MUSICAL INSTRUMENTS AS SCORES: A HYBRID APPROACH

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ABSTRACT

The development of new approaches to instrumentality during the decade of 1960 contributed to the dual perception of instruments as scores. For many performers, the instrument became the score of what they played. This artistic hybridization carries substantial questions about the nature of our scores and about the relationships among instruments, performers and musical works. This paper contextualizes the historical origins of this instrumental development within Drucker's theory of performative materiality. Then we examine the nature and notational scheme of this type of scores making use of the concept of *inherent score*. Finally, through the analysis of two examples (*tangible scores* and *choreographic objects*) and the notions of *affordance* and *constraint*, a compositional framework for shaping the inherent instrument score is presented.

1. INTRODUCTION

1.1 Inherent Scores: Origins of a Form

The idea that a musical instrument can be considered a musical score too, or that *the instrument is the score* has come to the academic discussion partly in the field of interfaces for musical expression [1], music notation [2] and performance of electronic music [3]. Certainly, when a performer approaches a musical instrument a number of limitations or constraints will be revealed. These characteristics of the instrument are often considered a score in virtue of its property of shaping the musical work. The following section contextualizes historically the origins of some musical practices fully supporting this idea.

It is widely considered that the creative interpretation of musical instruments as scores has its roots in the Sixties. Composers like Gordon Mumma, David Tudor or David Behrman built electronic music instruments that, once configured, can afford enough performative potentials to reveal a musical work. Alvin Lucier [4] describes how within many of the works produced by the Sonic Arts Union *there were no scores to follow; the scores were inherent in the circuitry*. In David Behrman's *Runthrough* (1968) an undefined number of performers interact with the instrument by illuminating parts of a light sensitive audio mixer. Conceived as an improvisational piece, Behrman allowed ample time for the possibilities offered by his circuit to unfold and explore the acoustics of the actual room used. In *Runthrough* performers are not provided with instructions about the type of sound sources to use, their durations, sections of the piece, etc. The general rules for performing are delegated to player's musical exploration.

In the same year, David Tudor composed *Rainforest* (1968) (Figure 1). In this work, a set of sculptural speakers are suspended in the installation space and act as unique resonant loudspeakers with sound emanating directly from the sculptural objects (each having a unique sound source). In *Rainforest* the compositional idea is that if you send sound through materials, the resonant nodes of the materials are released. It is a kind of physical filter. Visitors are encouraged to wander around and physically interact with the work. Tudor's notation of the composition is, in a deliberate way, only a circuit diagram (Figure 1). Like in *Runthrough*, *Rainforest* can be played without further instructions about durations, sound sources or number of sculptural speakers.

It is during this historical decade when an intense research on alternatives to traditional musical notation was produced. A seminal example is *Notations* (1969), a printed compendium of musical notation edited by John Cage and Alison Knowles. It is remarkable that among 269 compositions, in *Notations* we only find three musical works making use of circuit schematics as notation: Gordom Mumma's *Mesa* (1966), Max Neuhaus's *Max-Feed* (1966) and Fredic Rjewski's *Piece with Projectors and Photocell Mixer* (1966). Certainly, if circuits are configured in a specific way for their artistic use, the role of the composer, at an equidistant point among designers, composers and performers, would start with the configuration of the technical system behind the actual instrument. Indeed, performing becomes the creative exploration in freedom of the musical affordances, musical reactions or acoustic relations to the physical space performed, without the need of any kind of dedicated musical composition.

When Lucier exposes that *"the score is inherent in the circuitry"* we are facing the origins of a new compositional practice, often known as *composing inside electronics*. And in this sense it constitutes a new way of understanding instrumentality. Performers would not need an external cause, a precondition to play the instrument like in the case of traditional scores. The musical work would not only be only defined by the instrument, but more importantly, by the act of playing the instrument. The performer's role would be to reveal instances of the musical work inherently integrated in the circuitry. This type of embedded-in-the-instrument scores we will call *inherent*

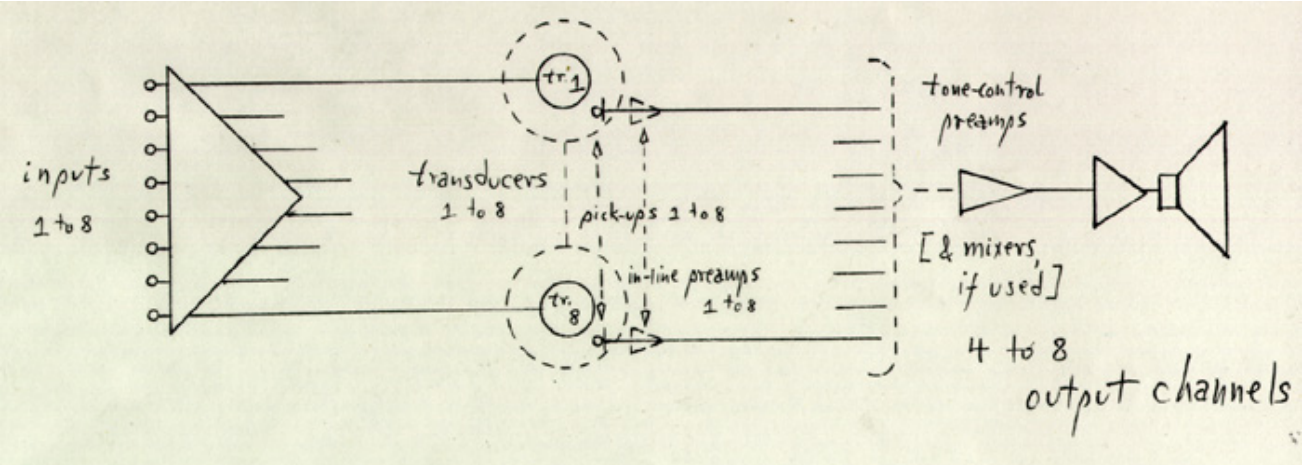

Figure 1. David Tudor's Rainforest (1968).

scores.

