Notes Aren’t Real: an Anti-framework for Entangled Instrument Design

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Figure 1: A new (fake) conspiracy theory. “Wake up NIME!! Do your own research!!”

Abstract

Interest is growing in how relational ontologies and more-than-human design methodologies – so-called "entanglement" theories – might inform the design of digital musical instruments (DMIs). Karen Barad’s philosophy of agential realism is the most prominent of several entanglement theories to reshape recent discourse within NIME and related communities, but to what extent does this discourse portend a change in technical or musical practices versus putting new gloss on longstanding ideas? Can or should entanglement theories be distilled into concrete design frameworks? This paper starts from the opposite premise: rather than offering an unambiguous roadmap for designers, entanglement theories are at their most powerful in destabilising ideas and worldviews that have become so ingrained as to become invisible. Within DMI research, this barely-visible infrastructure consists partly of an ecosystem of stable, context-agnostic concepts about music: analytical descriptors such as notes, pitches, onsets and gestures which get inverted into the building blocks of sound-producing technical systems. However, design is not as simple as inverted analysis. This paper argues that treating familiar musical concepts as authoritative is responsible for several of the longstanding conundrums facing DMI research, ranging from the challenge of making instruments that reliably conform to performer expectations to the persistence of certain design clichés. The paper juxtaposes ideas from entanglement literature with brief vignettes concerning instruments both new and old, arguing that musical instruments enact the very concepts they take as pre-existing, and that everything about musical discourse and practice should be up for grabs in the design of new instruments.

Keywords

entanglement, critical theory, agential realism, intra-action, representationalism

1 Introduction: Conspiracies and Critiques

In 2017, in a flippant response to right-wing protesters at a US political rally, Peter McIndoe created the satirical conspiracy theory *Birds Aren’t Real*,[1] alleging that the United States government has systematically replaced all birds with drone replicas designed to spy on the American public. The fake conspiracy has grown to internet meme status, with a large social media following, a substantial merchandising operation, and physical-world manifestations including billboards and protest rallies. Though facetious, Birds Aren’t Real serves as a pointed commentary on the fragmentary and low-trust information landscape of the present era, where claims seem to circulate at breakneck speed in direct proportion to their outlandishness.

This title of this paper, *Notes Aren’t Real*, began as an exercise imagining what a similarly farcical but more esoteric conspiracy theory might look like in the rarefied niche of digital musical instrument design (Figure 1). But upon living with the phrase, I became aware of a different level on which it might operate, as an

[1]https://birdsarentreal.com/

invitation to meticulously unpick facets of musical practice that seem so obvious as to be entirely beyond question. In doing so, this paper seeks to enact a kind of *anti-framework* for instrument design: where the design frameworks commonly published in the human-computer interaction (HCI) and NIME literature propose knowledge structures to guide and shape future research, this paper instead proposes that basic conceptual infrastructure such as notes, pitch and onsets *already* form a contextual and non-universal framework, and that alternate frameworks could exist.

This paper joins a growing tradition of critical enquiry within NIME as a research community, including the co-existence of scientific and artistic research methodologies [14, 15], the complex political and epistemological stances of the NIME community [19], its relationship to past eras of industrial engineering [32] and present-day political-economic agendas of commercial instrument design [38], and the problematising of rigid HCI-like success criteria for new instruments [16, 50], to name only a few. Like many of those papers, my proposition is not that instrument designers *should* follow a prescribed set of steps, nor that they *shouldn't* engage with the familiar conventions that come under the microscope in this paper.

Rather, responding to Snape and Born's contention that experimental digital music tools risk situating artistic practices within "familiar and consolidated technical-and-aesthetic universes" [54, p. 246], I speculate that challenges of aesthetic clustering (and even NIME clichés) might extend deeper still, to the conceptual vocabulary we use to describe music and the way we take language to be a representation of pre-existing worldly phenomena. By treating even the most familiar concepts as acts of designerly responsibility which open specific possibilities while foreclosing others, other ways of thinking become possible which could yield new forms of musical and technical practice.

