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Abstract

The classification of the acoustic, electronic, and digital in the literature of novel musical instrument making has often relied on final mechanical characteristics and the assumed innate identities of these mediums. This paper questions this perspective, proposing instead a holistic, bottom-up methodology rooted in specific artistic practices and the musicking process inherent in crafting novel musical instruments. Drawing upon Deleuzian metaphysics of the virtual/actual alongside Tim Ingold's anthropological studies of material correspondence, the article argues that the characteristics of media are not innate. Instead, they are processually formulated through hands-on material engagement and the holistic act of making. To further illustrate this idea, this paper presents a variety of musical practices involving novel musical instrument making, encompassing acoustic, electronic, and digital media, and demonstrates how distinct artistic practices yield unique, case-specific configurations of the acoustic, electronic, and digital realms. Ultimately, this research calls for a relational and practice-based understanding of media specificity, suggesting that the hands-on making of novel musical instruments functions as a profound form of artistic research with implications for broader scholarly inquiries.

1. INTRODUCTION

On January 29, 2025, at Roulette Intermedium in Brooklyn, New York, Ellen Fullman and Theresa Wong presented a workshop sharing a creative process centered on Fullman's renowned *Long String Instrument* (Fullman and Wong 2025). The *Long String Instrument* is a novel musical instrument developed by Fullman, consisting of metal strings installed horizontally across a room and connected to a wooden amplifier box. It is played by stroking the strings while pinching them gently between the fingers, Fullman's unique performance technique that produces prominent overtone shifts (Hopkin and Fullman 2021, 41). Over decades, Fullman has established a holistic musical practice comprising unique performance techniques, specialized notation, and compositional approaches tailored to the *Long String Instrument* (Fullman 2012, 8).

Taxonomically, Fullman's *Long String Instrument* is an acoustic instrument; sound is generated through longitudinal vibration across the strings and amplified by wooden sound boxes at each end. However, this simple classification based purely on the mechanics of the instrument itself does not reveal its full scope. In their workshop, Fullman and Wong shared a comprehensive workflow involving a suite of electronic and digital tools. Fullman and her team actively used CAD software for the instrument's soundbox design, utilized VSTs and TouchOSC to rapidly simulate compositional ideas, employed software tools to configure specific scales, and used a web app to explore the microtonal relations of just intonation intended for her compositions (Fullman and Wong 2025).

In this regard, it raises the pertinent question of whether the musicking associated with novel instrument-making can be fully grasped by focusing solely on mechanical classification. An analytical approach centered on the innate material and mechanical features of the acoustic, electronic, and digital domains has been a common conceptual framework for analyzing novel musical instruments and post-digital lutherie. For example, within the New Interfaces for Musical Expression (NIME) community, the significance of the mapping paradigm in instrument design and musicking is often associated specifically with digital technology under the classification of Digital Musical Instruments (DMI).

In this paper, I propose looking beyond the media specificity of the acoustic, electronic, and digital domains in novel musical instrument-making. Following this introduction, the paper discusses the theoretical groundwork that inverts the identity-focused perspectives on media specificity found in current literature. It then proposes a methodology focusing on the particularities of specific practitioners and projects, as well as the holistic musicking of art practices that center on novel musical instrument-making

2. INVERTING THE PERSPECTIVE OF UNDERSTANDING THE ACOUSTICS, ELECTRONICS, AND THE DIGITAL

Analyzing novel musical instrument-making through the lens of media specificity has been a common approach in the field. For instance, the research by Sergi Jordà on digital lutherie, which identified the mapping problem as a critical aspect coming from the arbitrary relationship between the physical controller and the sound engine (Jordà 2004). A more conceptual and comprehensive study on media specificity of novel musical instrument making has been conducted by Thor Magnusson, where he provided a sophisticated comparison between acoustical, electronic, and digital musical instruments.

Through the framing of embodiment/hermeneutic, enactivism, and media materiality, Magnusson posits the acoustic, electronic, and digital on a spectrum between the embodied and the hermeneutic. According to Magnusson, the lutherie and playing of acoustic musical instruments tends to be embodied; which means the "instrument becomes an extension of the body, where trained musicians are able to express themselves through incorporated knowledge that is primarily non-conceptual and tacit." (Magnusson 2009, 168) On the other hand, he views the human interaction between digital musical instruments as more

hermeneutic; which means the "the instrument is not an extension of the body, but rather a tool external to the body whose information we have to interpret." (168) Furthermore, Magnusson asserts that the core entity of digital musical instruments are the symbolic architecture (i.e. software code) and the primary interaction with digital musical instruments is symbolic (169).