Through the concept of *inherent scores* we can better analyze the complex and mediated relationship between composers, performers and their instruments, especially in the case of electronic musical instruments. It has been often stated that electronic music instruments are *open-ended systems* [25]. Many times it is difficult to define where the electronic instrument ends and the composition starts. Certainly, for defining the instrument it is necessary to implement some input to output mapping strategies. But normally these strategies are fully affected by the characteristics of the composition to which the instrument is dedicated. Remarking this observation, Schnell and Battier introduced the concept of *composed instruments* [5]. This term serves to explain how our digital instruments equally *"carry the notion of an instrument as that of a score"*, in the sense of determining various aspects of a musical work itself. This is coherent with the fact that during the technical implementation of the instrument, being hardware or software, we often incorporate many ideas of composition into the programmed system.

A substantial question to this new musical practice would be if it resulted from a compositional, instrumental or technical development. We can illustrate an answer through the analysis of David Tudor's *Bandoneon!* (1966). In the words of its author, *Bandoneon!* is a *combine* of programmed audio circuits, moving loudspeakers, TV images, and lighting, all controlled through the live sound of a bandoneon played by Tudor. From the program notes of this work's premiere we read that *"Bandoneon! uses no compositional means, since it composes itself out of its own composite instrumental nature"* [6]. Kuivila also asserts that we were in fact facing a new way of understanding instrumentality. In these self-composed instruments, Tudor acts as the interpreter and performer of a composition that composes itself out of these constituent parts. Or using Lucier's arguments, the composition is created from the inherent scores that can be found in the structural elements of a particular electronic configuration. This concept carries an extraordinary rendition: the acceptance that an electronic instrument is an entity that can display itself without the need of a composer or a composition. Probably the most important characteristic of these inherent scores is that they can reveal or display themselves to their performers only at the exact moment of being performed.

Therefore, we can now assert that the origins of this new musical practice, under the influence of electronics and the germinating attitudes of post-modernism [1] , trace their roots mainly on the appearance of a new approach to instrumentality. Thus, it does not mainly rely on the mere evolution of an existing compositional practice. The introduction of electronic components in composition definitely changed the understanding of what until that moment was defined as "playing". Many of this electronic circuitry was able to synthesize sound or modify sound without the need of direct manipulation. Then, instead of playing, performers "control" their instruments. John Fulleman [6], a frequent collaborator of John Cage, attributes David Tudor an *"ability to assert just enough control over the equipment to get through a concert"*.

In a lecture-talk given at the Oxford University [3] James Mooney explains how within an interview to the English experimental music band *Gentle Fire* in 1970, the band member Richard Bernas describes how he plays a custom sensor-based electronic music instrument called *qHong*. Bernas assures that: *"the instrument is the score of what we are playing"*. On his talk called *"the instrument is the score"* Mooney develops a framework where the relationships between instrument and score can be defined through shaping the affordances the instrument creates. For being more exact, its range of affordances. The concept of affordance in musical instruments will be explained and contextualized later in this paper. In addition, Mooney recognizes performers as another active shaping element of the musical composition. Consequently, for Mooney performers would have a crucial role in defining the musical work. Later this paper will recover Mooney's observations for proposing a theoretical framework for designing instrument-scores.

[1] Many artists labeled as postmodernists i.e. Frank Zappa or John Zorn declared how they were deeply influenced by this musical practice

2. PERFORMATIVE MATERIALITY

An important conclusion from our previous section is that inherent scores would be the result of an instrumental practice. Inherent scores only exist in virtue of a performer's commitment on interpreting some type of materiality as performative, being of physical, virtual or mixed origin. In order to explain the foundations of this instrumental practice, we will make use of the theory of *performative materiality*.

Jacucci and Wagner [7] have explained why the materiality of electronic musical instruments is not only a mere support for acoustic or digital sound machines. This materiality is performative too: *"material artefacts have a history, emerge as part of specific events in time and become part of performative action"*. Physical materiality has always a performative potential. The theory and application of performative materiality within Human Computer Interaction has been extensively studied by Johanna Drucker [8]. Drucker suggests that the materiality of a system *"only occurs when we action it, and only and at that moment we perceive and discover it, always distinct in each instance"*. For Drucker, *"material conditions provide an inscriptional base, a score, a point of departure, a provocation, from which a work is produced as an event"*. Certainly, as Brown and Duguid [27] have emphasized, material features, in their peripheral, evocative, and referential function, provide border resources for interaction. But can these features be considered scores?

In contemporary performative arts, scores can take diverse forms and materials: graphic scores, action scores, computational, sculptural, etc. Then, can anything be a score? The choreographer William Forsythe pointed out [9] that a score *"represents the potential of perceptual phenomena to instigate action, the result of which can be perceived by a sense of a different order"*. Following this idea, in traditional Western music a score would be the instigator of a transition from the visual to the aural via our body. In the case of non-traditional notation, how does a score define the way we interpret a musical work? Forsythe explains that *"a score is by nature open to a full palette of phenomenological instigations because it acknowledges the body as wholly designed to persistently read every signal from its environment"*. Forsythe lays more importance on the embodied relation with the performer: scores appear in the exact moment when a performer finds a performative potential within an object or a concept, deciding its phenomenological outcome on an open basis. Thus, each object would be an embodied device open to the phenomenological interpretation: a potential available to its conversion into a performative event. We could conclude that under this vision, any object has the potential to be a score. And definitely our musical instruments incorporate this potential too. Finally, if musical instruments are perceived as scores that would be essentially in virtue of their physical or performative materiality, as well as their high evocative power to instigate musical actions.

