The Electric Guitar: An Augmented Instrument and a Tool for Musical Composition

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Background in organology. The electrification of the guitar is probably the most important modification the instrument has undergone in the twentieth century (Séguret, 1997). It gave birth to a hybrid instrument integrating an acoustic sound source, electromagnetic pickups, amplification, as well as analog and digital signal processing. The electric guitar has been a precursor of technological innovation in music (Garfoot, 2006). Nowadays, it can be considered as an augmented instrument, defined as a network of sound production and processing units, spatially extended and configurable by the player according to the desired sonic results.

Background in composition. The electric guitar is a key instrument of the musical and cultural evolutions of the past sixty years. Its vigorous development was initially fuelled by its use in popular music. Subsequently, the electric guitar's use has extended to other repertoires, making its way into the contemporary music instrumentarium and as a tool of sonic avant-garde (Bennet & Dawe, 2001). The early phase of the electric guitar's integration to the contemporary orchestra was marked by the stylistic heritage of rock and jazz genres. Today, in the context of contemporary creation, the electric guitar has gained its own sonic and aesthetic signature, fully integrating a network as a module, a source for sound processing and an interface converging with digital programming and composing tools for live electronic such as Max/MSP (Quintans, 2010).

Aims. Our goal is to study the distinctive features of the electric guitar as an augmented and modular instrument, in relation to its uses as a tool for contemporary music composition.

Main contribution. The electric guitar's hybrid lutherie spans from acoustic to electromechanical and digital domains, enabling extended sonic possibilities. By its timbral versatility and its modular, user-configurable nature, the electric guitar challenges the notions of instrument, composition and instrumental praxis in a resolutely contemporary manner. Our study is conducive to the articulation of the complex network that the electric guitar represents today. In this context, compositional work integrates the totality of the instrumental environment, its modular constituents and signal networks. An example of a composition process based on the emergent properties of the network-instrument is discussed, showing how extended guitar playing techniques, analog and digital signal processing, and multi-temporal processes give rise to a variety of sound organisation strategies.

Implications. By its augmented and modular aspects, the electric guitar appears as an emblematic example of an instrument that is intimately connected to the present-day live electronic music praxes, thus presenting a significant case study for numerous aspects of contemporary (mixed) music.

Keywords: Electric guitar, Organology, Composition, Augmented Instrument
Introduction

Our work seeks to initiate a reflection on the particularity of the electric guitar as a modular and augmented instrument, as well as a tool for composition. To begin with, we approach this specificity from an organologic point of view, by studying the nature of the electric guitar’s technological hybridations, its augmented characteristics and its modular properties. Consequently, we study the electric guitar as a tool for composition by developing a prospective musicological approach in interaction with experimental musical creation. With this teamwork, we seek to develop an interdisciplinary and transversal research perspective for a musicology of the electric guitar.

The electric guitar, a glocal instrument (Robertson, 1995), is a key player in the musical and cultural evolutions of the past fifty years. Since its dazzling initial development fuelled by the popular music phenomenon, it has gained wide acceptance in many music styles and cultures, including the contemporary orchestra. The electric guitar has received little attention from scholars working in a musicological and interdisciplinary perspective, the main body of existing research on the subject focusing more on social sciences or organology. Yet, by its modular and augmented nature as well as its sonic versatility, the electric guitar questions the notions of instrument, composition, and that of a musical tool for live and studio contexts in a resolutely contemporary manner. Its hybrid lutherie is a source of expanded sonic and musical possibilities, as well as composition strategies based on the emergent properties of a network of sound processing modules.

The electric guitar, an augmented instrument

One should question the specificity of the electric guitar compared to other musical instruments. In order to utilize the full sonic range of the instrument, the musician must connect the guitar to an amplifier, de facto composing the timbre with an association of several modules and control zones such as the volume and tone potentiometers of the guitar itself and the various controls of the amplifier. Thus the electric guitar appears to possess a modular property. Organologic research into the birth and the development of the electric guitar shows that modularity is intrinsic to its conception. This property, in coherency with a contemporary view of modular object networks, bears a potential for future developments of the instrument in connection with digital technologies, especially for its “augmentability”.

