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Ergomimesis
Towards a Language Describing Instrumental Transductions

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Abstract

This speculative paper proposes a terminology of ergomimesis for engaging with the way new musical instruments derive their design from previous music technologies. What new instruments translate from earlier technologies are not simply the simulation of an interface, but a whole constellation of embodied contexts, where trained movements, musical actions, human-instrument relationships and other processes are transduced or moved over to a technology of a different material substratum (from organic to digital material). The concept of ergodynamics in a musical instrument is subsequently contextualised in relation to the semiotics of mapping, from the background of the Peircian analysis of the sign.

Keywords
Ergomimesis
HCI
NIME
Ergodynamics
Instrument Design
Affordances
Constraints

Introduction

> "To treat sound as a musical medium skirts musical technologies; better put, it stands in for the technologies that have been bypassed. Yet it would make just as much sense to talk about the media of music as consisting of the wood, metal, wires, reeds, pipes, valves, speakers, magnetic tape, vinyl, and circuits that we use to produce and record sounds. After all, sound is the effect produced by the battery of physical media." (Dolan 2012, 3)

Musical instruments are peculiar objects. They serve as media for musical expression, but in that, they concurrently reject their medium-ness and become objects that we are set in a dialogue with, through their oscillatory shifting of modes from what Heidegger famously called "being-at-hand" to "present-at-hand" (Heidegger 1962). In music, instruments are not the channel but the source of that communication: they are the message, as McLuhan would have said, collapsing a complex communicative scenario into a neat phrase (McLuhan 1964). Instruments are actors: they teach, adapt, explain, direct, suggest, entice. Instruments are impregnated with knowledge expressed as music theory, they adapt to our tunings, playing, manipulations; they explain the world, they demonstrate our theories of harmony, tunings and mathematical relationships; they direct our playing, suggest music, styles, behaviours. Musical instruments are objects of mystery and they can entice us into their world or be used to probe into our imaginary worlds, all through methods that go beyond conceptual language. These instruments are antennae into the unknown, into where rationality cannot take us, yet bringing back knowledge of the world and insight into the human condition.

The art of making musical instruments has diversified with our increasingly reticulated technological infrastructure. New materials have appeared, such as electric oscillators, filters, sensors, and interfaces, or digital chips, compilers and languages that enable us to define the body of our instruments through computational means, ever flexible, adaptive, evolutionary or learning.

1.Traditional and Digital Lutherie

We might quickly explore this diversity of technical material. Here we encounter the traditional luthier, say a violin maker, who is a person whose education involves an initiation of a long tradition reaching hundreds of years of technological progress. The knowledge of wood (e.g., spruce, maple, and ebony), glue (protein colloid glue made of animal connective tissues), strings (first made of sheep's intestines, now wound metal strings), horse hair, rosin, and other materials is transmitted from the master to the apprentice in the workshop through actual practice. The process is mimetic not theoretical, where the apprentice copies and receives advice from the master through the mediative object of the instrument. The use of manuals or textbooks in these practices, if available at all, are only secondary to the real passing of knowledge in this form of apprenticeship. The evolution of the instrument has focused on timbre and sound projection in combination with developments in composition and performance.

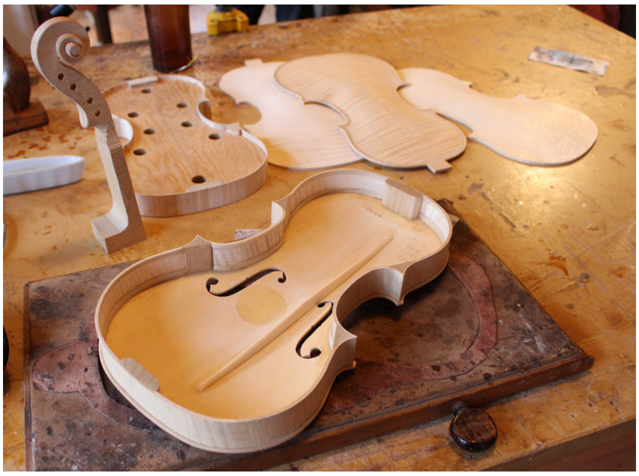

Figure 1. From the workshop of luthier Hans Johannsson

The luthier understands the role of tradition in musical culture. Performers learn instruments from other experienced instrumentalists; they need instruments of the same type in order to be able to learn. The fact that there are types of instruments makes it possible for composers to write for them. And interpreters perform the pieces. Thus, we get conservatories maintaining the lineage of canonical works, training instrumentalists in the tradition, as well as composers to continue and further that tradition. All with a shared common reference: the musical instruments themselves!