I will explore these arguments through so-called *entanglement* theories of HCI [11]; these underpin a growing movement on *more-than-human design* [42, 51] that declines to place human agency at the centre of every story, but instead argues for a more dynamic and relational interplay between the material world, cultural and discursive systems. Entanglement perspectives are increasingly prevalent in instrument design [4, 35, 39, 56, 57, 62], though it remains up for grabs whether they portend a major change in music-technical practices or mostly a shift in vocabulary around existing values.

I do not propose to make authoritative claims about what entanglement theory ought to mean for NIME writ large. On the contrary, I emphasise the specificity of my perspective by turning periodically to my personal experience as a classically-trained viola player, and discuss how the persistent frictions I experience between that part of my musical life and my professional status as a NIME researcher have helped me grapple with some of the thornier philosophical issues raised by entanglement theory.

2 Entanglement Theory for NIME

> "Language has been granted too much power." – Karen Barad (2003) [5]

Science and engineering research, including a substantial proportion of present-day HCI, inherits from a philosophical tradition of *positivism*, which proposes that an objective reality exists prior to, and independent of, any act of observation [11]. The positivist tradition proposes that knowledge is built through controlled measurement and logical deduction, discovering universal principles which are independent of the observer. Though it is widely influential across natural and human sciences [9], positivism has come under criticism in feminist scholarship as privileging certain perspectives as representing objective truth: Haraway describes this as the "God trick" of "seeing everything from nowhere" [17]. Frauenberger provides more context on the decades-long "science wars" between positivist and social constructivist perspectives which propose that knowledge is fabricated through language and social systems [11].

2.1 Representationalism in music technology

As Barad observes, a central tenet of both positivist and constructivist worldviews is *representationalism*: "the power of words to mirror preexisting phenomena" [5]. Barad elaborates: "The idea that beings exist as individuals with inherent attributes, anterior to their representation, is a metaphysical presupposition that underlies the belief in political, linguistic, and epistemological forms of representationalism. Or, to put the point the other way around, representationalism is the belief in the ontological distinction between representations and that which they purport to represent; in particular, that which is represented is held to be independent of all practices of representing." In the representationalist worldview, words and symbols enjoy special status by pointing to things that already exist in the world, and coming to terms with what they mean and how they relate to one another gets us to closer to understanding objective truth.

Representationalism is widely accepted in music technology research, especially in music informatics. This includes the premise that music can be considered an objective "thing" rather than a process or activity – for example, that datasets of recorded audio tracks *are* music for all practical purposes.[2] Representationalism also underpins the "retrieval" of conceptual information from signals, including transcription from audio to scores of discrete events characterised by pitch, loudness and timing, or the classification of audio tracks by genre, emotion or other factors, as if these words and numbers hold stable, universally-agreed meanings across contexts and cultures.

Much has been written in recent years about the resultant challenges of diversity and ethics in music informatics [8, 20], particularly with the increasing use of AI systems [37]. Here, it suffices to question (as I have at greater length [32, 39] whether these words and concepts were ever truly embedded in the music to begin with, or whether such analyses have the effect of reifying post-hoc descriptors *about* music into its purported generative basis [60]. To put it a different way: if an automated music transcription system turns and audio file into MIDI or sheet music (without obvious errors), has it therefore rediscovered the true and neutral basis for that music? Transcription is undeniably useful for practical analytical tasks, but the question of whether words and symbols faithfully represent underlying reality has important implications for the design of tools to create music.