An organology of the electric guitar: continuation and rupture

The guitar is one of the rare key instruments in present-day western music to benefit from a high degree of popularity on all continents and to have known deep organological changes during the past four centuries [9]. All parts of the instrument
have evolved over time to meet the expectations of guitarist-composers in very
different contexts and eras: musicians at the court of King Louis XIV, street
entertainers, recording studio musicians, rockers, virtuoso soloists, amateurs or
professionals. Through their craft, the guitar’s repertoire and playing techniques have
evolved and the instrument has gained the enthusiasm of audiences looking for new
sounds and emotions [12]. The guitar has appealed to musicians because of its
reasonable price, small dimensions and a moderate learning curve, all of which make
it user-friendly.

The electric guitar, as its name indicates, is above all a guitar: it has inherited the
knowledge and know-how acquired over several centuries. Nowadays, the majority of
electric guitars available are based on the crafting techniques applied on acoustic
guitars [20]: metallic strings, a glued or screwed neck, strengthened with a truss rod,
tone woods (maple or mahogany necks with a maple, rosewood or ebony
fingerboard), metallic frets, and a chromatic scale. However, the introduction of the
solid body electric guitar at the end of the 1940s marked a decisive rupture in guitar
lutherie by shifting the focus to electric amplification technologies instead of the
traditional acoustic ones. Prior to that, various strategies had been explored to
optimise the guitar’s volume and tone by acoustic means. For instance, the Torres
guitar (ca.1850) innovated with a soundboard incorporating a “fan” bracing, a longer
vibrating string length, higher string tension and a larger body, all of which offered a
louder sound with more dynamics and a different spectral balance than its
predecessors. During the same period, C. F. Martin experimented the “X-bracing”
which was more efficient on guitars equipped with metallic strings. Subsequently, the
quest for louder guitars led to instruments with oversized bodies jeopardising their
playability, such as certain models of State and Paramount guitars of the 1930s [11].
The solidbody guitar marks a new era where the acoustic instrument is “expanded”
with electric technologies of amplification and sound shaping. The initial sound
source (the acoustic guitar) becomes a part of an electro-acoustic chain. The
musician’s attention is directed to the ensemble of modules comprising the chain,
which may be relatively simple from a conceptual perspective but complex by its high
potential for sound creation. This electro-acoustic chain consists of the player and
his/her instrument (the electric guitar), various analog and digital audio processing
modules, and an amplifier (see Figure 1).

The electric guitar is equipped with one or more electro-magnetic pickups. These
sensors are made of magnets wrapped in a coil of fine enamelled copper wire. The
vibration of a metallic string perturbs the magnetic field, feeding a low voltage
alternating current through the coil of wire [6]. Thus, the induced current may be
modified by the electronic components of additional analog/digital audio processing
modules. At the end of the chain, the amplifier increases the current’s amplitude and
provides the power needed to move the loudspeaker cone(s). The perceived sound is
essentially radiated by loudspeakers and not by the “acoustic” instrument. The
elctrification of the guitar renewed the way of thinking and creating sounds, enabling
timbres previously impossible to obtain and increasing its sound volume. It instigated
the development of novel playing techniques like finger tapping (e.g. Eruption by Van Halen) or the use of the whammy bar (e.g. F.B.I. by The Shadows, Satch Boogie by Joe Satriani). It also originated the “feedback” phenomenon which provides remote control of the guitar’s vibrating behaviour: the sound pressure emitted by the loudspeaker can induce a sympathetic resonance in the instrument’s body, neck and strings, producing a characteristic “feedback” sound. This acoustic feedback is a valued artistic tool providing strong haptic sensations to the player and pushing the limits of acoustic lutherie towards an infinitely sustained note. Guitarists such as Carlos Santana or Jimi Hendrix were remarkable for their mastery of this effect.

Regarding its tight connection to the technological evolutions of the twentieth century, the electric guitar appears as a pioneer instrument. Since its conception, it has been the object of an intense organologic experimentation in the acoustic, electric and digital domains, shared by a vast community of guitarists, instrument makers and electronic engineers. The instrument’s development has been stimulated by the value attributed to sonic individuality within the musical styles commonly associated to the electric guitar.

