An Epistemic Dimension Space for Musical Devices

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ABSTRACT
The analysis of digital music systems has traditionally been characterized by an approach that can be defined as phenomenological. The focus has been on the body and its relationship to the machine, often neglecting the system's conceptual design. This paper brings into focus the epistemic features of digital systems, which implies emphasizing the cognitive, conceptual and music theoretical side of our musical instruments. An epistemic dimension space for the analysis of musical devices is proposed.

Keywords
Epistemic tools, music theory, dimension space, analysis.

1. INTRODUCTION
The NIME conference series, running for nearly a decade, epitomizes a historical approach to musical systems design, where musicians, computer scientists and engineers attempt to create engaging technologies for musical expression. Surveying the history of new digital musical instruments research, it is manifest that the emphasis has been on ergonomics, human-computer interaction, sensor interfaces, and general engineering issues, on the one hand, and musical performance, mapping and embodiment, on the other. Conceptual issues have been largely ignored, resulting in a research focus based on phenomenology, at the expense of a more 'epistemological' approach.

In order to demonstrate this observation above and discuss it with some concrete material, a direct reference is made to an older NIME paper, *A Dimension Space for Musical Devices* [2]. In that fine paper, Birnbaum et al. introduce a visual representation of a dimension space of digital musical devices. Birnbaum et al. represent what I will call the phenomenological approach in the analysis of musical instrument design. Their paper will serve as a reference point and a foundation for the form this paper will be cast. Consequently, another type of dimension space is presented here, namely one focusing on the conceptual and music theoretical content of musical instruments. It points at how our instruments are inscribed with knowledge, how they store it, and how we, as users, engage with this theoretical structure of our devices.

The aim of this paper is to engage with the epistemic nature digital systems, i.e., with the embedding of music theory and other systems of knowledge in the instruments themselves. Many of the music production tools available today embody a distinctive view of how music should be made and what it should sound like. This is productive for some musical genres, but less useful for others; consider traditions such as the Arabic or the Indian, or simply Western folk. The increasing amount of systematic structures in the digital instrument can lead to the diminution of expression. Responses have varied: whereas Machover [11] argues for time better spent than practicing acoustic instruments, celebrating how digital instruments can be designed for easy play, Jordà [6] stresses that the instrument should also be capable of bad playing; a fact that gives the performer the potential of mastery and in-depth knowledge.

2. EPISTEMIC TOOLS
Software is not just a device with which the user interacts; it is also the generator of a space in which the user lives. [14]

The philosophy of technology has much to contribute to the field of NIME. Ihde [5] reports on diverse phenomenological modalities in our relationship with tools. Here the acoustic musical instrument can be viewed as an illustrative example of a technology that gives us an *embodiment relationship* to the world. 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. In many ways, the digital musical instrument can be viewed in the context of another phenomenological mode: the *hermeneutic relationship*. It differs from the acoustic instrument in the sense that it is not an uninterrupted extension of the body, but rather an external tool whose information we have to interpret (thus hermeneutic). This instrument can be seen as a text, something we have to read in our use of it [9].

If *primary tools*, such as hammers, extend the body and prescribe certain processes through their affordances, *industrial machines* automate those processes with energy not derived from the human body. The machines are repetitive, which results in a normalized output. The machines perform and frame human tasks in a normalized and ideal way. The artistic response to the machine was to emphasize human eccentricity, uniqueness, and specialist craft. This observation materializes in the common thought that the invention of photography was simultaneously the invention of impressionist painting [7]. *Cybernetic machines* (or computers) do not only automate human work processes; they prescribe human thinking to an elevated degree through their symbolic structures. As the computer becomes a tool for creativity, it undeniably streamlines and automates human product. However, since the computer is a meta-machine, equally a tool for thinking and an executor of our ideas, we are able to resist such normalization through the use of this very same machine.

