, the people who made that hardware, so and so forth. Running our fingers along its veneered surfaces, to find and pick at its cracks and fissures, where its deliciated arranged hierarchies of affordances rupture against the intentions of its makers, is to open the potential for moments of disorientation that give rise to creative possibilities.

Some strategies for subverting the software

"The black beams can stretch. They can stretch really high."
(Tantacrul 2018, 17:02)

In 2018, the composer, UI designer and YouTuber Martin Keary, who goes by Tantacrul in his social media posts, released a video attacking Avid Sibelius for its poor user interface design and notorious instability. What starts as a normal review slowly descends into madness, replete with non sequiturs, bleeding sheet music and a very literal representation of software gore, an internet culture phrase referring to visual and semantic glitches arising from bugs. While the

video's main purpose is to eviscerate Avid for their poor maintenance of what is for many essential software, the multitude of frustrations Keary faces become the impetus for the video's dramaturgy as an art piece in its own right.

Although the more artful ending of the video tends toward exaggeration, it is true, for example, that the beams and their accompanying stems have seemingly limitless height for no apparent reason relating to the norms of engraving (perhaps to accommodate Xenakis-style engravings of keyboard music). The surprising flexibility of Sibelius' limit-points give rise to all kinds of possibilities for misuse and abuse at the edges of its design constraints, or where its affordances are at their most accidental or incidental. Like Sendak's Max banging holes in the walls that imprison him, balanced chaotically on a stack of books (Halberstam 2020, 4), these composers use the unstable edge-cases of their surroundings (in this case, the software itself) to break free of them.

Laila Arafah's *Sibelius studies: For your solo Sibelius* (Score Follower 2022) uses Sibelius' playback system against itself, exploring extremes of register and tempo well beyond the physical possibilities of the instruments it imitates and the performers it displaces. The perceptual distances between rhythm, pitch and timbre blur and fade as incoming MIDI events overwhelm buffers. Arafah's piece foregrounds the software's machine materiality, pushing the system from a set of stand-ins to an instrument in and of itself. Its inhuman abilities, its bloody-minded subservience to clock-time, and its imperviousness to interpretation and embodied imagination are amplified such that it is no longer a poor but convenient replacement for humans, but rather a performer in its own right that understands the material before it on its own terms. By disorientating us from the software's pretensions to acoustic performance, Arafah starkly reveals an answer to the question of "what exactly we are listening to" when we use notation software's audition features.

These kinds of subversions hint at the potential for a more interdisciplinary pedagogy in acoustic and/or score-oriented works, but more importantly, they show how the software itself can be turned from the inside out, disoriented from the norms of instrumental music production and reoriented towards things that take advantage of its perceived shortcomings. The end of *Sibelius Studies* adopts distorted and decontextualised mordents, trills, and other musical symbols strewn haphazardly across the staff and being interpreted wildly by the playback engine, a feat that appears to have been achieved entirely within the software.

This section in particular follows in a long line of mischievous reappropriation of the visual possibilities that notation software offers as a means to entirely different ends.

Works like Aaron Cassidy's *String Quartet* (2002) take advantage of Finale's flexibility in staff design, using them to represent multiple strata of physical actions taking place across multiple staves on a single instrument. The piece pushes to its logical conclusion comparable work by Klaus K. Hübler, Brian Ferneyhough, and Richard Barrett, which was largely hand drawn. A trivial observation is that the software's playback machine is rendered entirely incompetent in this scenario, but as Luc Döbereiner has pointed out, Cassidy's approach to musical material throws the concept of mastery itself, on the part of a human performer or otherwise, into question by highlighting the immanence of the material forces at play to the form these pieces ultimately take (Döbereiner 2020, 614). That is, the ideological substrate that *Finale* imposes on its users in this and similar cases is fatally undermined because it neither encodes an ideal performance nor allows for the possibility that an illusory one can be conjured. Cassidy's more recent work, such as *The wreck of former boundaries* (2014-16) abandons notation software altogether in favour of vector graphics software. In the last few years, several of my students, too, have turned to vector graphics and page layout software to take a more fine-grained approach to the *mise en page* of their work, or to add graphics that would be arduous or impossible to realise in the notation software alone.