Under this generalized definition of score, it is now possible to interpret electronic musical instruments as scores. Not mainly because of being musical instruments, but essentially from the performative materiality they engage. The generalization of this fact would suggest that any object can be a score. For exemplifying this idea, James Mooney [6] attributes the creation of improvisations out of found objects to composer Hugh Davies, who *"re-purposed (objects) as musical scores"*, in a way that *"any visual stimulus can be interpreted as a set of instructions that shape the development of music"*.

Additionally, we should clarify that physical materiality is not the only in charge of shaping the musical work. Nowadays, a great part of our digital instruments base their functionalities on the control of graphical user interfaces (GUIs). In this case, their performative materiality cannot be expressed through physical artefacts. From Thor Magnusson's research [10] we understand better how the inherent affordances and constraints of the constituent elements of graphical interfaces mediate on screen-based musical instruments. In a certain way, GUIs and tangibles can be unified by the theory of performative materiality.

3. NOTATION

3.1 Preliminary Questions

The idea that an instrument can be a score affords creative relationships. But, it also carries very substantial questions. For example, if an instrument is a score, is it true that a score is an instrument too? If one thing can be the other at the same time, are both the same thing? If an instrument is a score, can one part be separated from the other? Where can we physically find this inherent score within the instrument's body? Is an inherent score the addition of both forms or is it a new synthetic thing? How is an instrument-score interpreted or shaped by its performers?

For fully understanding the nature of inherent scores, they have to be contextualized within the ontology of notation, arts and music.

3.2 Notational Systems

Along this section, we are adopting Nelson Goodman's notation principles taken from *Languages of Art* [11] in order to spell out the kind of notation behind inherent scores.

If inherent scores are scores, it is because they manifest symbols to their readers. A symbol in a notational system refers to something (literal, metaphorical, indirect) and its interpretation depends on the system of symbolization. Furthermore, the sort of symbol it is -linguistic, musical, pictorial, diagrammatic, etc.- will be in virtue of its belonging to a specific system.

A symbol system, say, the English language, actually consists of a symbol scheme -i.e., of a collection of *characters*- with rules to combine them into new, compound characters associated to a field of reference. For Goodman, symbol systems are notational when:

1) the characters are correlated to the field of reference unambiguously (with no character being correlated to more than one class of reference, or compliance class)

2) what a character refers to -the compliance class- must not intersect the compliance class of another character (i.e., the characters must be semantically disjoint)

3) it is always possible to determine to which symbol an item in the field of reference complies (i.e., the system must be, semantically, finitely differentiated).

Languages like English have a notational scheme but fail to be a notational system because of ambiguities (in English, cape refers to a piece of land as well as to a piece of clothing) and lack of semantic disjointness (man and doctor have some referents in common).

Finally, let's apply these definitions to our artistic field. Sculptural or pictorial systems fail on both syntactic and semantic grounds so they are non-notational systems. Within Goodman's approach, a musical score is a character in a notational system only if it determines which performances belong to the work and, at the same time, is determined by each of those performances. Given the notational system and a performance of a score, the score is recoverable. This is ensured by the fact, and only by the fact, that the language in which a score is written must be notational, so it must satisfy Goodman's stated requirements.

3.3 Inherent Scores Notational Scheme

For bearing out the notational scheme of an inherent score we need to examine its symbol system and rules. If musicians consider that instruments, through their constraints and affordances, are scores too, then some kind of symbols and rules must exist. In this section we will first clarify where these symbols can be found. This analysis will help us to conclude if this system is notational or not. It is important to remark that our task here is not showing if it is possible to create a Goodman's notational system for electronic instruments. Our focus is on understanding what kind of notation is the one of an instrument, or the notation of an inherent score.

The initial and probably main complication consists in the total absence of rules within the field of reference. Normally, within instruments materiality i.e. a cello, elements are not discretized. The space of affordances against materiality is continuous. For this reason, traditional Western musical notation establishes a radical discretization on this space of affordances. For example, in Western musical notation, the space of frequencies has been entirely discretized with the use of notes and scales. Or as another example, among all the possible sounds that i.e. a cello can produce, our traditional Western notation has filtered out all kind of noises, being centered on the production of tones.

Additionally, within this continuum of materiality, if a constituent is defined as a symbol or not, it is a decision left to the actual performer of the inherent score. Goodman explains that these kind of systems are essentially *analog systems*. For every character there is an infinite amount of others such that referring to the same mark. We cannot possibly determine that the mark does not belong to all and such that for some object we cannot possibly determine that the object does not comply with all. A system like this kind is obviously the very antithesis of a notational system.

Figure 2. Earle Brown's December 1952

3.4 Non-Notational Systems and Musical Graphs

In the search for defining the properties of an inherent score and its symbols, there is a clear lack of terminology to apply here. For this purpose, we propose first analyzing the notational scheme of graphic scores, which nowadays are an accepted format of scores while they have been extensively studied within the ontology of music. From these results it would be easier to extrapolate some parts of our analysis. Although graphic and inherent scores are not the same thing they share many instrumental similarities. Later in this paper we will explain some interesting differences applied to instrumentality. Nevertheless, their terminology can be used for incorporating our inherent scores within the ontology of music.