Baird states in his materialist epistemology that things "bear" knowledge. The language and theories we come up with "serve instrumentally in the articulation and justification of knowledge borne by things" [1]. This is a reference to how things can contain theoretical knowledge before they are conceptualized or understood as such. Baird's definition of such incorporated knowledge is that "an artefact bears knowledge when it successfully accomplishes a function" [1]. Analogously, it is obvious how the violin bore knowledge of acoustics before

Fourier discovered the Fourier series or Helmholtz wrote his theories of timbre.

The computer is a special case of an epistemic tool. The only knowledge to be found in computer software is that which has been deliberately inscribed in it by humans. It is an entirely simulated system that has been designed from the level of micro transistors to machine language; to operating systems; to programming languages; to user interfaces. Unlike physical material, it does not contain natural affordances or mysteries. Epiphenomena like artificial life or emergence, that often give digital systems a degree of autonomy, are still defined by their initial rules. Digital instrument makers therefore get nothing for free, unlike makers of acoustic instruments who receive the gift of sonic timbre from the physical properties of the materials they work with. The computer mediates: instead of presenting, it represents. It encourages primarily top-down design processes, contrasting the experimental bottom-up process known to designers working with physical materials.

The nature of epistemic tools as augmentation of the mind questions the roles of the designers and the users of musical systems. From the designers it demands a self-understanding of the fundamental role they play in the users' work practices. Their ideas of music, musical culture, and musical work practices are inevitably embedded in the software. It also calls for an acknowledgement by the users, that the software they choose to work with conditions their thoughts, defines musical ideas, and streamlines how they work. It implies that they have to be critical to the ways of the software, scrutinize its underlying assumptions, and thus consciously accept or reject the script it presents.

3. THE EPISTEMIC DIMENSION SPACE

This paper engages with the epistemic nature of digital musical instruments by shifting the focus to the conceptual and theoretical nature of their design – as opposed to the phenomenological. For the sake of clarity, this is done through comparison with a paper by Birnbaum et al. [2]. The objective is to investigate and devise a dimension space that suits better an epistemic approach in the analysis of musical instruments.

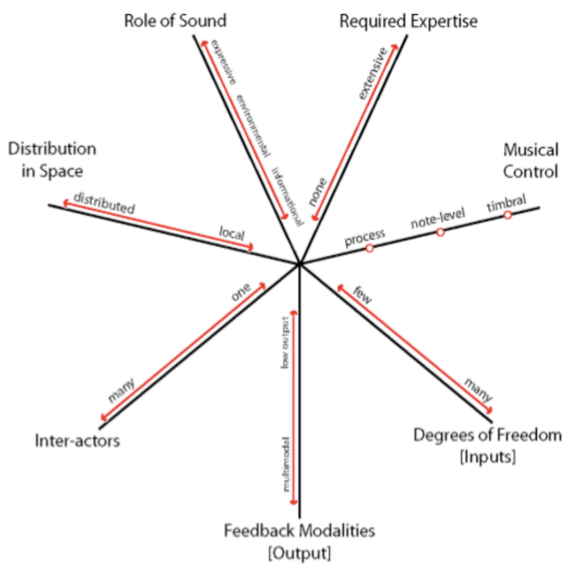


Figure 1. The 'phenomenological' dimension space from the 2005 paper by Birnbaum et al.

Birnbaum et al. [2] identify seven dimensions onto which the musical devices can be mapped, namely: *musical control* (whether the instrument's expression is at the timbral, note or score level); *degrees of freedom* (an axis that represents the number of input parameters that can be controlled); *feedback modalities* (the degree of real time feedback to the user); *inter-actors* (number of people involved in the performance of the device); *distribution in space* (the total physical area inhabited by the instrument); *role of sound* (informational, environmental or expressive); and *required expertise* (representing the level of practice and familiarity needed in the performance). Figure 1 demonstrates how this visualization of parameter spaces can be highly useful as a conceptual tool for evaluating and classifying digital musical instruments.