Tradition versus innovation is a delicate equation for the luthier. When producing instruments that are a fixed entity in the minds of thousands of composers, performers, and listeners, innovations and change in the build and sonic timbre of the instrument will have to be carefully implemented. There are issues with the ergonomics (violinists often have problems in the neck or repetitive strain injuries in their left hand, as well as some hearing damage in the left ear due to the proximity to the strings) of the instrument, and the shape of the instrument itself is not a necessary evolution resulting in the best sound. The f-shaped holes are not necessarily the ideal shape, although there are discussions about that (Nia et al. 2015).

The luthier is not concerned so much with current popular ideas of usability and smooth learning curves. For the luthier, the instrument is a locus for reaching spiritual depth via music, via mind-body virtuosity and control. And that takes time. The luthier has spent 10k hours learning to make a masterful instrument: they have no problem expecting the musician to dedicate the same amount of time to their vocation.

The *digital* luthier (Jordà 2004), on the other hand, perhaps better termed as computational luthier, is interested in the web, in connections, mapping, ergonomics, and the rhizomatic structures of control messages. The focus here is on an object that incorporates a particular vision of what music is and how it can be composed or played. The digital luthier understands musical ensembles differently from the composer. The composer provides a script for performers to play alongside each other. The digital luthier is more focussed on the musical instrument as a model of musical theory: and here a problem emerges in that this theoretical construct might not be compatible with other digital instruments, preventing deep collaboration or ensemble playing. This can be evidenced if we seek to find out how many digital instruments are designed for solo performance versus ensemble playing?

Since the digital luthier writes the music theory into the instrument itself, it shakes up ancient structures of composer-performer relationships. Improvisation becomes more relevant than notated music, and performing the instrument is often a process of exploration and a dialogue, not a transparent channelling of intention. The digital luthier is skilled in musical theory, acoustics, signal processing and performance. For him musical brilliance emerges if the right conditions have been established. The art is therefore to set up the network of technological nodes in a manner such that a relatively novice performer can get good music out of the system. For the digital luthier, intelligence and creativity is distributed. It does not have an origin in one place. Musical creativity is therefore contextual, not something that beams down into a composer's head via the muses.

2.Imitative Origins of New Digital Instruments

There is not much point in seriously maintaining a rigid distinction between acoustic, electronic, and digital instruments. Firstly, because the digital is analogue at diverse layers (e.g., the top interface layer and the electronics layer), and the acoustic is often discrete, with a good example in piano keys. In actual practice, we constantly move beyond these distinctions, but for the sake of analysis they can be useful, as, if prompted, musicians report on common perceptions that are too often latent and not explored. It might actually be equally relevant to talk about old and new instruments, as this distinction does not contain references to information-material properties, such as acoustics, electronics, or digital. Using the old/new distinction we apply an acoustic versus digital dichotomy in practice as there are clearly no electronics in old instruments, and most new ones introduced to the market will involve computer chips and electronics. We therefore need to consider our instruments as hybrid objects, pulling in technologies from different application domains, cultures, or embodied practices. Another way musical instruments are hybrid are their production models: they range from commercial businesses (Steinway, Fender, Ableton) to individuals creating their own technologies (instruments and interfaces, DIY, open source).

A phenomenological description of the difference between an acoustic (old) and digital instrument (new) might be due: We can begin by looking at the materiality of the instruments. Here the acoustic instrument's body is a resonator (either through a string instrument body's cavity or a wind instrument's tube) and we feel its vibration during playing. The body resonates due to human energy exerted through some excitation source, for example a skin membrane, a string, a reed, or a brass mouthpiece. The type of material matters and the physical shape is an important factor in how the instrument sounds and feels. The instrumentalist forges a strong bond with the individual instrument, one that becomes part of the performer's body. For the audience, it is very clear how the human effort, often one of intense continuous focus, results in the shaping of the sounds coming out of the instrument. The instrument becomes a central focus, it occupies a location in space from where we hear the sounds.