[2]As Georgina Born reminds us, "musical sound – as an aural, non-representational abstraction – is never experienced as pure and autonomous. Whether it is perceptually focal or not, musical sound invariably comes to us not only embodied in the socialities of musical performance but inflected by other social processes and relations, infused by beliefs and discourses, embedded in physical and technological environments, and thus entangled in 'mixed realities'." [7]

2.2 Entanglement should mean more than just interaction

Before continuing, I would like to lay down a personal marker on my use of terminology from Barad's *agential realism* (HCI- and NIME-adjacent summaries of which can be found in [11, 48]). Barad reads insights from Niels Bohr's quantum "philosophy-physics" through the feminist scholarship of Judith Butler and Donna Haraway (and vice versa) to challenge existing systems of scientific knowledge and representation. Barad's project does not reject all science or the idea of a knowable reality; rather, agential realism proposes that the fundamental units of existence are not things ("independent objects with inherent boundaries and properties") but *phenomena*: "relations without preexisting relata" [5, p. 815]. For this reason, agential realism is often described as a "relational ontology" [11], and putting relations at the foundation of existence leads Barad to a reconfiguring of terminology: *intra-action* (rather than interaction); *diffraction* (rather than reflection); *agential cuts* (bringing into existence localised patterns of cause and effect); and many more.

Having spent several years grappling with this terminology, I am sure that I am not using it with the precision that Barad and their contemporaries have brought to it. Still, I see a risk that NIME and HCI authors may adopt these new terms as drop-in replacements for more familiar ones, leading to confusion on what entanglement theories might have to offer. For example, it isn't necessary or helpful to use entanglement (or intra-action, or any other Barad-ism) to describe the movement and collisions of billiard balls on a table; classical physics is perfectly adequate for this.[3] Similarly, plenty of insightful literature exists on mutually interacting musical stakeholders [28, 44] and on the relationships between performers and instruments [22, 43, 59]. Insofar as these sources assume that "human" and "instrument" are categories with well-defined boundaries and identities, entanglement thinking is not needed to make such points.

My interest in entanglement theories is rather in how they can destabilise concepts we take for granted, by proposing that boundaries are enacted rather than inherent. Barad draws out this point using Niels Bohr's famous proposition that the apparatus of measurement is inseparably entangled with the thing that it measures – observer and observed mutually produce the phenomenon (and each other). As Barad puts it, "concepts are specific material configurations" [23, p. 12] rather than representations mirroring an underlying reality. This suggests that words like "instrument", "player", "gesture" and "music" are not well-defined entities waiting for a precise general definition, but instead, they are enacted through specific and localised contexts, materials and practices.

With this in mind, when I say "X isn't real", more precisely I mean that X does not have a inherent identity independent of its relations, and conversely that the word for "X" doesn't have a stable meaning representing something that already exists in the world. Instead, the act of describing or measuring X is what brings X into being in the first place, in a process that should always remain open to scrutiny.

[3]This is not to say that an entanglement perspective on billiard balls couldn't exist: it might have more to do with what makes the objects identified as billiard balls at all, the various socioeconomic dependencies of 'billiards' as an activity, the contestable boundaries between a billiards player and their sporting equipment, and so forth.

3 Notes Aren't Real

"Nothing comes without its world." – Donna Haraway (1997) [18]

Notes are omnipresent in digital music. The MIDI standard, codified in 1982 by a self-appointed consortium of mostly North American and Japanese keyboard and synth companies, remains the dominant symbolic format in commercial music software, and it was also the *lingua franca* for most interactive music systems of the 1980's and 1990's, from controllers like Waisvisz's *The Hands* [61] to open-ended software like early Max (prior to Max/MSP) [47]. Complaints on the limitations of MIDI and proposals for alternate standards are nearly as old as MIDI itself [25, 30, 36]. More recent scholarship has explored the many ways MIDI promotes a *claviocentric* (i.e. keyboard-focused) ideology [10, 39], not least through its assumption that music decomposes into discrete notes characterised by an instantaneous onset and an integer specifying pitch in (typically equal-tempered) semitones [45]. Despite these culturally-specific assumptions, MIDI and the tools which use it have travelled around the world, reconfiguring musical practices in their image [27].

This paper will not rehash the various technical arguments for or against MIDI. In any case, a great many digital instruments and interactive systems manipulate audio and other signals without the use of MIDI. However, I want to call attention to how a more abstract concept of *note* (and its constituent properties) is deeply embedded in music technology discourse.[4] Notes exist within, and give meaning to, a system of notation, but no notation system is ever universal. Magnusson describes designing notation systems as "a process of selective abstraction and classification." They "define which parameters are 'valued', and these get abstracted out and assigned a symbol" [26, pp. 123-124]. Notation is thus premised on representationalism, something made explicit in the title of the TENOR conference ("Technologies for Music Notation and Representation"), which has run annually for over a decade. What are the implications of this situation?