Bodily affect in the visuality of the score

Simply stepping out of the safe haven an engraving-specific provides is daunting and revelatory for many, and aspects of notation that the software had previously made automatically, such as the precise position of the treble clef or appropriate ledger-line spacing, quickly become opportunities for decision-making and negotiation. Importantly, these are decisions that *must be made* rather than pushed into the background by buried affordances that otherwise fall back to easily overlooked defaults. Introducing another framework, or another set of affordances, forms an interdependent ecosystem where moving from one orientation to the other opens up new possibilities not conducive to either alone.

What in many cases starts as a source of frustration becomes a blend of stylistic idiosyncrasies and notational personality quirks that are rarely seen in professionally engraved scores and, pertinently, that have the potential to become relevant to a performer's interpretation of the piece as it collides with their embodied musical imagination. For example, a recent student of mine pointed to the uncanny imperfection of their scores, edited in Inkscape, as a visual catalyst of bodily-felt affect complementing the qualities of abjection and the erotic essential to the conceptual and sounding aspects of their work. This use of the visual to induce a process of embodied meaning-making is not dissimilar in aim to the solo pieces of Brian Ferneyhough's "Black Scherzo" era (Fitch 2014, 70), the circles, crosses and spirals in George Crumb's *Makrokosmos* (Burns 2004), or, indeed the *Ars Subtilior* manuscripts from which the latter likely took inspiration. The import of visual affect to perceptions of the score in performance has more recently been argued for from a phenomenological perspective by Rob Casey (2015).

This shift back towards the power of the visual in sparking the musical imagination marks an ontological shift in score conception, away from essentialist notions that they are encapsulations of a perfect performance in the mind's ear and away from the idea that they are deficient attempts at it. We arrive, instead, back at an ontology of notation that enables it to be considered part of the stuff of composition itself. First, as part of the complex network of interconnected tools for composition, and second, as a porous and complex interface for performance, the specifics of which arise out of constant negotiation (see Aulich 2016, 12). Although showing students a plethora of historical and contemporary examples is also useful, actively encouraging them to take steps within their own artistic processes, however tentative, beyond the apparent or real limits of their notation software offers a flexible path towards the achievement of their own artistic aims.

In introducing the concept of disorientation, I raised the concomitant "drift" in the consciousness of the composer from the software to the things it relegates to distractions. For this final, more future-oriented part of the paper, I turn my attention to some of the specifics as to how some of these backgrounded elements might be brought forward into a more rounded ecosystem of compositional tools. As before, my use of the word ecosystem here is to continue to signal that loose network of interacting parts, which composers can choose to engage with

or not, rather than suggest we superimpose or substitute one rigid framework for another. While I cannot hope to capture everything notation software excludes or deprioritises, my suggestions for a technologically infused way forward here are drawn from repeated encounters with the creative conundrums my students have faced in their working processes and from exploring the potential for long-term solutions to them.

Acoustics, space and spatialisation

As Emma-Kate Matthews has highlighted, the historical import of architecture and physical acoustics to acoustic composition cannot be overstated, both in terms of resultant qualities of sound and spatialisation, and in terms of the practical and social forces governing the positions of musicians in a given performance environment (Matthews 2019, 2). Similarly, when we engage with stereo sound as it is presented by notation software's playback features, for example, a degree of flattening takes place that "denies the listener the interactive potential inherent in the rich reciprocal diagram between space, sound source and listener" (Matthews 2019, 2). I would go a step further and suggest that the default reverberation generally applied to the output signal from notation software necessarily generates an anonymous, generic and transparent space that precludes spatial thinking during the audition process.