With the digital instrument, on the other hand, the sounds are not of its body, which is typically of plastic or metal, with glass screens, and it does not resonate with the complexity of the sound coming out of the speakers, even if the interface includes a tactile or haptic feedback system. The speakers are often located on either side of the stage, splitting the instrument's sound source into two distant locations. In the digital instrument there is no necessary mapping between the human and the sonic energy: the performer might trigger a sound that prolongs until it is actively stopped. However, sensors on the interface might change the sound, through gestural movements, but those might not be isomorphic to the physics of the sound (a strong gestural movement could be mapped to softer sound, or any such disparity between hard/soft, fast/slow, up/down, wide/narrow, and so on) as all mappings are arbitrary. It is rare that a performer forges a strong bond with a controller or a digital instrument in the same way we find with acoustic and electric instruments.

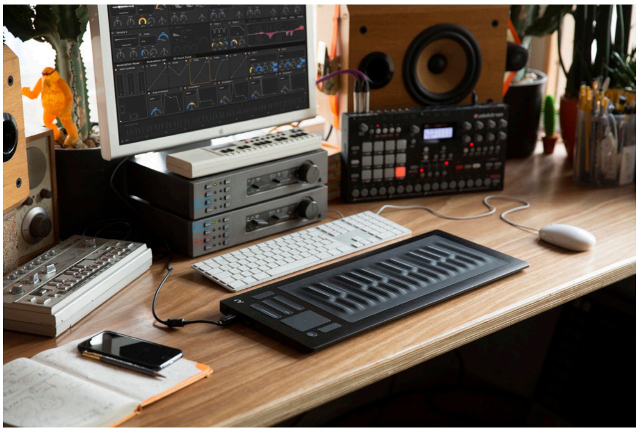

Figure 2. The Seaboard, as an example of a typical new instrument, leveraging tradition in design, mapped to software

Yet, considering the material differences in these musical technologies, the instrument and the interface, it is quite remarkable how new instruments are designed through a process of imitating existing music technologies. This is, of course, a natural process as it leverages people's knowledge, imagination, and skill. Importantly for business, it also enables a marketing where the new is contextualised in the terms of the past, with narratives such as "the professional recording studio in your bedroom" (for DAW software). But this is a real question for software developers: if we can implement everything in the software and hardware that we are developing, where do we set the constraints? Where do we create the bottleneck

(Jack, Stockman and McPherson 2017) that defines the instrument as it is? This is often done through an imitation not simply of the functionality, sound, look of a musical instrument, but more importantly about the actions that make that object possible. Because before the snare drum there was stick beating on a tree trunk, or a more recent example: before the typewriter, there were pianos (and, according to Kittler (1999), women becoming secretaries as they could reapply the finger dexterity from their piano practice on the type writer.

3.Ergomimesis

What conceptual tools do we have when we analyse the change or transduction that happens when ideas, techniques, methods and technologies from established instruments and music technologies are implemented in our new digital instruments? I use the word "transduction" in the general sense that it involves converting systems of energy flow from one form to another. To freeze water is a process of transduction, but so is the function of the analogue-digital converter (ADC). More nuanced sense of the transduction process in media studies can be found in the work of Simondon (2017) and Mackenzie (2002), both of whom analyse transduction as a process of transforming constitutive structures. It involves the study of "how things become what they are rather than what they are." (Mackenzie 2002, 16). From a media theoretical perspective, we are borrowing as well as remediating (Bolter and Grusin 1999), but what name should we give to this transduction of musical instruments? Objects so complex that they involve physics, materials, ergonomics, aesthetics, community, expression, performance, ideation, art.

Stiegler's concepts of *epiphylogenetics* and *tertiary memory* (technological memory) are useful in explaining how technology constitutes the human our thinking (Stiegler 1998), but they are less useful in explaining the transmission process and the mechanics of design. For our analysis we need to emphasise the socio-technical appropriation and continuation (passing on) of ideas, techniques, methods, and technologies. Instead of technology as our tertiary memory (the first being genetic and second epigenetic memory) storing our culture, I'm interested in a concept that focuses on action; our movements or kinetic memory. The Greek word for work is *ergon,* and we might as well call this *ergogenetic* memory for now; that is, the affiliated memory of how to use an object. A bone with holes in it is not a flute if the Divje Babe cave dweller has never heard (of) a flute. The actions affiliated with technological objects are *of* the objects, but they can be borrowed and used in other technological contexts.