Graphic scores appeared in the musical avant-garde as a way to release composers from the constraints of writing their music using the notation of a traditional Western score. Consequently the representation of a musical idea opened to the personal and subjective selection of graphic figures that inspire new and imaginative ways of interpretation. One of the first examples of graphic scores is Earle Brown' *December 1952* (Figure 2).

Are graphic scores notational systems? Earle Brown did not specify how his graphical symbols should be interpreted. Therefore, depending on just how the symbols are interpreted, syntactic and semantic disjointness may be lacking. In cases like *December 1952*, composers are using systems that only slightly restrict the performer's freedom to play what and as he pleases. The system furnishes no means of identifying a work from performance to performance. Furthermore, we can say that the system of *December 1952* is non-notational, like inherent scores.

An early but fundamental contribution describing, illustrating and classifying the symbols used by modern composers was Erhard Karkoschka's *Notation in New Music* (1965) [12]. Karkoschka developed the following typology of musical systems:

- Precise Notation: where every note is named
- Range Notation: where for example, only the limits of

the ranges of notes are set

- Suggestive Notation: where at most relations of notes, or approximate limits of ranges, are specified.
- Musical Graphics

Certainly, musical graphics are non-notational because they lack both syntactic or semantic articulation. We should note Karkoschka's intuition in not calling them *musical graphics notation*. In *Languages of Art* Goodman explains that Musical Graphics are another example of *analog systems*. For every character there is an infinite amount of others referring to the same mark.

We must remark that *musical graphics* -as they were coined by Karkoschka- are non-notational systems but they are still scores. The implications of classifying traditional Western scores as notational systems and musical graphs as non-notational do not restrict us from saying that *December 1952* is a score. The appreciation of -what is- and -what is not- a score has changed historically with the introduction of new musical poetics. Finally, it is a fact that Earle Brown's *December 1952* has inspired hundreds of musical realizations. Thus it must be a score.

A very important property of graphic scores is that they are usually not created with the interest of substituting a "normal" score. As discussed by Rebelo [13] or Vlagopoulos[14], and by Earle Brown himself on his seminal *On December 1952*, graphic scores are usually created as improvisational scores. They appear with the mere intention of guaranteeing an unique way of performing. But graphic scores are not "the performance". Furthermore, the graphic score is a trigger for the interrelation among performers in the rehearsal phase, if it exists. A graphic score is a provocation to solve a musical challenge with our own poetics on communication with ourselves and the other performers. This strategy would be congruent with the practice of musical improvisation. For suggesting an open improvisation, certainly a non-notational system can be a very valid creative trigger. Any effort in the direction of discretizing the system of symbols used during a performance (e.g. with a notational system) would lead to discretization of the musical response as well.

Updating Karkoschka's typology, nowadays our musical graphs can adopt any form and any dimension. It is remarkable that historically a big percentage of these graphic scores have eminently used paper as the medium, in an inexplicable and non necessary conceptual analogy to the traditional format of the traditional score. We had to wait until the advent of digital interfaces to see musical notations that can be interactive, dynamic, fragmented or non linear. Examples would include the animated scores of Miyashita [15] or the three-dimensional scores of Berghaus [16].

3.5 Instrumentality of Graphic and Inherent Scores

Graphic and inherent scores are non-notational systems manifesting interesting differences in their instrumentality.

The first difference we can observe is that graphic scores exist in physical or virtual forms. They can adopt diverse forms. Even they can be virtual or dynamic. But they are always perceived through our senses and they can be analyzed before we start playing the instrument. On the contrary, inherent scores display themselves through the creative exploration of the constituents of a musical instrument. And this happens only at the moment of performance. Therefore, inherent scores cannot be formally understood as objects. They are a purely mental activity enacted from the interaction of a performer with an instrument.

Interestingly, when an author or a performer declares that a visual composition should be considered as a graphic score, the original graphic object extends itself towards music and in a non physical way. It acquires a new abstract dimension able to enact musical compositions. The graphic object becomes a new mental category, in a similar way to inherent scores. However, conceiving music from a graphic score demands some rational. Performing a graphic score means giving visually perceived content a musical meaning. As we remarked, graphic scores do not substitute traditional scores. They are a kind of mental provocation. But this translation from the visual to the aural needs an interpreter, being it an individual, a collective or even a technological device. To this rational many external elements can be added: in-situ possibilities, sociocultural influences, etc. All this plethora of information makes the realization of a graphic score an unique musical work, intimately connected to its performers.

On the contrary, there is nothing to translate when performing inherent scores. The decision-making process during performance is normally intimately connected with our creative exploration and the resulting sonic reinforcements. Understanding the specific performative potentials of an instrument is an *a posteriori* process. It happens once we have already started playing. The performer of an inherent score does not need a translation from the physical to the aural. Even more, many times the instrument can sound without our interaction [2]. Therefore, the performer's task is closer to the role of controlling or modifying this continuous flow of sound. Indeed, many times, these sonic affordances are not predictable. They can change or evolve during a performance with the conditions of the room, the situation of the performer or the instrument configuration. All this makes very difficult to prepare a concert plan in advance but allows ample space for experimentation. In contrast, for playing graphic scores, performers usually will require some *aprioristic* thinking. Sounds usually are produced after some cognitive process of interpretation from the graphic elements found in the score.

4. THE FORM OF AN INHERENT SCORE

4.1 Hybrid Arts Forms

Another substantial problem is the artistic form of the musical work that an inherent score affords. And how it functions in relation to other visual or physical elements existing in the instrument.