Rock and jazz playing is characterised by the absence of a written repertoire which sets a normative model for timbre and playing techniques. Artists with an original and clearly distinguishable sound (and style) are often valued. The birth of a sonic individuality is the result of a bricolage (Lévi-Strauss, 1969) within a set of elements consisting of the musician’s body as well as his/her technological environment: playing techniques, guitar types, amplification, signal processing modules... In order
to illustrate this process, one may refer to the collaboration between the guitarist Eddie Van Halen and the inventor Floyd Rose, which enabled the development of a floating tremolo system unravelling new possibilities for glissandi and vibrato techniques unheard of before. These skills became the trademark of Van Halen’s playing style and they have considerably influenced the development of rock solo electric guitar playing (Floyd Rose).

The electric guitar’s evolution has been kept in motion by an interplay of mutual influences between an industry producing sonic tools and a community of guitar players validating (or not) these tools according to their aesthetic and practical criteria. The economic weight of the musicians’ choices influences in turn the industry’s future product lines. A great diversity of means and technologies has been mobilised in this experimental process, and the electric guitar appears to have a high degree of technological permeability. The dynamics of this process has given birth to a vast number of sonic tools, some of which are widely used to the present date, others having been discarded and forgotten. The research began in the 60’s in the analog domain, with a variety of signal processing methods or “effects” (temporal effects, filtering, overdrive/distortion), and went on to the analog guitar synthesizer in 1977 (Roland GR-500). In 1984 the electric guitar was connected to the digital domain with the conversion of some of the audio signal’s aspects into MIDI data (MIDI guitar synthesizer, e.g., the Roland GR-700), in parallel to the generalisation of digital audio processing tools or digital “multieffects”. Guitar-to-computer interfaces appeared alongside the development of personal computers, expanding the instrument into a dematerialised dimension offering new perspectives with digital audio workstations, audio programming environments, as well as amplifier and effect modelling.

The electric guitar has been progressively adopted by a multitude of cultures, acquiring a global dimension with local adaptations. Being transformed with new technologies, adapting to the market, enabling a wide variety of sounds in different aesthetic contexts in many parts of the globe; the electric guitar has become multiple. Its morphology, soundscape and musical role have been renewed in all of the local contexts in which it has emerged. The interaction between a global idea of the electric guitar and the way it has been reinvented locally has given rise to the concept of glocal guitars (Bennet & Dawe, 2001).

A modular instrument

Currently, the electric guitar appears as a user-configurable, hybrid and modular instrument. It is comprised of acoustic, electromechanical and digital parts, all of which are integrated into an instrumental environment. These parts form distinct modules for sound production, processing, and broadcasting, expanded in a physical space and in a virtual (digital) domain. The instrumental environment offers a high degree of configurability for the musician: tone woods, pick-ups, effects, amplifiers, loudspeakers etc. All these elements can be chosen separately and therefore allow for
a thorough customization of the instrument. As a result, a wide variety of diverse objects coexist under the common name “the electric guitar”. One might think of the gap between a simple traditional guitar-amplifier coupling and the stadium-sized instrument of the guitarist “the Edge” (of the rock band U2) with its multiple control, processing and broadcasting modules.

Computer music is essential to the complex network that the electric guitar constitutes at the present time, particularly for the following reasons.

1) It alters the temporal linearity of the basic electro-acoustic signal chain, giving more freedom to the guitar in its role as a non real-time sound source (for example, with the augmenting possibilities of computer calculus and micro-time sound processing, the linear process of recording/playback can be produced fast enough to appear to the human ear as “real-time”. Thus, one can play a note and apparently simultaneously produce a sonic mass generated from fragments of the initial note via granular synthesis techniques (Roads, 2004)).

2) It cuts, again due to the micro-temporal possibilities of live electronics, the temporal unity of the signal chain, enabling the simultaneous generation of numerous sound layers ranging from the meso-timescale to the “microtine”.

A current trend in digital audio environments favours an object-oriented paradigm, as illustrated by Max/MSP and Pure Data softwares. These software environments resemble analog synthesiser design in their conception, comprised of sound processing modules and signal routing paths, similar to the electric guitar’s instrumental environment. The electric guitar’s modularity is convergent with the digital control and audio software environments, as they are themselves modular and “networkable”.