Therefore, if we copy work processes from one domain to another we can call this *ergomimesis*. We mime and imitate actions and processes of one area and we implement the same in a different one. Intrinsic to the concept of ergomimesis is the fact that any repetition, copying, or translation is a new event in itself, involving noise, errors, misunderstandings, abstractions, and new affordances. This noise in the translation is clearly the source of much creative solutions and adaptations. The field of *ergography* would study how technological things emerge from previous actions and processes, translated into a new domain; this involves classifying key musical gestures (plucking, hitting, fingering, stroking, blowing, etc.) and trace how a particular behaviour, movement, or design trope, carries over to new instruments (the Greek *organon*, for instrument, is etymologically related to *ergon*). This product of transduction or "carrying over" might therefore be called an *ergophore* (like a metaphore), as it "contains" the trope, the embodied inscribed pattern of motoric memory over to a new physical object, a new instrument. Finally, in a musical instrument we have infinite dimensions for expression. The instrument has a latent potential, some directly perceivable as affordances, others more hidden and discovered as constraints (Magnusson 2010). This discovery of an instrument is a dynamic process, it happens through time, and through it we find the object's power and potential (*potens*, *dyna-*

mis). In Greek, the power of a word can be called dynamis, as well as ability, skill, value. I do think that we can benefit from the concept of *ergodynamics* when analysing musical instruments. This concept expresses the instrument's potential for expression, what lies in it, not directly perceivable (like affordances) and not simply its limits (like the constraints), but an acknowledgement that the instrument is an object that never rests, every time we pick it up there are new things to discover, new patterns our fingers know (from another instrument? From typing on an ascii keyboard? From cooking?)

To take a concrete example of such an ergography, we could take the *swipe* ergophore as an example. This movement is familiar to us as we turn the pages of a book or a newspaper, or operate with other layered objects, such as a deck of cards. For the HCI designer who wanted to represent stacked information, the swipe is therefore an ergomimetic implementation of a well-known human action. We could then talk about the ergodynamics of a PDF reader mobile app, as it supports well known actions from book reading books, but it also supports things such as zooming into the text, copying it, highlighting, and so on.

4.The Semiotics of Ergomimetic Design

Translation, implantation of metaphors in design, derived from actions in a source domain (the flicking of a book page becoming a swipe design in a screen-based device), thus *ergophores*, is a striking character of new musical instruments. They are novel and alien objects in our new world, but they pretend they drag with them the culture of the past. They want to be something they are not, but through that, they become what they are. This refers to electric as well as digital instruments. Like Ihde's dentist, who with a metal probe is able to find irregularities in the tooth, experiences an extension to the body, and amplification of sense, yet losing experience too, for example the warmth and wetness of the mouth (Ihde 1979, p. 21.)

Mapping is therefore a key difference in the way new musical instruments work. From a semiotic perspective, we could apply the Peircian trichotomy (Peirce 1955) that divides signs into the types of *icon*, *index* and *symbol*. Briefly explained, the *iconic* sign is one where the represented thing resembles, imitates or reflects the qualities of the signified object. A statue, a gendered toilet sign, or onomatopoetic words are iconic. They physically resemble (visually, sonically, etc.) the signified. The *indexical* sign does not have to resemble what it stands for. However, it is directly connected to it, for example foot prints in the snow are indexical signs, or a phone ring tone. These are learned signs, but they contiguous with the origin. Finally, *symbolic* signs are arbitrarily assigned structures where the signifier and the signified might have no relation at all. This is based on convention, and a population of users. Peirce notes that these signs often overlap, and, for example, that a symbolic sign might contain an iconic element.

This semiotic model can be applied to the manner in which musical instruments work, in order to understand and try make explicit a certain unease of qualitative differences between acoustic, electronic, and digital instruments. Here we note that acoustic instruments are of *iconic* nature: the string on the guitar is at the same time the sign, the interface, and the sound source. There is a direct and necessary relationship between interface and sound, one based on acoustics or physical laws. Electronic instruments can be seen as *indexical*. There is a link between the sign and the signified (e.g., between the filter knob and the filter behaviour) and this link is contiguous. A voltage controlled low-pass filter works a certain way, and its behaviour is clear. We might however wire the knob such that it increases the cut-off frequency when we turn it to the left, and decreases the frequency when turned right. That is a convention, an index, but it is not arbitrary, as the behaviour is still based on the principles of electronics. Digital instruments are *symbolic* (and I have used the words “epistemic,” “theoretical” and “ergomimetic,” to signify from different perspectives that open yet machinic mapping between input and output). The mapping between the interface element, whether screen-based or physical, is arbitrary: there are no natural laws that limit our design options. A soft touch could result in a loud sound, and vice versa. A lively acrobatic gesture might result in a timbrally simple sound, where no movement could yield a sound of rich sonic spectra.