It is clear how the computer affords new design features for digital music systems. The performer's control can range from the microscale of sound to the macroscale of musical structure. Below is a refined and extended version of a list initially presented by Wanderley [13] of various control modes:

- *Filtering* (time and frequency domain manipulation of an audio signal)
- *Sonic texture generation* (layers of audio generated through synthesis or sampling)
- *Single musical notes* (where pitch, envelope, amplitude and timbre is controlled)
- *Continuous feature modulation of both note and phrase* (timbre, amplitude, pitch)
- *Musical gestures* (glissandi, trills, grace notes, etc.)
- *Simple scales and arpeggios* (of various speed, range and articulation)
- *Phrases with different contours* (from monotonic to random)
- *Control of sampled material* (loop-points, rate, granulation, pitch, filtering)
- *Synchronization of musical processes*
- *High-level control of recorded material* (as seen with DJs)

Inspecting the above, it is clear that only the first half is possible with acoustic instruments. Although the digital musical instrument makes use of all these controls, it is in the latter half where it excels. This is where the musical instrument is inscribed with music theory and models of musical performance to such a degree that one can talk about "composed instruments" [12]. What makes the digital musical instrument so profoundly intriguing for analysis is that it constantly transcends boundaries and fuses categories [4]. The philosopher Mumford echoes Marx by pointing out that "the difference between tools and machines lies primarily in the degree of automatism they have reached" [10]. This distinction can be applied onto our digital musical instruments as well, but in the same stroke, the division has to be rejected; our modern devices of expression should be viewed as both tools and machines; as both instruments for manual dexterity and mechanisms for automation; both as extensions of the body and cognitive scaffoldings of the mind [3].

Considering the latter part of the above list, I propose, in this paper, to look at musical systems from the epistemological or music-theoretical perspective and forge another type of a dimension space, that of epistemic tools. Whereas Birnbaum et al's [2] approach is phenomenological and focuses on the human body and its expressive potential in the relationship with digital music systems, the epistemic dimension space addresses the culture-theoretical aspects that so prominently define their nature.

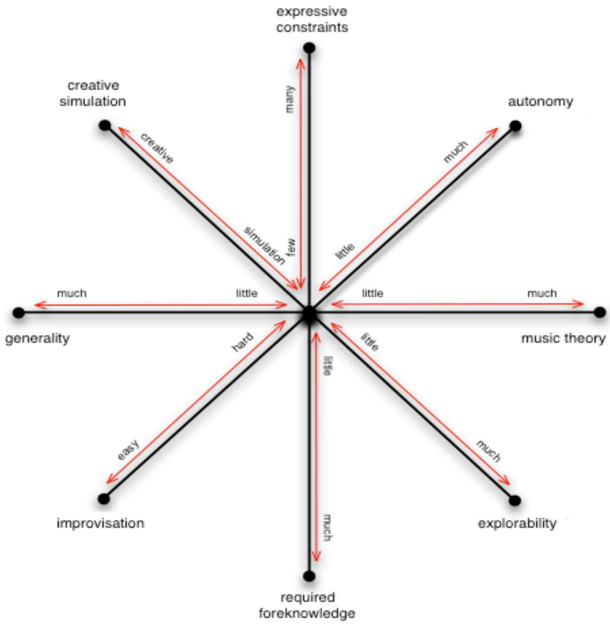


Figure 2. The epistemic dimension space proposed here.

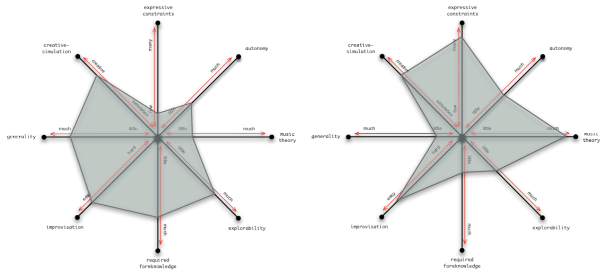
Here below is a description of the parameter axes of the epistemic dimension space found in Figure 2.