An augmented instrument

Instrument augmentation can be defined as a process in which a given instrument’s sonic possibilities are expanded by technological means, without jeopardizing the initial instrument’s playing, its sonic and expressive possibilities as well as its ergonomics (Miranda & Wanderley, 2006). In this perspective, the electric guitar can be seen as an augmented acoustic guitar where the electromechanical and digital lutheries are over-layered to the acoustic one. The electric guitar’s various sound shaping and amplification modules form a set of augmentations concatenated to the initial acoustic sound source. Thus the electric guitar presents a long history of instrument augmentation starting with the analog technology and expanding to the digital domain with hardware effects units and, more recently, software modules and programming environments. The electric guitar as an augmented instrument displays a wide range of sonic possibilities such as sustained sounds (feedback, compression and overdrive/distortion, electromagnetic sustainers like the “e-bow”), timbral alterations (filtering, chorus/flanger effects), and time-based effects and processes (delays, echoes, non real-time loops).
One direct consequence of instrument augmentation beyond the acoustic domain is the need for multiple interfaces and the necessity for control messages. In order to include the augmentations in the elaboration of a musical discourse it is necessary to be able to interact with them in real-time. This imperative for control introduces a flow of information into the instrumental environment, which coexists with the energetic causality of the gesture-sound relationship in the acoustic domain (Cadoz, 1999). In the case of the electric guitar, the control level is manifested physically by gesture interfaces designed to coexist with the acoustic instrument such as effect pedals, knobs and switches, gesture sensors (e.g., Source Audio "Hot Hands" effects), or even oral interfaces ("Talk Box"). Another strategy is to extract control data from the guitar’s sound signal itself, as in the case on the auto-adaptive audio effects such as the compressor or the auto-filter (Verfaille, 2003).

The issue of control is central to instrument augmentation. The increase of an instrument’s sonic possibilities and control interfaces may complexify the instrumental environment beyond the musician’s capacities of real-time control. In the case of the electric guitar, this has been avoided by a great simplicity of the augmented level’s interfaces and their positioning in the periphery of the instrumental gestures (feet, hands outside of the traditional playing technique’s gestures). In return, this approach opens few possibilities for a truly dynamic interaction with the augmentations leading to the sonic stasis common in electric guitar playing: the player chooses a specific sound for a musical part with “on/off” effect switches, playing with the same timbre until the next “monolithic” modification. The instrument offers a vast range of sonic possibilities, but little means for real-time control. Presently, various academic and industrial projects explore strategies for extending the musician’s control over the augmented part of his/her instrument (Lähdeoja, 2008/1, MIT Hyperinstruments). One example of such research is the augmented guitar developed at the CICM MSH Paris-Nord by Otso Lähdeoja. The goal of the project is to integrate the initial instrument and the augmentations into a coherent instrumental environment by taking the musician’s corporeality and his/her haptic experience of the “augmented” playing as a starting point (Lähdeoja, 2008/2). The sonic extensions explored within this project include electric guitar body percussions (“electric golpe”), synthesised infinite sustain, audio effect control by the musician’s ancillary movements or by certain sonic aspects of the playing (Wanderley & Depalle, 2001).

Another research perspective is provided by the exploration of the novel musical possibilities of the electric guitar’s current modular working environment. The guitar with its augmentations can be viewed as a network-instrument providing a wide variety of tools for sound creation and processing, instigating compositional strategies based on the affordances and the constraints of the network and its constituent modules. In this case, composition and sound creation form an emergent phenomenon stemming from the modular instrumental environment. The second part of the present article discusses this approach with a particular focus on the composition process of Santiago Quintan’s piece 5 fragments pour guitare électrique.
The electric guitar offers an interesting case study in a context of generalisation of live electronics and acoustic-electronic-digital hybrids in music currently taking place. With more than seventy years of development and a worldwide user community, the electric guitar appears as a solidly anchored augmented (and augmentable) instrument. Its hybrid instrumental praxis is widely integrated by guitarists who routinely work with the acoustic, electric and digital parts of their instrument. Many aspects of live electronic music are confronted to a tangible experimentation in “real-life” concert and studio contexts. These aspects are (i) simultaneous use of different temporalities, (ii) mixing of acoustic and processed sounds, and (iii) hybrid instruments which form environments comprised of software and hardware. The results do not point towards a common direction but rather towards a multitude of prospective propositions, which are of great interest to the contemporary musical creation at large, reaching beyond the electric guitar itself.