It is therefore relatively uncomplicated to notate for iconic instruments, a blob on staff represents a pitch (or even an action), but it has a location on the fingerboard, and an expected setup on the instrument. It is not so easy to create symbols for the behaviour of electronic instruments. The instruments are unstable, they are never the same (it is well known that you can never get exactly the same sonic structure on a modular synthesizer), so the symbolic notation can hardly refer directly to a defined outcome. Thus, we might apply more imprecise notation for imprecise instruments. The trouble triples with digital instruments. They change like the wind, a parameter in the code could result in a very different instrument, the sound engines change as well as the mapping engines. For the composer, it is not clear then what kind of object is being notated for. Here the notation has to be not of pitch or tempo, but of general design: the notation becomes the structure of the instrument itself, for example in a Max, Kyma, Pd or SuperCollider patch. That becomes the notational piece, just like a graphic score or the Greek music theory, and the performer improvises out of that platform.

This “problem of notation” ceases to be a problem when we consider how musical practices change with the advent of the new instruments. The former roles of composer, performer, instrument maker, sound engineer, audience member, etc. begin to unite, in different ways for every new piece of instrument, work, or installation, transforming our concepts of notation, musical work, and performance.

Conclusion

This paper has articulated the problems we are experiencing today with all the new instruments invented, typically through an ergomimetic process, yet they cannot infiltrate the established culture of traditional musics, from classical and

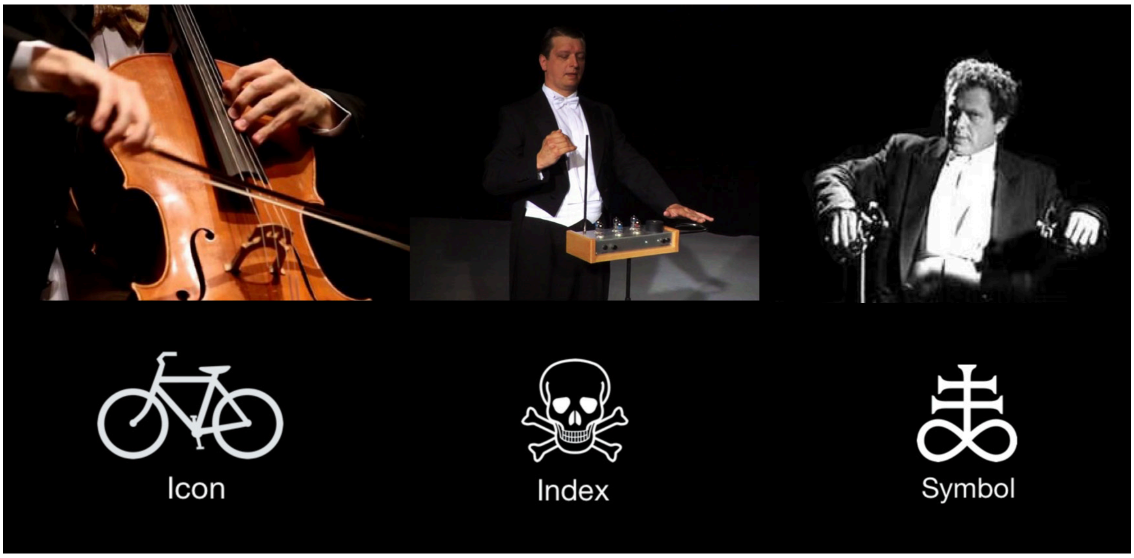

Figure 3. The different semiotic mapping modes in musical instruments (Steven Bradley - www.vanseodesign.com)

jazz to popular music. The new instruments are in a particular solipsistic void where they work on their own, as a theory of music that fits their designers musical purpose, but they are often poor for ensemble or orchestral contexts where they form part of an improvisatory or notated musical performance.

This speculative paper has introduced preliminary thoughts regarding the semiotics of mapping in new instruments and how they relate to the ergomimetic translation process of moving actions, ideas, techniques, and physical design from one domain to another – the physical, the electronic, and the digital are distinct, albeit at times overlapping, platforms that share proprioceptive or kinaesthetic action, musical ideas, design, yet on a material substrata so completely different. The paper proposed ergomimetics, with affiliated cluster of words, as an HCI, NIME, and musicological terminology for defining the processual potential of an instrument, what it offers in terms of musical potential, how one plays it, and what it brings from other musical contexts (traces of other musical contexts). Just like the game critic expresses that a particular video game has a good gameplay, we want to be able to say that an instrument has an interesting ergodynamic.

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