- The *Expressive Constraints* axis focuses on the expressive limitations outlined by the tool's design. This is the space of musical possibilities.
- The *Autonomy* axis specifies the degree to which the instrument provides the functionality of an automata. Certain musical tasks are delegated to the instrument (often using artificial intelligence), possibly responding to a performer.
- The *Music Theory* axis represents the amount of culturally specific music theory encapsulated in the instrument, in terms of the possibilities for various tonal and rhythmical structures, as well as signal processing. This could typically be scales, chords, arpeggios, or time signatures.
- The *Explorability* axis represents how much depth the instrument holds. This factor is critical with regards to how engaging the instrument is and affects learning curve and the possibility of flow.
- The *Required Foreknowledge* axis represents the fact that many systems do not require much musical knowledge in their design or performance as they contain it already.
- The *Improvisation* axis indicates the degree to which the instrument lends itself to free improvisation. How responsive is it, how open for changes in real time performance and how quickly can it be adapted to those?
- The *Generality* axis denotes how open in expression the instrument is and how well it copes with the multiplicity different of musical situations.
- The *Creative-Simulation* axis captures whether the instrument is novel in terms of interaction, sound and function or an imitation of established tools and practices.

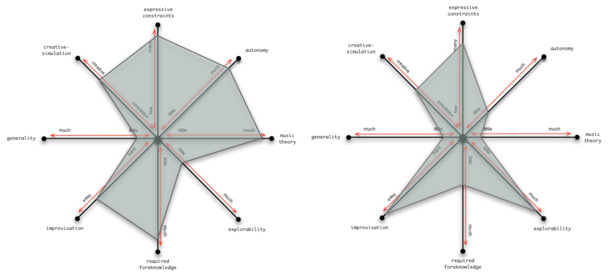
Obviously, many of these axes would not be relevant in the analysis of acoustic instruments. The epistemic nature of digital tools makes such dimension space pertinent in the analysis of digital musical instruments. The above dimensions address parameters that are unique to heavily abstract, conceptualized and symbolically designed musical tools.

4. THE DIMENSION SPACE APPLIED

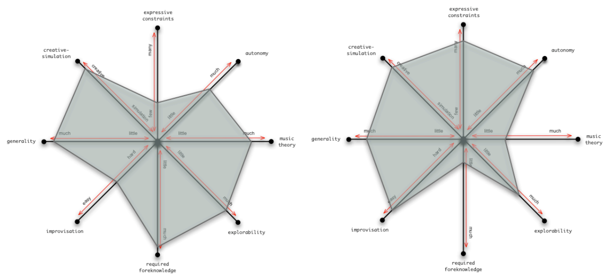
Below, an attempt will be made to map a few well known digital musical systems onto the epistemic dimension space. Naturally, this is a subjective mapping, and as Birnbaum et al. [2] mention, such mappings would ideally be performed by way of user surveys. It is appropriate to begin by analyzing Waisvisz's instrument The Hands. Firstly, because it is one of the most well known digital musical instruments, but secondly, due to Waisvisz's statement that he regularly "froze" the development of his instruments in order to gain an in-depth relationship to them. The analysis of the Hands is divided into two distinct graphs, one for the general interface (the physical controller) and the other for the specific instrument (when the controller is coupled to a mapping and sound engine).



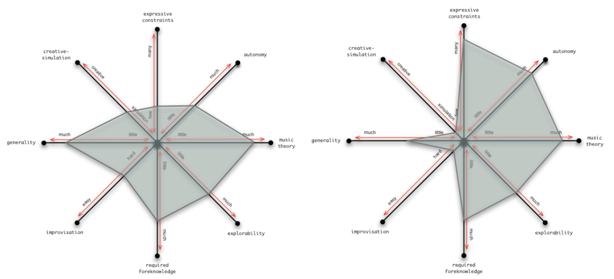
a) The Hands as an interface b) The Hands as an instrument



c) The Voyager d) reacTable



e) SuperCollider f) ixiQuarks



g) Reaktor h) Reason

Figure 3. Dimension spaces of known environments.