The electric guitar as a tool for composition

Traditionally used as a popular music instrument, the electric guitar has nowadays merged into the contemporary orchestra and is finding its place as a tool in the composer’s working environment. In order to stimulate a musicology of the electric guitar, one should integrate organology, sound engineering, computer music studies, as well as the study of the poiesis and praxis of musicians and composers into a cross-disciplinary approach. The work of our team is directed towards the so-called “emerging” or “experimental” creation, meaning music produced outside the standard industry models, often in interaction with theoretical, technical and technological research. A close study of the musical praxes related to the electric guitar shows that part of its potential remains unexplored in contemporary composition. The untapped aspects of the electric guitar include (i) its use as an acoustic sound source, (ii) rock (and related styles) playing and studio techniques, (iii) signal processing units as sources for compositional and morphologic processes, and (iv) the use of the electric guitar’s signal network as a source of temporal, organizational and timbral complexity.

The electric guitar used as an acoustic sound source activates a second signal network, parallel to the electric one, creating a hybrid tone: acoustic, but with an unreal character (attacks and metallic string sounds are exaggerated). The combination of the acoustic tone with the signal of the electromagnetic pickups opens up a new soundscape with extended sonic and dynamic possibilities and nuances. From the eighties onwards, rock musicians have developed new playing techniques for the electric guitar such as “sweep picking”, “tapping”, and “whammy-bar” effects. Their use remains generally limited to heavy metal styles, but they may prove of interest for contemporary composition as well. Signal processing tools hold potential for the instigation of compositional processes and sonic morphologies. The integration of programming environments such as Max/MSP as an augmented part of
The electric guitar enables novel strategies for composition, in connection with the techniques and aesthetics of electro-acoustic music.

The electric guitar in contemporary composition

Parallel to its development in the popular music domain, the electric guitar’s use has progressively been extended to other repertoires and aesthetics, becoming a tool for contemporary composition and an instrument of sonic avant-garde (Bennet & Dawe, 2001). Strongly present in today’s experimental creation related to improvisational approaches, the electric guitar has integrated the written music repertoire in Europe through the work of composers such as Georges Aperghis, Tristan Murail, Hugues Dufourt, the L’itinéraire ensemble with the guitarist Claude Pavy, or more recently the Belgian Ictus ensemble with Tom Pauwels. This integration is marked by a stylistical and sonic heritage from jazz and rock (e.g. Vampyr !, 1984, T. Murail, Index of metals, 2003, or Trash TV Trance, 2002, F. Romitelli).

The composition Seven (2007) by Peter Eötvös is an example of a thorough integration of the electric guitar in an orchestra of forty seven musicians divided into seven groups. The guitar is grouped with a synthesiser, a harp and percussions. It is used with a broad range of its augmentations: volume and delay pedals, an octaver, distortion, tremolo arm and slide. The electric guitar’s musical usage is characterised by the following.

1) The creation of sonic objects (resembling the aesthetics of Pierre Schaeffer’s “Objets sonores”: “noisy” dynamic sounds, sonic masses, non-pitched electro-acoustic sounds), often combined with the percussions and the harp.
2) The generation of long glissandi, (more than one octave per string), descending from the highest pitches of the instrument and imitating the string section. In Eötvös’ work, the electric guitar has mainly an orchestral function, which helps shape the sound of the orchestral ensemble. Other composers like Hugues Dufourt (Saturne, 1979) or Tristan Murail (Contes cruels, 2007) have also successfully integrated the electric guitar to their orchestrational style.

One cannot refer to the electric guitar without calling to mind Steve Reich and his composition Electric Counterpoint which has widely influenced the North-American music world. Building on a collaboration with the guitarist Pat Metheny, Reich made fecund use of jazz playing techniques and articulations that bring to life the structure of the composition. However, Reich uses the guitar as a mono-timbral instrument, choosing not to work with the large variety of sonic possibilities allowed by the electric guitar’s sound processing modules (with the exception of reverb).

New conceptual approaches: the electric guitar as an object within a network of objects

Beyond the integration of the electric guitar to the orchestra and the appropriation/transformation of rock/jazz-related playing styles, other approaches can be identified today in the live electronic and mixed music praxes as well as in the improvised music scene. These approaches testify to musical, technological and
instrumental thought, based on modules and networks both material and virtual. The present-day electric guitar can be seen as an instrument-object within a network including the software environments, they themselves structured as object networks.