However, there are cases of artists in novel musical instrument making where it doesn't fit this framing. For instance, Harry Partch's purely acoustic instruments are manifestations of his notion of *corporeality*; a musical conception advocating "emotionally tactile" rituals such as epic chants of ancient civilizations. This musical emphasis led to his interest in the human voice and choreographic movements in musical performance. This interest in voice led to his fond to just-intonation, which his instruments were specifically tuned to. Furthermore, Partch envisioned each instrument as a sculpture with a "strong presence on stage," resulting in beautifully crafted objects that transcend mere functionality. Furthermore, the massive scale of these instruments necessitates full-body engagement from the performers, reflecting Partch's vision of musical performance as an act of profound physical presence (Ralli 2022, 34). Here, the giant sculptural presence and just intonation are not simply a materialistic implementation, but a manifestation of *corporeality*, which is Partch's central musical ethos. Therefore, a strong conceptual thread was prominently embedded in Partch's acoustical instrument lutherie.

Similarly, Michel Waisvisz's *The Hands* depict an extremely embodied interaction through digital-based mapping strategies. Waisvisz's instrument *The Hands* is a glove-like instrument worn during performance that would "afford gestural hand movements, allowing for movement about on the stage, and dance." (Magnusson 2019, 37) The device consists of various sensors, buttons, and switches, all mapped to a sound engine (Torre, Andersen, and Baldé 2016). Waisvisz explored numerous mapping configurations between the controller and the sound engine, dedicating himself to discovering a setup that resonated with his sensibilities before thoroughly studying and rigorously practicing the instrument (Magnusson 2019, 37). For Waisvisz, creating an instrument and configuring its mappings was not merely a technical task, but a compositional process that unfolded through embodied engagement (37). In fact, Waisvisz consistently prioritized the body in his musical practice, treating physical effort "as a crucial musical ingredient" in live electronic music (Waisvisz 1999, 119). Most critically, in Waisvisz's case, the symbolic itself is insufficient for fulfilling the musical meaning of his work and it must be performed and realized through his embodied engagement to be fulfilled.

This is also well pronounced in *Spring Spyre*, an instrument by Laetitia Sonami created through the collaboration with Rebecca Fiebrink. For this instrument, Sonami and Fiebrink utilized *Wekinator* that "allows musicians, composers, and new instrument designers to interactively train and modify many standard machine learning algorithms in real-time."(Fiebrink, Trueman, and Cook 2009, 280) Wekinator's mapping is based on a bottom-up approach, based on a "process of physically interacting with a malleable complex mapping

that can be shaped but does not have to be built from the ground up." (284) As a result, the mapping system for *Spring Spyre* as an "interactive world that invites exploration and discovery" rather than a top down rule-based method (Fiebrink and Sonami 2020, 240). This case also reveals that even in a heavily software-based digital musical instrument project, the musical meaning of the work is heavily determined by the embodied interaction instead of the symbolic core of the system.

In fact, this is not to claim that Magnusson's framing is incorrect; rather, it is to emphasize that contemporary and experimental artistic practices frequently present exceptions due to their inherent particularities. Consequently, this necessitates a more nuanced conceptual treatment of media specificity in novel musical instrument making. An important aspect to highlight is the foundational material condition of the acoustic, electronic, and digital domains. From a practical perspective, each of these is stacked into dependent layers: digital computation cannot exist independently of electronics, and electronics require a form of acoustic or physical output for the musical realization of the processed signal. This material reality implies that the specific medium itself is not self-sufficient to formulating its own artistic expression or musical meaning, which shifts the discourse from what distinguishes these media to how they are connected.