3.1 Reification and additive representations

I advocate for a greater awareness amongst designers of how building tools with notation (of any sort) acts as a reification: not a descriptive representation of what was already there so much as an inscription [2] of which parameters will *become* valued, which then serves to shape future practice through the things it makes easier or harder to do [31]. Arguably, this is the idea behind a number of digital instruments which self-consciously merge the concepts of "instrument" and "score": composed instruments [41, 52], tangible scores [58], magnetic scores [46], agential scores [4] and so forth. Here the ideological non-neutrality of the notational system itself becomes part of the give-and-take between performer and instrument, and I suspect that few of these designers would suggest that the notation bound up in their instrument should be used as a representation of a broad swathe of other musical practices.

However, it remains common across digital audio workstations and music programming languages alike to propose that music should be generated using one or more systems of symbolic notation. These notation systems might encode relatively

[4]Notes also loom large in the popular imagination, to the point that symbols from Western music notation are an omnipresent visual icon to suggest music itself, something that Figure 1 alludes to.

specific conventions (such as MIDI or shorthand names for specific sounds found in live coding languages like Tidal Cycles or Sonic Pi [1, 29]), or they might be more abstract (such as OSC or the programmer-defined parameter values that follow the time fields in a Csound score). In practice, systems with strong conventions are rarely completely restrictive (e.g. many keyboard-like conventions can be challenged with the careful use of MIDI Pitch Wheel or Control Change messages), while supposedly open-ended systems are often still used in conventional ways [33]. But we see in all of these systems an additive property, where music is produced through combinations of smaller encapsulated elements. Even textural music without conventional "notes" can be generated from additive processes such as granular or concatenative synthesis [53], while spatial audio might be produced from an accumulation of sound objects given discrete locations and radiation patterns [63].

To be clear, I do not claim that any of these tools, languages or notation systems are better or worse than any other. But any assumption that the individual quasi-atomic elements of notation are a "real" representation of pre-existing musical phenomena risks inverting cause and effect. To further explore this point, I will turn to my experience in the highly traditional, notated music practice of classical string playing.

3.2 Why are MIDI string synths so bad?

Like many classically-trained string players, I have a poor opinion of most MIDI bowed-string synths, especially solo strings (as opposed to orchestral sections). Why, to my ears anyway, do so many of these systems sound like a pale imitation of good string technique? In early MIDI synthesis, the situation might have been attributed to the challenges of producing a realistic audio facsimile of a violin using the synthesis methods of the time (e.g. FM, subtractive, or low-bandwidth sampling). Audio recording is clearly no longer the driving limitation in modern sample libraries. Later, in my own DMI design [34], I attributed it to a lack of sufficient real-time "expressive" control over parameters such as vibrato (often relegated to mechanical-sounding LFOs) or dynamics (often chopped up into note-level modulations rather than unfolding naturally over a phrase). I thought that putting those parameters under the fingertips of the DMI player might yield a more realistic emulation.

I now believe the problem speaks to a deeper incompatibility between assuming MIDI messages to be the generative substrate of music, versus what I do when I play the viola. As an orchestral and chamber player, almost all of my playing is from notation. However, as musicians have known for centuries but technologists still sometimes forget, standard Western notation acts as more of a culturally- and historically-situated *aide-mémoire* than a literal description of precisely what acoustic events will take place.[5] Notwithstanding Magnusson's description of notation as choosing what is valued [26], there are many aspects of string playing that are highly valued but not assigned symbols.