Our use of the concepts of network and object is influenced by the writings of Horacio Vaggione, who has developed an object-based compositional approach. This influence comes from a trend in computer music that sees a similarity between computing paradigms (particularly object-based programming) and composition, thus suggesting the idea of the digital musical object (Vaggione, 1991, 1995). The composer/researcher sees this "object" as an active entity with a specific behaviour: an entity that processes information and performs operations that have been previously defined. Such object has a certain status, can perform multiple variable tasks and processes, and thus behave in a particular manner. It can contain a network within, be a part of a larger network or connect to other objects. In the domain of computing, objects are virtual representations that process and shape data flows. The function of such an object in musical composition is sound creation or transformation.

Based on this conceptual system, the electric guitar and its augmentations (pedals, computers, etc.) become an object that can be composed, designed (objet composable). Being an assembly of different modules, the guitar becomes an open network: a hybrid work environment that can be modified and transformed for each particular project (Carvalho, 2010, Vaggione, 1998). This conceptual framework allows us to see the guitar as a system that can be composed and manipulated from the outside, with a composer's view, or from the inside, from the player's standpoint.

Composing can be viewed as organizing and building a coherent whole. Thinking in terms of network, composing can mean "generating particular events and articulating them in groups of increasing size without altering their original singularity" (Vaggione, 1998). Singularity or identity can come from a musical gesture, a sound object, musical notation or a looping process. Articulating events in groups of increasing size means composing an overall environment of tools where a particular event can be developed, processed, or generate other events. We may then think of the network as a complex environment where a musical object emanating from the guitar is transformed. As it grows in complexity, the network model becomes, what we could describe as, a place-to-be-composed: an environment where sound can emerge, if we think of it as a dynamic ecosystem (Di Scipio, 2008).

In order to illustrate the prospective goals of creative-oriented musicology, we move on to discuss an example of composition based on this concept: a work-in-progress developed at CICM/Maison de Sciences de l'Homme Paris Nord. What follows is an account of a musicologist describing his work as a composer.

**An example of the electric guitar as a musical composition tool**

We would like to discuss certain aspects of the piece *5 Fragments pour Guitare Electrique*, a work-in-progress by composer/guitarist Santiago Quintans'.

This piece is built in five movements (fragments), each exploring a different possibility of the electric guitar's network: each fragment suggests a new way of
combining a musical gesture with analog and digital signal processing.
- Fragment #1 consists of a sonic process evolving from a tonal, analog sounding static chord to chaotic, digital granular activity.
- Fragment #2 explores the possibilities of the hammer-on/pull-off (i.e. legato) technique and the use of digital processing to create odd-temperaments; this movement depends heavily on improvisation for the development of basic musical cells.
- Fragment #3 explores the limits of the guitar neck to construct large interval chords, which, altered with a ring modulation effect, serve to create unusual, percussive-type sounds.
- Fragment #4 explores a prepared guitar and is process-oriented: different looping processes define different physical objects to “prepare” the guitar with (clips, slides, etc).
- Fragment #5 is a reversed mirror of fragment #1 where the processes (timbre and harmonic) are played and generated backwards.

Quintans thinks of the guitar network as a large system of linked "objects", an object being an entity (a machine, a system, a behaviour) that produces or modifies a sonic flow. This system constitutes a compositional environment specifically designed by the composer for a particular project. In our example, the different "objects" of the network, are:

a) Musical notation: this part involves writing music away from the instrument and devising large-scale compositional forms and strategies.

b) Musical gestures, or the physical relationship between the player and the guitar. The encounter of hand gestures, with the “geography” of the guitar neck (distribution of notes) and its topography (shape, hardness, feel of strings) suggests new and different solutions for musical materials previously devised in pre-compositional work.

c) Improvisation techniques: the performer generates and develops musical forms in real-time. In Quintans’ case, improvising is a way of developing previously written processes and forms. In other words, written composition, away from the instrument, provides overall form and strategy, setting a framework for the improvisation of the actual musical discourse in real-time.

d) Pedals. Mainly two functions: coloring or altering the timbre (as with distortion), and creating processes (as with looping).

e) Real-time sound processing with Max/MSP software: this computer program, which is also in itself a composer-generated network, can provide time polyphony (microsounds, audio buffers and playback), as well as overall enhancement of the sonic complexity of the system.