Acoustic instruments are eminently defined from their physical materiality. Electronic music instruments consist

[2] For example a "voltage controlled oscillator" can sound since the moment it is connected to a power supply

of hardware and software. Both the visual and physical part of an instrument can be specifically designed to infer some kind of limitation or, in other words, to shape the musical work. Inherent scores are the combination of existing forms resulting in a kind of hybridization.

Within the ontology of arts, philosophers have studied the identity or nature of the art object in *physical arts* (painting, sculpture, etc) and in the so called *non-physical arts* (mainly music and literature). In the latter, there is no particular "thing" to be considered the artwork itself. The score of a musical sonata or the printed paper of a novel are not considered the art object itself but its representation. Some authors like Croce [17], have suggested that music and literary works are purely mental.

In philosophy, there is a wide-spread consensus [3] that a musical work is a variety of abstract object, a structural type or kind. If like in classical Western music, composers have not created the sounds to be heard in a performance, where is the actual work? Is it in the score? Scores are the mere representation of the musical work. They are the symbols to concatenate during a performance plan. But scores do not sound per definition so they cannot be the musical work. Introducing the wide debate on the identity of the musical work would require a longer extension but since there are artists claiming that their interfaces and instruments are scores, then we should at least introduce the problem of defining the musical object into our discussion.

An interesting approach for deducing the form of inherent scores can be taken from Jerrol Levinson's theory of hybrid art [18]. Levinson notes that not all kind of arts are pure, some are hybrids. Examples like kinetic sculpture or interactive audiovisual installation show us that independently of their complexity, these forms of art show elements of multiple art forms. A kinetic sculpture would be the encounter of sculpture and dance. An audiovisual installation would consist of multiple media: cinema, music, sculpture, etc. On the contrary, we perceive a traditional figurative painting as an instance of its category. For Levinson the hybrid status is primarily a *historical* thing, in a way, as is being a biological hybrid. An art form is hybrid *"only in virtue of its development and origin, in virtue of its emergence out of a field of previously existing artistic activities and concerns, two or more of which it in some sense combines"*. Inherent scores are good candidates to be considered hybrid forms. At this stage of the explanation, we could describe them intuitively as the mixture of a musical work and performative materiality enacted from physical or virtual objects. For us, the most important feature that this theory exhibits is that if an art form is hybrid then it must be understood in terms of the combination of its original components.

Levinson extends his theory of hybrid art to the combination of existing art forms and technological processes. For example, laser sculpture, computer music. computer graphics, video installation, etc would be a result of this combination. Thus, Levinson features clearly the plausibility of new art species creation from the hybridization with technologies. The resulting possibilities for this process are three: juxtaposition (or addition), synthesis (or fusion) and transformation (or alteration). In all these three cases of process, Levinson explains that the hybrid combination of art form A and B to produce C, will change the properties that A or B exemplifies in the joint context. These properties would be relative to what one of the original forms would exemplify on its own, or at least affect the prominence of what each exemplifies after combination.

As we have discussed before, the object embedding an inherent score stays in an identical physical form after its perception as a score too. The consideration that an instrument is a score is produced at a mental level. Thus, this change of perception does not carry physical changes. The same occurs in the case of graphic scores. Graphic scores seem to be a good example of hybrid art form resulting from painting and music. As well in this case, the consideration that "a painting as a score" does not bring changes to the painting form itself. In graphic scores, this hybridization changes the perception of a very known physical object (the painting) transforming it into a hybrid of a physical and a non-physical entity, an object and a musical work. The same would happen to a sculpture if at some moment we manifest understanding it as a score. This example supports the idea that hybrid art forms are essentially new historical forms. Once the artistic practice adopts a hybrid art form and it becomes general, we will not refer to its hybrid origin anymore.

Coming back to the discussion on our inherent scores, we have gained an adequate theoretical framework for interpreting the combination of both the physical and performative materiality of an instrument as a new type of hybrid form. This hybrid art form, the inherent score, would be the fusion of two existing forms (physical materiality and performative materiality) resulting on the synthesis of a new kind. Like in the case of graphic scores, the existence of this new hybrid form is congruent with the perception of performers of being playing a score when they manipulate the instrument. Performers have the perception of playing a specific form. Therefore, this inherent score would be a new abstract object perceived no longer as only the physical instrument. It is perceived as a performative potential of the instrument shaping every moment during the act of playing. Certainly, the result of this fusion alters the perception of the original forms. Instrument's physical materiality gets augmented and extends itself towards a compositional object, acquiring some abstract attribute. In the same way, performative materiality gets some kind of order. It defines itself for a specific use and a particular performer.

At this stage we can now answer some of our preliminary questions we left open. For example, when an instrument is a score, our question was if one part can be separated from the other. Having concluded that an inherent score is a new abstract object synthesized from the fusion of two already existing, we can now assert that this separation is not possible. There is nothing to separate. The instrument

[3] A complete review on the debate of "what a musical work is" cannot be afforded here, but we can divide between two actual tendencies. First Platonist or realist theorists holding that musical works are collections of concrete particulars e.g. Goodman 1968, Kivy 1983, Levinson 1980, Davies 2001; and those anti-realists who deny there are any such thing as musical works e.g. Rudner 1950, Cameron 2008, Stecker 2009.

still exists but a new abstract musical object appears on stage as an attribute in the system. There is no possibility of explaining the inherent score to others without the instrument itself. Additionally, as we have shown before in this paper, this inherent score is eminently a subjective and mental creative attribute that can be interpreted differently by every performer. Separating the score from the instrument if possible, would still require information on the performer involved to be understood. The importance of performers for shaping an inherent score will be more exhaustively analyzed in this paper when studying their physical embodiment (section 5.2).