Figure 3a represents the Hands as gestural interface: it is open for improvisation; it affords large areas for exploration and there is relatively high degree of musical foreknowledge required to design the tool or compose for it. The controller is very general and could be used in almost any type of music. From its nature as a sensor device, we see there is little music theory inscribed in it (a keyboard has much more for example), and few expressive constraints. Conversely, Figure 3b depicts the Hands as a musical instrument. Here it is not a neutral sensor interface anymore [9]. On the dimension space graph, the music theory has become stronger, there is more autonomy and expressive constraints have been designed into the system. It is therefore less general and can be used in fewer musical contexts. It can still be ideal for improvisation.

Lewis' Voyager is a generative performance system that analyses the playing of the human performer and responds appropriately. As such, it is less an instrument than a co-player. As seen in Figure 3c, it scores high on improvisation, music theory and expressive constraints. It is clearly a system that is designed by Lewis, for Lewis, and would not work for all musicians, though others, e.g., Evan Parker, have played with it.

The reacTable (Figure 3d), in its current state, is an excellent improvisational tool and it affords much explorability. It does not require a strong musical knowledge, nor does it contain much music theory as its functions is primarily on audio synthesis, simulating the modular synthesizer (this is why it fits in the middle of the creative-simulation axis). It is quite constrained in expressivity; and in the context of generality, it depends whether we are analyzing the physical interface itself or its mapping and sound engine.

SuperCollider, represented in Figure 3e, is by many considered the most expressive and free musical environment available today. Such freedom naturally comes at the cost of a rather low-level working space, where much foreknowledge is required. It also implies certain music theoretical concepts, for example in the way its Pattern libraries are built. It affords great explorability, it is very general in its use and scope, and it opens up to almost infinite fields of creative productions. Naturally, considering SuperCollider's openness, it can used in the design of systems that can be located practically anywhere on all the axes. An example of a high-level system built in SuperCollider are the ixiQuarks [8] shown in Figure 3f. This system is built for live-performance and direct interaction with sound.

Reaktor (Figure 3g) is in many ways related to Max/MSP or Pure Data in its design. However, the building blocks of Reaktor are typically on a much higher level than in Max or Pd, resulting in less expressivity, yet providing a smoother learning curve. This also means that it is easier for the user to get "good sounding" patches working quickly, as there is more knowledge (both musical and signal processing) built into the individual building blocks than in, for example, Pure Data.

Unlike Reaktor, Reason (Figure 3h) tries to realistically simulate the rack hardware devices typically found in recording studios. It is a representational simulator where the screws, the masking tape (for labeling knobs), and the swinging cables on the back attempt to create the feeling of the "real thing." Reason scores low on improvisation, as it is not really a device for embodied expressivity. It is highly deterministic and contains expressive constraints and music theory to a large degree.

The above is a rough analysis of a few selected systems. When making such analyses, it is important to stress the distinction between the interface (such as the Hands) or the musical system (such as SuperCollider), on the one hand, and their *instantiation* as an expressive musical system, on the other. The Hands are not a musical instrument without a sound engine. SuperCollider is not an instrument until some system has been designed in it (except in the case of live coding, where it *is* an instrument).

5. DISCUSSION

This paper has highlighted the epistemic dimension in digital musical instruments. Such analysis can inform system designers who, often unconsciously, inscribe their culturally conditioned understanding of what music is and how it should be made into complex digital technologies. This approach can therefore yield benefits to musical cultures that have difficulties in expressing themselves with modern digital technologies. The imperative would be to open up the systems, either by providing the source code or by making them modular, thus rendering them adaptable to the diverse musical contexts.

6. CONCLUSION

In this paper, a decision was taken to emphasize the difference between the phenomenological and the epistemological approaches through a dialogue with a paper that serves as an example for the former. Naturally, these two approaches do not exclude each other; they should be seen as complimentary and overlapping. And indeed, just as Birnbaum et al. [2] never claim that their dimension space is final or exhaustive, the one presented in this paper should not be considered that either, but rather open for improvement and adapted to context.

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