This is well exemplified in the design philosophy of Max/MSP. David Zicarelli, the founder of Cycling '74, described Max's focus is centered on the process and connection instead of the innate content or data, which he described it as a "universal language of meaningless numbers."(Zicarelli 2002, 45) He urged that within the Max environment, the arbitrary relationships between components hold greater significance than the individual components themselves. In fact, he called that specific Max components alone are "incomplete," and also argued that the prioritization of connection over component itself is expanded to broader spheres :

> One way to think about Max is that it exists as a set of hierarchically related layers of incompleteness. In short, constructing a system is not enough: one must still operate it to achieve results. But this incompleteness extends to lower levels-most importantly, within the software itself. Rather than solve a particular problem in a particular way, Max creates an ecology within which combinations of elements can form a solution. I like to think Max resembles an "ecosystem" more than a language. (45)

This clearly demonstrates that focusing solely on media specificity to analyze the musical meaning and significance in novel musical instrument making may not be adequate. Instead, a perspective focusing more on its connections and relationships between components, within and beyond the instrument, is necessary.

In fact, Magnusson's theoretical works provide a useful scholarly apparatus for configuring these relations. He suggests a rhizomatic and heterarchical organology for analyzing Digital Musical Instruments (DMIs). Because Magnusson views the topology of data interaction as the most critical aspect of the system, he proposes viewing the DMI as a rhizomatic network

consisting of several nodes (Magnusson 2017, 298). Magnusson references Deleuze's notion of the *rhizome* for this conception, describing the organology of these instruments as a "map that must be produced, constructed, a map that is always detachable, connectable, reversible, modifiable, and has multiple entryways and exits and its own lines of flight." (Deleuze and Guattari 1979, 10; Magnusson 2017, 298)

This Deleuzian perpsective, combined with the foundational material commonality between the acoustic, electronic, and digital domains, enables an expanded conception of rhizomatic and heterarchical organology. To fully grasp this, a brief discussion of the metaphysics Deleuze describes in *Difference and Repetition* is critical. As a concise summary, a core thesis of this magnum opus is that difference precedes identity; furthermore, difference is the primary origin of all phenomena, a concept he refers to as "Difference in Itself." (Deleuze 1994) Repetition, in this sense, is not the replication of an original identity but rather the individuation of an entity through difference.

From this foundation, Deleuze expands into a grand metaphysical structure consisting of the virtual and the actual. The actual constitutes lived experience, while the virtual serves as the underlying condition of that experience. The *virtual* operates through the mechanism of difference, acting as a range of dynamic potentialities. Through a process driven by repetition, the *virtual* becomes *actual* via actualization. In this framework, the *virtual* and the *actual* are not discrete; instead, "every actual surrounds itself with a cloud of virtual images. This cloud is composed of a series of more or less extensive coexisting circuits, along which the virtual images are distributed, and around which they run."(Deleuze and Parnet 2007, 148) Deleuzian metaphysics thus presents a process of existence that is not predicated on the innate identity of an entity, but rather on actualization from a field of differentiable potentialities.

The acoustic, electronic, and digital domains can also be approached from this perspective. The innate qualities of each medium, which are frequently discussed in NIME and electronic/digital/post-digital lutherie, can be considered the most common forms actualized from a wide array of potentialities within the *virtual*. This argument is further reinforced by the shared material foundation of these domains, where they are dependent on each other in a nested form. Thus, the acoustic, electronic, and digital are actualized versions of the *virtual* emerging from these material configurations. This also closely resembles Deleuze and Guattari's notion of the *desiring-machine*, where desire is evoked through the arrangement of neutral protein molecules (Deleuze 2004, 243). In this regard, the general conception of the acoustic, electronic, and digital in musical instruments is derived not from innate qualities, but from the broader relations and dynamics they inhabit. The more one attempts to generalize based on innate qualities, the more one merely reflects the most common, or perhaps mainstream, understanding of them.

However, experimental music, specifically in the realms of novel instrument making and electronic/digital/post-digital lutherie, has the potential to suggest a different conception of these media. Artistic practice often strives for extreme particularity, as a successful practice

does not naively comply with mainstream dogmas. A novel musical instrument built within such a practice can be seen as an actualized version of a highly specific case drawn from its associated *virtuality*, encompassing the unique actualization of the instrument's acoustic, electronic, and digital dimensions. The following section will address the subsequent question: how does the hands-on practice of novel musical instrument-making enable this specific actualization?