From the perspective of acoustic composition, the sense of space and spatialisation is often beyond our control, being dependent on any number of venues that we hope would play host to repeat performances. Nonetheless, if we know in advance where the premiere would take place, it is possible to keep its specific characteristics in mind throughout the compositional process, which can strongly enrich and inform musical decisions from the precise arrangements of players on the stage (or otherwise) to orchestrational, textural, and gestural considerations, as evidenced by a variety of spatially-aware notated musics from the antiphonal choir music of renaissance composer Adrian Williart (Zvonar 2005) to Xenakis' spatialised percussion piece *Persephassa* (1969) (Barthel-Calvet 2009, 30–31).

Sensitivity to a specific space and the positioning of players and audience in the musical imagination is a learned skill that comes from repeated experience

and exposure. Allowing for something of that experience and exposure to take place throughout the compositional process, even where practicalities and logistics preclude repeated workshopping in a given venue, is a valuable step forward for composers interested in strengthening the immanence of their music to the positions of the instrumentalists and the places in which it is performed.

An imperfect but practical solution I often suggest is to have student composers interested in the spatial aspects of composition replace the built-in reverb with a convolution VST. An impulse response could be selected that closely matches the acoustic properties of the space the composer imagines it will be performed in, producing an artificial reverb that responds to the incoming sounds in a similar way to if it were being played in the space. A slightly more onerous but very valuable exercise would be to visit the premiere performance space if it is known and take a direct impulse response from the position of the audience, specialist equipment permitting, more directly inviting the acoustic properties of the space as an active agential force into the compositional ecosystem.

Since beginning to make these kinds of suggestions to my students, I have embarked on an as-yet-nascent side-project with the UCL-based composer Emma-Kate Matthews to allow student composers to visualise spatialised audio in a 3D-modelled space. Each instrument is represented as a ball that changes size and colour according to incoming MIDI and can be moved around the space using the mouse. Although this project is in its early stages, we hope to eventually implement incoming audio, binaural spatialisation, and a ray-tracing virtual acoustics algorithm similar to those found in architectural 3D modelling packages. Our motivation is emphatically not to displace a real performance or to help expand the capabilities of playback engines to encompass evermore realism, but rather to reorientate composers towards space as an active compositional parameter. As such, it is hoped that this augmentation would draw attention to the ways that musical decisions impact space (and vice versa) in a way that can be immediately attuned to in settings not amenable to trial and error with human performers.

Physicality and instrumentality

Intimately connected to space, the embodied and physical nature of musical performance is easily lost in the abstractions presented by notation software, but it is fundamental to our perception of it in performance and listening (O'Modhrain and Gillespie 2018). One of the tendencies that notation software, used alone, can imbue is a sense of cut-and-paste transferability from one instrument to another. While this is an incredibly practical feature, it can often result in musical materials that have distant relationships with the particularities of any given instrument. Here, I am referring less to so-called idiomatic writing, which most students at a tertiary level have a good grasp of, and more to conceptualisations of musical material that emerge from an embodied sense of instrumentalism, such as in the work of Rebecca Saunders, which "sounds like it is to play" (Adlington 1999, 50).

There is a precedent for drawing direct physical sensations into musical experiences, which could be expanded into the compositional process during audition. Hapticity is becoming an increasingly explicit part of pieces involving live electronics, where a system's outputs can include motorised actuators as well as sound and video (Giordano, Sullivan, and Wanderley 2018). Luke Nickel uses a rollercoaster simulator and its accompanying physics engine to determine constant tempo changes in *Hhiiddenn Vvoorrttiicceess* (2021), which communicates the resultant pulse to a live performer using Soundbrenner's digital haptic metronomes (Nickel 2022) vibrating according to an incoming pulse. Tactile feedback has also been used in educational settings, such as in the teaching and learning of fundamental rhythm skills (Holland, Bouwer, and Hödl 2018).