One of these aspects is *articulation*, the complex acoustic-tactile transients that occur between (and sometimes within) notated events. Contrary to the MIDI worldview, these are neither instantaneous events (e.g. note velocity), nor are they amenable to manipulation at a "control rate" suitable for human fingers turning plastic knobs. Sample libraries sometimes attempt to classify articulation into discrete linguistic categories (*legato*, *staccato*, *spiccato*, *martélé* etc.) as if these words have stable, well-defined meanings across different instruments and players (or even across a single performance). The MIDI 2.0 specification even includes a *Note On with Orchestral Articulation* message[6] featuring an 8-bit classification for articulation type and various subclasses covering commonly used words about string playing, including bowing, left-hand techniques and which string a note should be played on. It might be a step forward from mere note number and velocity, but the proliferation of sub-categories and attributes also suggests an attempt to shoehorn string playing into a protocol that fundamentally is not suited for it.

Ultimately, the practice of bowed string playing isn't additive from small atomic units, nor is auditory-motor imagery a linguistic or conceptual process. Its musical language is both bigger (phrasing) and smaller (articulation) than notes, and it emerges from a process of 4E cognition deep and reciprocal enough to challenge the very notion of the separation of "performer" and "instrument" into well-defined entities [43]. Notation can guide this process, and it can be transcribed *post hoc* from a performance, but to think of it as the "real" generative basis of the practice will always leave the technologist playing catch-up.

4 Pitch Isn't Real

MIDI proposes music to be composed of discrete events with deterministic pitch, loudness and timing. If the previous section made a case against discreteness, this section makes a more provocative claim: that *pitch doesn't exist*, except through an entanglement with a specific apparatus of measurement. *Apparatus* carries specific meaning in Barad's agential realism [6], which I unpack in more detail elsewhere [48]. Niels Bohr's theory of quantum indeterminacy proposes that the existence of a quantity depends on the specific apparatus used to measure it: for example, "position" as a property of a particle only carries meaning in relation to a particle detector with rigid parts, while "momentum" only carries meaning in relation to a detector with movable parts. The two configurations are mutually incompatible, and so too are the theoretical concepts that they measure. According to Bohr and Barad, it is not merely that the two measurements cannot be simultaneously conducted, it is that making one concept determinate excludes the existence of the other. Hence Barad's statement that "concepts are specific material configurations" [23].

4.1 Frequency doesn't (inherently) exist

To put the argument into clearer relief, I will leave aside the complexities of human pitch perception; my argument here is not that frequency is objective but pitch is subjective. Instead, I will take fundamental frequency (periodicity) as a direct correlate to pitch and argue that *frequency doesn't exist* as an independent entity, but only as a phenomenon co-produced by an entanglement with the apparatus of measurement, the frequency detector. Fourier theory tells us that a basic prerequisite for any frequency detector is a time window long enough to cover at least one period of the signal, and that precision in the frequency domain comes at the direct cost of imprecision in the time domain (i.e. longer time windows are needed to resolve finer details in frequency). The most obvious implication, as is well known in audio engineering,

[5]Not all notation describes sonic or musical qualities: many 20th- and 21st-century composers employ *prescriptive notation* which specifies physical execution techniques rather than resulting sounds [24]. This raises questions of whether those notated techniques are any more or less "real" than the musical qualities in traditional notation.

[6]See MIDI Association document M2-123-UM

is that frequency detection on real-time signals necessarily incurs a significant latency, and that the lower the frequency to be detected, the longer this latency becomes.

Frequency is a useful analytical frame, especially for offline or latency-insensitive applications. But does that make it a fundamental, context-independent basis for musical sounds? Even leaving aside inharmonic ("unpitched") instruments like drums and noise-based musical practices, audio signals that we take to have well-defined pitch often exhibit significant regions of ambiguous periodicity or non-periodicity. This is particularly true for transients, where establishing regularity of oscillation after an input of energy can take tens or hundreds of milliseconds. Frequency detectors are easily stymied by this behaviour, such that designers often resort to waiting for even longer time periods to elapse before taking measurements of the frequency – even as they purport that frequency is a fundamental generative property of the audio signal. Put another way, instantaneous temporal onsets and deterministic frequency depend on mutually incompatible apparatuses.