Figure 2. presents a technical description of the network:
Figure 2: Signal network of 5 *Fragments pour guitare électrique*. Incoming signal (in) is split with a Electro-harmonix POG pedal (an octave pedal acting as a splitter.) Two volume pedals control the two signal flows going to amplifier and computer respectively. The arrows show the different outgoing signal flows (continuous line: guitar signal; non-continuous line: looped sound mass; dotted line: computer processed sound).

Creative possibilities of the network

The network of 5 *fragments pour guitare électrique* presented in figure 2 suggests several parallel flow patterns (signal, outcoming looped sound, acoustic sound of the electric guitar, Max/MSP), constituting a modular network as previously described. The following are examples of the different creative possibilities that this network offers:

1) Creating sound masses
- The use of the POG pedal (allowing for higher and lower octave transpositions) in combination with the Line 6 Loop pedal (for real-time continued recording of sounds), enables the creation of spectral harmonies/sound masses. The octave pedal expands the guitar's physical register (adding two extra octaves) and the looper records the different chords sequentially in order to generate complex and thick harmonic masses (ex. fragment #1, figure 3).
- Creating spatially-dynamic granular textures can be achieved with the Max/MSP software. In this example, the composer has built several patches where the guitar signal is cut up into sound grains of 0 to 100ms in size. Grain size, density and grain position in the stereo spectrum are defined by the intensity and speed of the attacks of the guitar.
The electric guitar

Figure 3. Fragment #1 score. The overall network status is in the orange box: blue indicates digital flow and the Max/MSP preset; green indicates the Line 6 Looper status; red indicates the POG's status. Musical notation shows chord-construction in four steps: 1) a first chord in the actual guitar range, 2) low E string lowered by an octave (with the POG), 3) deactivation of the POG pedal and chord in normal range, 4) activation of the POG and play chord a 15th higher than written. The arrows following the indication of "spectral loop" show that these chords will be looped to create a sonic texture.

2) Creating new musical syntaxes and vocabularies
- The interaction between the guitar as a tool and the musical gesture of the performer generates musical materials. This approach consists of finding a relationship between written musical materials (usually a pitch set) and the open strings of the guitar. By studying the interaction between the guitar and the motion of the hand we can come up with new, unexpected ideas. In the case of Fragment #2, a group of previously-written pitch sets (presented in figure 4) were developed into fully-grown musical ideas by studying a) how the notes of these sets could be performed mixing open and stopped strings, and b) which was the most efficient, elegant movement of the left hand to perform them.

Figure 4. Fragment #2. Written interval plan (ninths and sevenths). The size of intervals suggests a particular left-hand position.

One of the possible results emerging from the pre-defined pitch set is the motif presented in figure 5, the main theme of Fragment #2 (open strings and fingered notes are written differently). The movement required to perform a certain, pre-written pitch set implies a particular gesture of the left hand, especially if large intervals are
involved. Therefore, at a preliminary stage, pitch sets define hand motion. Later, when gestures become more fluid, different motions evolve into rhythms, thus suggesting a complete musical idea or a *motif*.

![Figure 5](image-url)

**Figure 5.** Fragment #2. Left hand hammer-ons and pull-offs serve to combine fingered pitch sets and open strings. The resulting phrase evokes a new kind of vocabulary based on a particular combination of rhythm, gesture and timbre.

The overall sonic complexity of these new, awkward musical phrases is increased with digital processing: a Max/MSP patch creating doppler effects generates an “odd-temperament” type of sonority, where notes are bent sharp or flat in quarter tones or in continuous glissandi.

3) Extended guitar techniques as sources of musical materials
- Pointillist textures generated by tapping\(^4\) (ex. Fragment #5, figure 6).
- Tapping as a means of adding harmonic extensions to chords. Notes may be added to the chords formed by the left hand’s fingers by right hand tapping gestures.

![Figure 6](image-url)

**Figure 6.** Fragment #5. Chords cut-up into intervals (each stave indicating a hand) are performed with improvised tapped gestures, creating a pointillist harmonic sound. The circled pattern indicates a possible performance sequence.