Such haptic feedback might also be used in compositional pedagogy, as a way of reinforcing associations between musical materials and the physicality of performance as students audition their own work in notation software. For example, the feel and weight of musical materials at extremes of register or volume, involving abnormal levels of backpressure, or involving awkward or strained physical motions, could be communicated from the playback system in real-time using a haptic wristband as a means of connecting the composing body to the materials at hand. This could be accompanied by an automated or

semi-automated visual cue showing the degree of instrumental and physiological resistance present in the material, along similar lines to those present in the lap steel guitar version of Cassidy's *The wreck of former boundaries* (2016).

The possibility of adding physical outputs to the compositional environment also raises the possibility of physical inputs. While keyboard MIDI controllers are ubiquitous among electronic musicians, and a mainstay in the computer music classroom, both for acoustic composition and use with DAWs, they rarely push back in a satisfactorily physical way, nor do they allow for the encoding of physical gestures less conducive to keyboard music. Julie Zhu's *Deep Drawing* (2024) is an intermedia piece that takes as its input the tactile sounds of a graphite pencil against wood, and uses a listening AI to try to recreate the image, which is projected to a live audience (Zhu et al. 2024).

The gestural physicality and presence of the performer is essential to both the production of the sound and the AI's drawing, and in my experience of the piece at the Denis Arnold Hall in Oxford, I found the three to be profoundly and intimately connected. Along similar lines, Patrick Hartono's *Ciung Wanara* (2023), integrates AI analysis of Indonesian shadow puppet battles to interpret hand gestures made by a performer, which controls a spatialised live electronics setup, intimately connecting the production of the music and visuals to the motions of the performer in a context in which there is often a strong degree of disconnect (Hartono 2024).

A potential point of further exploration, then, is to whether it might be possible to render live motions made by a composer into notated, instrumentally appropriate gestures to be further manipulated in a score and eventually performed by a musician, placing the physical gesture at the origin-point of musical material. A less technologically infused solution to this forms part of my own practice, where, for example, I have experimented with building scale models of large instruments to get an impression of how the performing body manoeuvres around them in undertaking particular actions and used those impressions to inform narratives of affective change underpinning large-scale form.

Conclusion: teaching ecologically

It is already clear how expansions of the technological and physical reference points for acoustic composers can give them the power to subvert the ideological underpinnings of their tools or overcome their limitations. In line with ecosystems thinking, many of the strategies I have hitherto outlined have been around softening perceived borders, weakening imposed structures, and prioritizing processes over objects. I now briefly turn to composition pedagogy itself, or rather our construction of the pedagogical environment, as something that can itself be rethought along similar lines.

Such undertakings can give teachers and composers the impetus to break down our own silos and, with the careful and explicit acknowledgement that we are doing so, step beyond our expertise in order to be useful to our students in recognising and cultivating their own compositional environments. I do not mean to suggest that we sideline the bread-and-butter issues of technique, wider context and aesthetics we are perhaps more used to proffering guidance on, but rather, as Ian Power (2022, 61–66) has suggested, that we acknowledge that the models of teaching and assessment we offer are increasingly insufficient to prepare our students, and ourselves, both within and beyond art music. There are more collaborative and interdisciplinary approaches to teaching in the pedagogy of sound art which we can draw into our own discipline, insofar as they are distinct, by taking a more experiential, ludic and open approach than might be possible in the apprentice-master model traditional to the field (see Caines 2019).

As such, an ecological approach to teaching requires us to loosen our instructional structures and weaken their borders, such that students see us as elements in a broader pedagogical network rather than a single point of periodic departure and return within which all the guidance, critique, questioning and learning takes place. This could be as simple (conceptually if not practically) as creating institutional mechanisms for students to meet with other pedagogues from different disciplines, including those whose expertise lies beyond the arts and humanities, and loosening or complicating the hierarchical connection between a single composer as pedagogue and individual students, a form of productive ungrounding that would require us to advocate, wary as I am of the risk, for a more slippery approach to the confines of our discipline.