Of course, myriad digital and analog instruments feature frequency generators (oscillators) alongside some means of producing transient signals (envelope generators). Practically, even a simple oscillator and voltage-controlled amplifier (VCA) can avoid the latency problem that afflicts more complex instruments (like MIDI guitars) which use audio feature analysis to control synthesis processes. Analytically, every audio system faces the same mathematical constraints around frequency measurement and window sizes. Does this mean frequency and onset should indeed be considered inherent properties of musical audio, independent of any representation?

Reconciliation can be found once again in Barad's statement that "concepts are specific material configurations" [23]. They continue: "the details of the apparatus – like the bolts fixing one part of the apparatus to another, or springs that enable parts of the apparatus to move and be responsive – are of fundamental importance." Here, both the oscillator and the frequency detector are specific material configurations that enact a concept of "frequency", but despite the shared word, the two concepts are not necessarily identical. To examine the implications in more detail, I will return to the case of viola playing.

4.2 Where is "pitch" located on the viola?

This sounds like the setup to a bad viola joke, but I intend it as a serious question. What are the material properties I should inspect on a viola to discover the pitch it produces? The obvious answer from musical acoustics is to examine the length, tension and mass density of the strings to calculate their resonant modes. In this idealised account, the rest of the instrument (bow, bridge, body, air, any part of the player's body other than the immediate contact point with the string) might alter the spectrum or dynamics of the sound, but to a close approximation will be irrelevant to determining frequency.

However, when I begin to draw the bow on the string, "frequency" doesn't immediately jump out. Rather, patterns of stick-slip friction emerge at the region of bow-string contact and propagate in both directions along the string, chaotically at first, and eventually (with the right playing technique) reinforcing one another in a periodic process known as *Helmholtz motion*. Acousticians have shown the establishment of Helmholtz motion on a bowed string to have chaotic properties, dependent on particular combinations and micro-details of bow speed and pressure [64]. In my own playing – largely as a result of my imperfect technique – some transients unpredictably settle into other vibration regimes such as *multiple flyback* (a harsh, buzzy sound) or *multiple slip* (producing airy, *flautando* sounds or harmonics). Acoustically, there is no *a priori* physical manifestation of pitch within the instrument, only complex spatial-temporal phenomena that *mostly* resolve into periodic oscillation in between periods of instability.

Lest this seem like so much (bow)hair-splitting, there is a further wrinkle. My viola, like many larger violin-family instruments, has a *wolf tone*, a high-Q resonant mode within the instrument body. Vibrations in acoustic instruments are bidirectionally coupled: string vibrations couple through the bridge to the body of the instrument, and the same is true in reverse. Wolf tones occur when the back-propagated energy from a resonance in the instrument's body interferes with the establishment of Helmholtz motion on the string [13]. On my instrument, the resonance occurs near the pitch notated as F above middle C (349Hz). As a result, under certain playing conditions – quiet dynamics, light bow pressure, high up the lowest (C) string – it is nearly impossible to get the instrument to speak at this pitch at all. Instead of clear periodicity that would match an analytical concept of frequency, I get a strange warbling, with concomitant changes in tone quality and tactile sensations through the bow. If "frequency" is actually a material configuration, it is an idiosyncratic one, and those idiosyncrasies become part of my playing.

5 Accounting for Intentionality

> "The cello is not just a transducer. In one sense it is, as it converts my manual gesture into a line of sound. But in another sense – at the moment I begin to play – the cello seems to explode. What had been a recognisable, coherent entity becomes something more like a bundle of affects, a meeting of bowhair, rosin, metallic strings, wood and fingers, coupled with resonant air. Bundle them together and sound erupts as through a fissure." – Tim Ingold (2017) [21, p. 111]

The discussion thus far has been primarily object-focused. But the term "musical instrument" is also not a representation of some inherent, pre-existing category of objects. Continuing with Barad's framing, instruments are enacted together with instrumentalists, gaining their *instrumentality* through intentional use in a musical context [3, 43]. One consequence of this relational framing is that, like Ingold's quote above, it is not always determinate where the player ends and the instrument begins – e.g. are the trumpeter's lips part of the player, the instrument, or both [3]? Another consequence is that we should draw the boundaries of musical concepts widely enough to account for their entanglement with the intentions of the performer.