3. THE EXPLORATIVE AND EMBODIED NATURE OF HANDS-ON NOVEL MUSICAL INSTRUMENT MAKING

In their research on the modular synthesis community, Eliot Bates finds the vast array of scholarly definitions for the term "interface" to be insufficient and even contradictory when attempting to grasp the community's diverse practices. To address this challenge, Bates proposes a robust methodology, described as follows.

> So interfaces could be parts of a more complex material technological object (Pinch and Trocco), a *site of mediation* (Butler), an unknowable "something" between two epistemes (Ihde), *points* that govern exchange between discrete objects (Bratton), *processes and not* points or things (Galloway), and the *dissolution* of subject and object and of the dimensionality of space itself (Virilio), all of which ignore the interfacial *surfaces* of chemistry. When considering any one interface, *at least* two of these have to be wrong; from even the most elementary understanding of mathematical topology, no concept/thing can be simultaneously a material object, a site, a surface, a point, a process that is not a point, *and* a dissolution ... Instead, I propose that we take seriously the multiple modes of interfacing that can happen during modular synthesizer "use." (Bates 2021, 177)

Bates's critique is highly relevant to this paper. The contradiction and confusion surrounding the conception of the term "interface" closely mirrors the discourse on the acoustic, electronic, and digital domains within the novel musical instrument community. Accordingly, Bates suggests focusing on the actual use of the instrument. Moreover, this notion of "use" can be expanded to encompass the hands-on making, playing, testing, and prototyping of novel musical instruments.

Unlike traditional lutherie, the art practice of novel musical instrument making is not strictly regulated by pre-determined instrument designs or existing musical tradition. Instead, the artist must often create the entire musical fabric surrounding the instrument from scratch. Most importantly, this creation occurs concurrently with the artist's hands-on material engagement. Consequently, the making of the instrument becomes an immensely exploratory process.

Tim Ingold provides a holistic study of how hands-on making is conducted in a processual fashion through embodied material engagement. Ingold argues that "even if the maker has a form in mind, it is not this form that creates the work. It is the engagement with materials. And it is therefore to this engagement that we must attend if we are to understand how things are made." (Ingold 2013, 22) He urges scholars and practitioners to shift the perspective of

making "from the endless shuttling back and forth from image to object and from object to image... to the material flows and currents of sensory awareness in which images and objects reciprocally take shape." (20) This is demonstrated through various examples in his anthropological and ethnographic research, medieval craftspeople being one of them. Ingold found that medieval craftspeople constructed buildings without precise measurement tools or detailed plans; "operat[ing] not with theorems but with rules of thumb." (47) These craftspeople acknowledged that the construction process rarely follows a predetermined schedule, requiring them to "continually improvise solutions to problems that could not have been anticipated, and to wrestle with materials that are not necessarily disposed to fall, let alone remain, in the shapes required of them." (48) Therefore, the building process is executed through a flow of interaction between mind, body, and material, a process Ingold calls *correspondence*. (105)

The formulation of the notion of the acoustics, electronics, and the digital can also be understood in this context. As Bates formulated the notion of the 'interface' by focusing on the use by the modular synthesis community, the conception of the digital/electronics/acoustics can also be populated through activities involving those mediums. Furthermore, Ingold's theoretical framing implies the processual and enactive nature of this conceptual formulation, driven by a mind-body-material interaction that Ingold calls it *correspondence*. The art practice of novel musical instrument making does not necessarily bound to a preceding musical tradition or complies to a pre-existing instrument design. These suggests a potential that the formulation of the acoustic, electronics, and the digital in these practices should also be understood based on these particularities. Furthermore, this also implies that each artists have their own configuration of different medium in their instrument making practices, which have the potential to greatly broaden our understanding on media specificity and technology in general. This is especially pronounced when the analysis includes the broader musicking instead of solely focusing on the work itself.