Another question formulated was if in the case an instrument is considered as a score, then if it is true that a score would be an instrument too. As we have explained before, every object can have specific performative potentials to be perceived as a score. On the contrary, inherent scores are abstract musical objects and they usually do not embed any specialized feature for music creation except the natural sound their physical constituents produce. Therefore, in general scores are not perceived as instruments [4] .

4.2 Inherent Scores: typology of symbols

For the analysis of this hypothesis of hybridization we are suggesting here a typology of symbols that we can find within our instruments. Due to the important role that technology holds at many of our actual music instruments, we will focus our attention on those instruments incorporating some kind of computational system behind their configuration.

The first type of symbols are purely *extrinsic*. These would be mainly representational. They give us information about the computational status of the musical instrument being played. For example, the visual composition of tokens on a table-top interface like a Reactable [5] [19] (Figure 3) is an example of extrinsic symbols. They represent the status of the algorithms an user is running at every moment and how they are interconnected. In this case, the systems affords less on the materiality of these tokens (e.g. form, color, material, texture, etc). If instead of using these original acrylic tokens we use other ones made of wood, the sound mapping or the overall sonic output will not be affected.

The second type of symbols are *intrinsic*. These would be inherent to the affordances of the physical interface. Furthermore, we talk about intrinsic symbols when their physical affordances determine various features of what is aurally enacted. Using the same example, *Reactable*'s round table form affords to the multi-player or collaborative performance. Through this specific intrinsic property, the instrument's materiality definitely shapes performative materiality and finally the way the instrument can be played.

[4] An exceptional example of "a score that sounds" is the project *Tangible Scores*, a technological hybrid allowing a visual score being the controller of a sound synthesis. This will be showcased later in this paper at section 6.1

[5] The Reactable is a round form electronic music instrument. By placing blocks called tangibles on the table, and interfacing with the visual display via the tangibles or fingertips, a virtual modular synthesizer is operated, creating music or sound effects.

Figure 3. A Reactable. Photo by Daniel Williams

We can find both types of symbols within instruments and their combinations are possible. For example, a modified *Reactable* incorporating the same type of representational tokens but featuring recognition of specific physical properties of these tokens. For example, the stretch force applied to rubber made tokens could control the volume of an associated sound synthesis. In this case the extrinsic composition of tokens can be affected by the properties of the intrinsic physical materiality supporting it.

5. COMPOSING INHERENT SCORES

5.1 Affordances and Constraints of an instrument

For composing the inherent score every instrument embeds we will follow the principles proposed by James Mooney [3]: shaping its affordances and constraints.

Affordances, as psychologist J.J.Gibson defined them, are the properties of the relationship between the environment and the agent. In our case, the environment would be the musical instrument as a reference frame. The agent would be a performer. Between agent and environment, infinite relationships can be created, but the potentials of performing some event are less probable than others. Sometimes even impossible. A violin affords playing sounds, but it does not afford traveling.

A remarkable propery of affordances is that they are highly dependent on the reference frame where they are inscribed. For example, cultural contexts or personal backgrounds. What an object affords to a a person can be different to another, even living in the same sociocultural environment [20]. Therefore, affordances could be essentially subjective perceptions influenced by our social constructs. And this condition can reach the maximum of dependency in the case of performative arts. From classic ethnographic studies we know how performances are central to human understanding [21] and post-modernism have drawn attention to the way performances seek to reinforce and communicate our identities in society [22]. Recent research on socio-situated interface design [23] is coherent with the idea of socio-oriented performing frames. These theories suggest that when using an interface, cognitive scaffolds can only exist in the context of a social setting. Certainly,

the capability of performing carries a substantial context and the sociological ecology of acting in front of others.

In parallel we have the notion of constraint. The application of the concepts of affordance and constraint in electronic music instruments has been deeply studied by Thor Magnusson. The author explains [10] how Margaret A. Boden [25] defines constraints as one of the fundamental sources for creativity: *[F]ar from being the antithesis of creativity, constraints on thinking are what make it possible. ...Constraints map out a territory of structural possibilities which can then be explored, and perhaps transformed to give another one.*. This assessment remarks the potential of constraints as a trigger for creative enactments. Constraints would be characters in the performative materiality of an object, being it physical or virtual.

Within the discipline of improvisation with electronics, the instrument's affordances take the important role of shaping the way an interface is played through its different constraints. But more important for our discussion, if they are considered as scores then they would suggest what is played too. As we have seen before in this paper, this inherent score can afford interesting performative enactments.

Mooney [3] supports the idea that a musical instrument can be designed from the perspective of which kind of music relationships it affords. Also, Mooney identifies the possibility of defining the "spectrum of musical affordance" of instruments. This can be achieved by designing the instrument or interface and establishing a range of musical practices the instrument can support. For example, although very complex textures of sounds can be played and controlled with a *Reactable*, it would be rather difficult to play *Mary had a little lamb*. It is then noticeable that the spectrum of affordance is not comparable to difficulty or to complexity of the instrument. Affordances are fully mediated by the embodied relationship between instrument and performer. Even if the performer knows the musical notes of *Mary had a little lamb* it will be impossible to play it correctly on time with a *Reactable*. Therefore, instrument's performative affordance and other types of affordance, like musical affordance, expressiveness affordance, etc cannot necessarily match.