On the viola, pitch may be an idiosyncratic spatio-temporal phenomenon rather than an idealised concept made manifest in physical materials, but when I play, pitch is also an intention. Prior to making any sound, my playing (like all instrumentalists) is guided by auditory-motor imagery of what sound should emerge and how it will feel to produce that sound. The neuroscience of auditory-motor imagery is not fully settled, but there appears to be substantial overlap in the brain pathways for perceiving a sensory stimulus or moving muscles versus imagining the same thing [12]. This imagery is also surely enculturated through years of listening and playing. As such, I may well imagine musical events through the structures of Western classical music and its notational systems (and, conversely, struggle to imagine sounds of other musics I am less familiar with, even if they could be played on the same instrument).

To avoid a romanticised notion of human intentionality, two caveats are important. First, this imagery is predominantly non-linguistic, more amenable to study through (micro-)phenomenology [49] than discourse analysis. Second, the imagery is strongly conditioned by the instrument in my hands, which guides and constrains my imagination [59]. In this way, the reciprocity between human and material agency often proposed in digital instrument research [40, 55, 57] is a property of *any* instrument – perhaps even one of the core aspects that turns an inert "thing" into an instrument in the first place.

The upshot is that the Baradian apparatuses which give meaning to concepts like notes and frequencies must be drawn widely enough to incorporate (more-than-)human cognition and cultural systems. But this view presents direct challenges to the digital instrument designer. We have no technical means to observe the intentions or sensorimotor imagery of a performer, nor any robust way for a digital instrument to be aware of and adapt to the larger cultural situation of its use. As a result, the opposite tends to happen: relying on narrow mathematical or engineering-driven definitions of concepts ends up reconfiguring both human thinking and musical cultures around those definitions. Concepts, humans, materials and discourses are still entangled, but technology-led decision-making ends up enacting what Barad calls an *agential cut*, giving meaning to the boundaries between entities and opening up certain possibilities while foreclosing others [5]. Notes *become* real through our own designerly actions, and we believe they were there all along.

6 Conclusion

Notes may not be "real" in any universal, representationalist sense, but bringing the concept of *note* into existence in specific musical contexts may still be useful. Plenty of compelling music remains to be made with MIDI and other familiar systems. However, uncritical adoption of any system as a true and neutral substrate for music-making can coax a designer through a series of decisions that lead to familiar DMI clichés [31, 54] or to tools unwittingly inscribed with cultural values that then reconfigure other musical practices [27, 33].

This paper has proposed entanglement theory, and specifically Karen Barad's agential realism [6], as a way of destabilising concepts that seem too obvious to be worth questioning. Similar arguments could be explored around many other familiar words in the NIME canon: *onset*, *gesture*, *interface*, *control*, *mapping* and so forth.[7] Inverting the usual language of HCI, I propose these explorations as a kind of *anti-framework*, in that even a reader who vehemently rejects my particular choice of frame might be led to reconsider existing frameworks of musical thinking and either alter or reaffirm them as a deliberate and responsible choice.

7 Ethical Standards

Referencing conspiracy theories, however facetiously, runs the risk of misinterpretation. All conspiracy theories described in this paper are fake. I do not endorse *Birds Aren't Real* nor any actions of its founder or fans, and *Notes Aren't Real* is intended as a productive challenge rather than a suggestion of nefarious activity on the part of any person or entity.

This paper attempts to bring NIME practices into conversation with entanglement theories, advocating against oversimplified reliance on either the elements of musical notation or of caricatures of those theories. However, my own perspective is no more universal than the perspectives that I critique, and the paper could run the risk of promoting its own narrowly prescriptive approach to musical practice. Ultimately my hope is that a greater awareness of these issues will lead to productive new ideas in DMI design, even where diametrically opposed to the perspective in this essay. As a theoretical paper, no human participants or datasets were used in the research, so no institutional ethics board review was deemed necessary.

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