As mentioned in the beginning of the paper, Ellen Fullman's practice and artistic process is a good example. Although Fullman's *Long String Instrument* and musical performance is fully acoustic, the holistic musicking involves a variety of electronic and digital medium. Her compositional process demands meticulous accuracy and structure, as she employs precise tuning and complex intonation systems (Fullman and Wong 2025). In her workshop, the software tools she introduced were mainly in three categories; tools focused on the analysis of and material generation in just intonation, playing/monitoring the composition she is working on, and designing/building her *Long String Instrument*. The first category includes software tools like Heiji, Scale Workshop, Tuning Vine. For the second category, she preferred to use a VST, such as PianoTEQ, and play it using her iPad through TouchOSC. For the third category, she uses CAD software to design the *Long String Instrument* and specific measurement tools, such as the Peterson StroboPLUS HDC tuner. This enables Fullman to achieve the level of precision her music and *Long String Instrument* requires. This is specifically important for her since tuning is a critical aspect in her practice, which she explicitly mentioned in the QnA session during her workshop at Roulette Intermedium. For

Fullman, the digital and electronic serves as a precise measurement system and simulation for her composition and performance, which supports the realization of her *Long String Instrument* work with precision and efficiency.

The *Rainforest* series by David Tudor and Composers Inside Electronics (CIE) also presents a unique topology between electronics and acoustic medium. *Rainforest* consists of electronic music pieces that use found objects amplified via transducers. Each object possesses unique resonant frequencies that filter the audio signal from the transducer, resulting in distinct timbral and spatial qualities. These transduced sounds were also captured using piezo contact microphones and amplified through a PA system (Rogalsky 2006). The core objective of Tudor's project was to articulate his unique conception of nature, which he described in a conversation with Larry Austin. This mantra of expressing objects as they are, or from the "inside" of the instrument (Nakai 2021), rendered the artistic process profoundly processual and exploratory.

> I need to observe something in a way that I don't put any prejudice. I want to see what it tells me. My experience with Alvin [Lucier] is that he approaches things more like a romantic, so that he's an appreciator of these phenomena, and he appreciates their specific beauty. Then, ... he wants to display those characteristics, which seem beautiful to him. Whereas, in my case, I want to show it as something in nature. You know, I don't want to display it, I want it to display itself (Kuivila 2004, 20).

More specifically, this was realized through an extensive investigation into the acoustics of the installation space and the unique resonance of each found object, involving intense collective listening and the hands-on construction of electronics and sculptural installation. Furthermore, Tudor and the CIE embraced this conception of nature at its core; they rejected the notion of preservation and instead viewed each iteration of Rainforest as an evolving continuum (Driscoll and Rogalsky 2004, 25). In a 1988 interview, Tudor stated, "my preference is to use modular materials which can change from piece to piece. And also it enables me to expand a piece by adding components to it which were not in the original formation."(Driscoll and Rogalsky 2004, 25) This tendency is also reflected in the notation of Rainforest IV, where the "icons refer to specific pieces of electronic hardware, but that hardware may change between performances as equipment breaks down or new components become available." (Kuivila 2004, 21)

In Tudor and CIE's *Rainforest*, the acoustic and the electronics are tightly intertwined. This is primarily due to how the sound is produced in this piece, which is through electronic transducers vibrating the found objects. In this process, the sound's characteristics and audibility depend heavily on the object's frequency response. This was particularly critical at the time the work was created, given the low power of early electronic amplifiers. This fundamental feature of media topology extends further within the project. The sonic outcome greatly depends on the objects CIE members bring, which makes it impossible to predict how the sonic outcome of the installation. It inevitably requires a collective listening and site-specific design of the object placement and sound design, which leads to the organic and

processual feature of the artistic process. Due to the process, it was crucial to build the system in a modular fashion so that CIE members can dynamically re-create the installation every iterations. Holistically, this resonates with Tudor's keen interest of re-creating 'nature,' and the tight connection between electronic and acoustic medium was the technological condition that enabled this artistic vision.

In the realm of software instruments, Wekinator can be an interesting case study. Although it was developed in 2009, the paradigm it embarked still stays greatly relevant, still applied in more recent software tools like MuBu or FluCoMa. As discussed previously through the collaboration between Laetitia Sonami and Rebecca Fiebrink, who is also the inventor of Wekinator, the mapping paradigm pioneered by Wekinator suggests a gesture-focused and bottom-up based mapping approach where the algorithm is processualy created through physical interaction. The critical part in this system is that the software mapping algorithm itself is totally meaningless. It becomes artistically meaningful only when it is activated through the physical gesture specifically by the agent that was involved in mapping creation process. Therefore, in this specific case, the digital software becomes a mediator, which simply responds to the input data, and creates an output, and the musical significance and meaning exists in-between the artist, performer, and digital tools, which is outside the digital software.