Weakening such borders can also soften the distinctions between what is permissible inside and outside the academy. It is essential that students are empowered to draw their 'outside' interests into the compositional world they are constructing (Hickey-Moody 2013, 119–31). There are profound things, I contend, that one could learn about speed and motion as it applies to music, for example, from watching wildlife or playing video games, given the means to develop the tools to embark on those lines of thought and analysis.

These are, of course, things many of us already do insofar as it is currently possible. John Godfrey has pointed to the inseparability of technique and imagination, developing a pedagogical practice around recognising "the value of [students'] embodied knowledge" (2022, 52–53), by allowing for a musical creativity that operates outside of our own experience as they learn, incorporate and 'misuse' the techniques we introduce to them. Following where my students lead has brought me from my own comfort zones towards acoustic ecology, eastern cultural traditions, transcultural feminism, and renaissance voice leading and church architecture to name a few. My learnings from all of these encounters are organically finding their own ways into my practice as a composer and will doubtless inform future encounters with students as well.

This speaks to a broader notion in which we allow for a more fluid teacher-learner dynamic; if they are to learn from us, we also need to learn how to teach them *personally.* That is, in the specific, as well as in the general, and as such, allow for our own disorientation in orienting ourselves towards their developing practice. To do this effectively, we might also develop our openness to learning impact of our own approaches, allowing for crosspollination that expands our own creative horizons in the process of working with others in educational settings, a notion ripe for further research at the intersection of an ecosystem-oriented pedagogy and creative practice.

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TOWARDS TECHNOLOGICAL ECOLOGIES AS COMPOSITIONAL ENVIRONMENTS IN THE PEDAGOGY OF ACOUSTIC COMPOSITION (summary)

In light of the proliferation of new approaches to contemporary art music, I question the place of music notation software in current pedagogical practice and make some tentative suggestions towards expanding student composers' toolsets through ecosystem-oriented thinking. Beginning with an outline of the usefulness of music notation in the development of elementary musical skills and the importance of familiarity with it in professional settings, I interrogate the ontology of the score from the perspective of music notation software and its playback features. In doing so, I highlight its tendency to imbue a sense of completion on unfinished material and point to the prevalence of high modernist ideological assumptions in the relationship it reinforces between the score and its playback features.

This is followed by a brief examination of the place of the score itself in contemporary art music and the ways in which its ontology can be otherwise, against both the high modernist conceptions of it as an encoding of ideal performance, and against the recently developed notion that it is a deficient attempt at the same. Drawing from work of Claudia Molitor, Morton Feldman, and Cassandra Miller, I then trace out the import of materiality and physicality to composers' working environments, exploring the means by which the materiality of notation software itself might be subverted to creative ends. This includes changes in the physical environment, the use of embodied recollection as a compositional strategy, and the juxtaposition of vocal physicality with the misuse of software.

Using as a starting point Sara Ahmed's notion of disorientation and Patricia Alessandrini's recommendations around failure and collaboration, I follow this by offering a number of possibilities for subverting and/or expanding notation software at its limit-points, first through the examples of early Aaron Cassidy, Tantacrul's infamous video essay on Sibelius' user interface, and Laila Arafah's conversion of Sibelius into an electronic instrument in Sibelius studies: For your solo Sibelius (2022). A series of tentative suggestions for the expansion of students' compositional ecosystem, centered particularly but not exclusively around audition using the playback system, is then drawn from my own peda-

gogical experiences, which explore the different possibilities, primarily technological, around visuality, acoustics, physicality and gesture.

I conclude by inviting further research towards notions of disorientation that we as pedagogues could enter into to develop an ecosystem-inspired pedagogy in opposition to the traditional master-apprentice approach. In so doing, I suggest that we can learn from the often more improvisatory and communal pedagogy of sound art and allow for a more fluid and flexible approach to teacher and learner roles, such that we can further learn how to teach particular composers as individuals who are developing their own creative practice.

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