5.2 Physical Embodiment

As we have seen, performing with an electronic music instrument would be the creation of relations and meaningful structures between the inherent score and its enacted audiovisual interpretations. But these are always mediated and shaped by our embodiment. A good instrumentalist is able to create embodied relationships with the instrument, leading to a feeling of intimacy and control. Undoubtedly this will be perceived as a key factor to evaluate the expressiveness of a good performance.

This evidence was used by Mooney [3] to introduce intuitively the "performer" as another shaping parameter of the musical work. If the instrument is the score, then many of the decisions taken, even shaped by the instrument, will be result of performer's acts in freedom. Although Mooney did not develop further this argument, he introduced another variable in the equation: performer's reference frame and performer's embodiment. First, the sociocultural context of the performer, even the actual mental conditions at the moment of approaching a performance will shape its result. For example, the expressiveness of a first musical approach with a *Reactable* depends highly on knowing the elements of computer music in advance (what is a synthesizer, a sequencer, etc). Second, more objective factors connected with the embodiment can conduct the musical outcome. For example, if the electronic instrument depends highly on a physical ability that cannot be achieved by a specific performer i.e. *through some disability*, all the performative affordances designed can appear hidden or invisible.

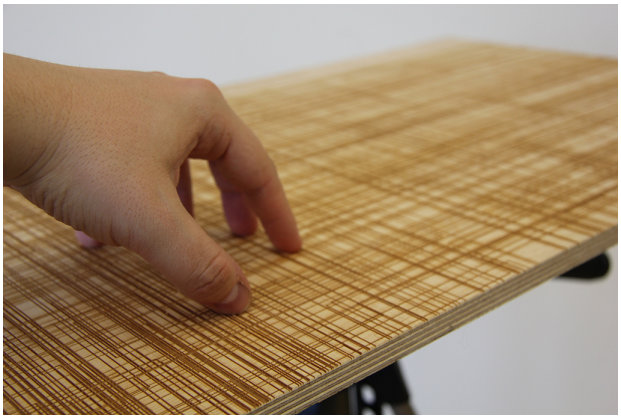

Figure 4. A Tangible Score example.

Thus, we can conclude that design models centered only on defining constraints and affordances must include "the performer" as an influencial parameter. Therefore, we could only speak of inherent scores when connected to a particular performer. In *Rainforest* we would describe Tudor's version, John Cage's realization, etc. Probably all the instances of the same musical work will be very different.

6. TWO EXAMPLES

6.1 Tangible Scores

In 2014, together with Martin Kaltenbrunner, I presented the paper *Tangible Scores: Shaping the Instrument Inherent Score* [1] at the New Interfaces for Musical Expression conference (NIME). *Tangible Scores* are a new paradigm for musical instrument design with a physical configuration inspired by graphic scores (figure 4). This instrument implements practically many of the concepts and ideas of the so called instrument-scores, and it has been reviewed by Maestri and Vlagopoulos a the first TENOR conference in 2015 [2]. Many aspects of the theories explained here were achieved during the practical development of *Tangibles Scores*. Therefore, my intention is now contextualizing the instrument *Tangible Scores* within the framework previously explained.

A Tangible Score [6] is a tactile interface for musical expression that incorporates a score in its physical shape,

[6] Full information on the project and videos can be found online at the following URL: http://interface.ufg.ac.at/tmg/projects/tangible-scores/

surface structure or spatial configuration. Creating an intuitive, modular and expressive instrument for textural music was the primary driving force. Following these criteria, we literally incorporated a musical score onto the surface of the instrument as a way of continuously controlling several parameters of the sound synthesis. Tangible Scores are played with both hands and they can adopt multiple physical forms. Complex and expressive sound textures can be easily played over a variety of timbres, enabling precise control in a natural manner. Using sound as a continuous input signal, both synthesis and control are available simultaneously through direct manipulation on the engraved patterns of the physical score.

Every *tangible score* is conceived from a different graphical score (Figure 5) that still represents a musical idea but it has been also specially designed for providing a diverse palette of acoustic signals when touched. But more important, the tactile scores define and propose specific gestural behaviors due to the different affordances and constraints of the object in front. Sound is generated through a polyphonic concatenative synthesis driven by a real-time analysis and classification of input signal spectra. Each of the scores is loaded with a specific sound corpus that defines its sonic identity. Thus, a *tangible score* provides a implicit visual and haptic feedback in addition to its sonic core functionality, making it intuitive and learnable but as well suitable as an interface for musical improvisation and sonic exploration.

At the moment of designing our paradigm, we were quite influenced by Lucier's quote: *"there were no scores to follow; the scores were inherent in the circuitry"*. We accepted it. It matched our instrumentalist intuition as long time electroacoustic music improvisers. Additionally, it was possible for us to contextualize the instrument within the field of tangible interfaces and human computer interaction (where we have been working for a long time too).

We first understood that, not only musical instruments, but any physical or virtual object loaded with performative materiality affords being played. And second, that any physical or virtual object has the potential of instigate actions so it can potentially afford being interpreted as a score. Then, our direction had to follow the direction of trying to shape those potentials. By intentionally limiting or constraining the infinite possible interpretations of a specific object within its reference frame, we are shaping the inherent score it contains. And we do it in a deliberate act of musical composition.

In order to shape those potentials, we decided conducting or inspiring particular gestures by incorporating contrasting visual and tangible patterns on the surface of the instrument. For the first series of tangible scores, we first composed a set of generative patterns that we later engraved on wooden surfaces. For finding the adequate patterns, not only an attractive a visual or gestural idea was searched. We had to negotiate its form with the adequate sonic result when touched. This relationship mediates radically the sound synthesis of the instrument.