The case of Wekinator demonstrates that embodied musicking is central to digital lutherie. Model creation within this system is primarily embodiment-driven; the model itself does not self-sufficiently encapsulate a music-theoretical framework. Instead, it operates organologically, meaning that enactive and embodied interaction with the software creates musical meaning. Without this physical engagement, the model is reduced to a cluster of mathematical functions acting arbitrarily. Only through embodied interaction, the computation model becomes relevant.

Alan Blackwell's analysis on live coding performance also demonstrates a mediated functionality of digital media in musical performance. Blackwell's analysis comes from Umberto Eco's critique on information theory by Claude Shannon. Through his essay "Openness, Information, Communication" in his book *The Open Work*, Eco criticize that classic information theory treats information and meaning synonymously. Instead, he argues that meaning and information should be treated differently; arguing that "information (qua entropy and coexistence of all possibilities) is a characteristic of the source of messages: the moment this initial equi-probability is filtered, there is selection and therefore order, and therefore meaning."(Eco 1989, 66) In other words, this means that how the receiver, which can be broadly understood, process/filters/renders the message that ends of formulating the meaning. This becomes especially important for Eco in poetry and experimental art practice during the mid-late 20th century, which greatly incorporated chance and audience's agency. Blackwell applied Eco's analysis to live-coding performance as follows :

> The execution of this[live coding] program (or "performance" of the notation) is a mechanical rendering ... The programming language semantics are predetermined, and the computer will

> always create music that follows those semantics. In information theory terms, no information is added by the machine...However, just as with a turntablist or concert pianist, the live coding audience is also observing technical proficiency with a user interface-here, the interface of the programming language and development environment. Improvised programming is a virtuosic achievement ... Whereas the minimum description length of a live coded score may seem small by comparison to a Beethoven symphony, the freedom of the performer is very large, and the audience is able to explore, not only the sonic experience, but the interpretation of its score (Blackwell 2018, 179).

The instrument of the live-coding instrument is obviously the live coding software program, and Blackwell accurately pinpoints that the musical meaning of the performance comes from the proficiency of the performer with the programming language. This proficiency includes a broad range of sensitivity, not only limited to the programming language itself but also reading the floor and the crowd, and the vibe of the venue. The live coding software itself, as pointed by Blackwell, is simply a mechanical rendering of the code from predetermined semantics, which is absent of the holistic musical meaning and experience. The musical expression occurs through the proficiency of the performer, which is also largely embodied knowledge as Blackwell described it as indistinguishable with a turntablist or concert pianist.

In this context, the code itself in the live coding is not the entity that encapsulates the ethos of the live coding performance. For example, even someone types the same code for the live coding performance, its musical salience and meaning greatly differs based on the proficiency, timing, venue, floor vibe, and audience interaction. Therefore, the music-theoretical epistemology is indifferent from the code base of the live coding software, instead the enactive relations it forms becomes the main factor.

4. CONCLUSION : INVERTING MEDIA SPECIFICITY THROUGH NOVEL MUSICAL INSTRUMENT MAKING

This article has discussed how media specificity in novel musical instrument-making should be analyzed from a bottom-up perspective, focusing on the particularities of individual artistic projects. To demonstrate this approach, the discussion was illustrated through a broad range of practices in novel musical instrument making.

The artistic practice of novel musical instrument making creates a particular configuration of materiality by creating an instrument, which is then actualized through the enactive and embodied interaction. Media specificity is formulated through this holistic process, which can drastically differ among artists to artists and project to project. This implies the broad significance of novel musical instrument making as an art practice and research. Each project has the potential to suggest a unique formulation of media specificity, which can greatly differ from the industrialized and commercialized mainstream engineering practice.

This urges an inverted perspective on the research of post-digital lutherie; a methodology that provides a conceptual description of the unique media specificity formulated through the enactive material engagements of novel musical instrument making. This demonstrates how

the unique particularities of artistically driven instrument-making practice can formulate unconventional media entities and technicity. This aspect of novel musical instrument making has the potential to drastically expand our imagination of media technology through a full operational instrument and a musical work created with it. Therefore, this implies that practice and research of novel musical instrument making have broader implications beyond musical spheres, extending to media studies, technology studies, and related fields.

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