For evaluating the instrument, apart from performing with them at different concerts, we offered and showcased some

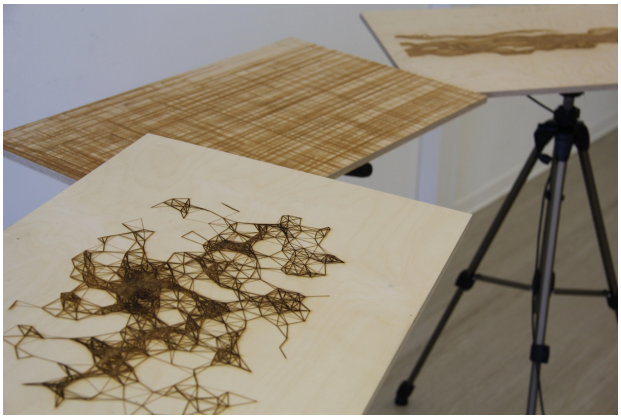

Figure 5. Different designs for Tangible Scores

tangible scores to professional performers and composers (mainly in Linz, Austria). Additionally, we showcased the instrument as a sound installation during two mass audience festivals (*Sonar* and *Ars Electronica* 2014) were thousands of visitors could play it. From the analysis of these experiences, for us was clearly evaluated and proved that both physical gestures and sound gestures were mainly inspired by the visual and tangible patterns: their direction, size, intention, etc.

One important decision taken in this first series of tangible scores was that our design should rely only on intrinsic elements or symbols. Although a tangible scores is fully a digital instrument, we decided not displaying representational information on the instrument. Due to this decision, the computational status is hidden and the sonic mapping depends intimately on the embodied relationship between player and instrument. Due to this unification of score and instrument, the instrument provides the representation and control within a single musical artifact, fully concentrating the performer's attention on the interaction with the musical composition in a physical way.

6.2 Choreographic Objects

Within the field of contemporary dance, the choreographer William Forsythe created the concept of *choreographic objects* [9]. Physical objects, of various types, are considered choreographic when they are able to enact particular behaviors and movements via ballet dancers. These objects reveal a choreography that is inherent to their physical materiality.

This idea comes from Forsythe's intuition on perceiving every object as a source of enactments. As we described earlier in this paper, for Forsythe a score *"represents the potential of perceptual phenomena to instigate action, the result of which can be perceived by a sense of a different order"*. As well *"a score is by nature open to a full palette of phenomenological instigations because it acknowledges the body as wholly designed to persistently read every signal from its environment"*.

An example of the use of choreographic objects is the work *Nowhere and Everywhere at the Same Time, No.2* (Figure 6) created for a solo dancer and 400 pendulums suspended from automatic grids. When activated they ini-

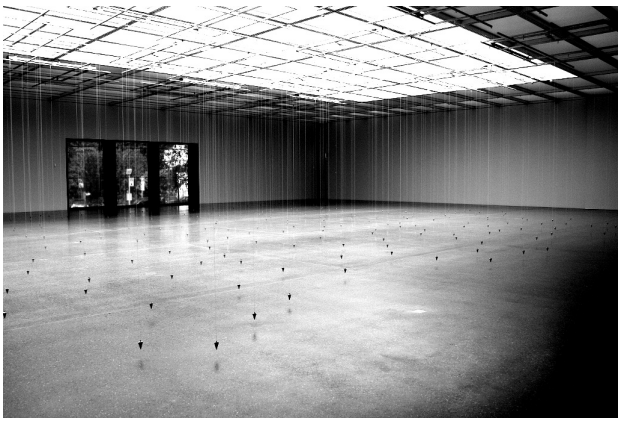

Figure 6. The *choreographic object* "Nowhere and Everywhere at the Same Time, No.2" by W. Forsythe.

tiate a sweeping 15 part counterpoint of tempi, spacial juxtaposition and gradients of centrifugal force which offers a constantly morphing labyrinth of significant complexity. This setup privileges the unconscious choreographic competence induced by this special choreographic situation. For Erin Manning [24], choreographic objects are *"an affordance that provokes a singular taking-form: the conjunctive force for the activity of relation"*.

In a similar way to tangible scores, choreographic objects have been traditionally considered a constraint. Forsythe develops an active stage, a composed reference frame suitable for performative enactments. If stage scenographies are usually representational, choreographic objects do not represent anything else than a potential to move.

In the case of the work *Nowhere and Everywhere at the Same Time, No.2*, Forsythe gives a fundamental form to the space. Through this morphophoric affordance, the danceable space and all the possible movements are discretized by the inertial materiality of the pendulums. In this work, the dancing score can be found in the performative affordance of a myriad pendulums defining a composed space around them.

Undoubtedly, choreographic objects have the ability of inducting creative movements and gestures in its performers. Especially in large spaces and multi-user contexts, we are convinced that the notion of choreographic objects can be useful to inspire the creation of novel interpretation of scores as well as new phenomenological enactments.

7. CONCLUSIONS

Along this paper, we have proved the validity of using the concept of inherent scores for describing the mediated relationship between performer, score and instruments. Especially in electronic music instruments. We have explained how the theory of performative materiality serves well to explain the fact that any object can be understood as a score. We have defined the notational scheme of inherent scores as non-notational and we have described the remarkable differences in instrumentality between inherent and graphic scores. We have elucidated the nature of inherent scores particularizing them as a hybrid forms resulting from the fusion of performative and physical materiality. Finally, we have proposed a framework for composing or shaping musical works, demonstrating its possibilities with two examples: tangible scores and choreographic objects.

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