4) Noise-oriented sonorities, non-harmonic sounds
- Prepared guitar (i.e. miscellaneous physical objects added on the guitar in order to alter its sound), sonorities resembling “*musique concrète*” (ex. Fragment #4, figure 7).

5) Theatrical aspect, movement and gesture as sources of form
- Stepping on pedals: clicking sound and gesture become a part of the composition.
- Visualizing different processes: Fragment #4, presented in figure 7, is a movement for prepared guitar. It is built around a successive accumulation of noises created by different physical objects attacking the guitar. A paper clip between strings, or hitting
the guitar with a piece of metal are significant gestures resulting in visual effects that accompany the sonic structure of the piece.

**Figure 7.** Fragment #4 original score. From left to right, different processes of accumulation: 1) non-processed signal, attack with a paper clipping, 2) start looping, 3) bigger clipping, play with slide in different octaves, 4) improvisation gets denser 5) gesture called “Eötvös monster slides” (inspired by Peter Eötvös' piece *Seven*), lower octave, delay, volume pedal. Each step is recorded in the looping pedal, which progressively creates a noisy, chaotic sound mass.

**An environment of emerging possibilities**

Regarding the organization of materials, it appears that the network is a complex source of organization since each one of its components supplies materials and form. Composing in this environment means studying the emerging possibilities of the network and their arrangement into an aesthetically-coherent sonic flow.

In this piece, the composer tries to stress:

- **The formal aspect of certain processes inside the network:** the process of creating sonic textures built out of spectral harmonies in Fragment #1, accumulation (stacking) procedures in Fragment #4.
- **The possibility of dissociating the different sonorities of the network:** this suggests a sonic environment particular to this specific network, one based on sonic counterpoint and spatial perspective. For example, the difference between the static texture emerging from the looper, and the chaotic granular texture from the computer creates a rather expressive form of counterpoint. (Fragments #1, #3, #5)
The possibility of associating different sonorities emerging from the network. Working with sonic materials of similar nature, it is possible to stack them as multiple layers of a new synthetic sound. And example of this is mixing the following: a new sound where the attack is provided by the electric guitar’s acoustic sound, the "body" of the sound provided by the computer, digitally, and the decay of the sound, provided by the amplifier and the room microphones (Fragment #2).

New approaches for improvisation. Written constraints, new sonic possibilities provided by the network, and a desire to imitate the repetitive processes of looping pedals: all of these suggest a style of improvisation based on repetition, rhythmic cell contrast and sonic domain counterpoint (Fragment #2).

Network-based guitar composition offers a wide array of surprising possibilities. Work on this piece brought the composer to the conclusion that manipulating a network of compositional “objects” allows him to combine creative domains and processes that were unrelated for him previous to this work. The electric guitar has provided a way of overcoming dated concepts opposing composition and improvisation.

In this approach, composing for the guitar becomes an all-encompassing activity ranging from musical notation to digital studio manipulation, with pedals and computer (Max/MSP) acting as compositional tools. The guitar/tool is at the centre of a network-based compositional environment, allowing the guitar to become an aesthetically independent instrument, far from the sonic "clichés" that mark its identity in contemporary music.

The consequences of this model for musical composition are numerous. In our view, the most significant one concerns the nature of the creative process: in a network-based guitar environment, the act of composition shifts towards the construction of an environment (the network) and its individual, material-generating components.

Conclusion

In this quatuor article, we have attempted to establish a fruitful interaction between two approaches to the electric guitar as an augmented instrument and a tool for composition: one centred on the organology of an ever evolving instrument, the other on a musicology oriented towards the creation of new music. Our goal is to initiate new and meaningful approaches to the electric guitar as an object of scholarly study. Regarding such an emblematic instrument, the two specialized domains that are musicology and organology call for complementary approaches from the areas of computer music studies, composition and sociology.

In the case of an artistic work which draws both from scientific knowledge and artistic creation, the creative work, transversal by nature, becomes a space for experimentation, for qualitative (in)validation and for the application or rejection of scientific hypotheses. In this article, we have tried to show how an analysis of the electric guitar as an augmented and modular instrument gives rise to new strategies
for composition, based on the emergent properties of the network-instrument. Thus, the electric guitar becomes a source of a wide variety of musical materials, such as multi-temporal sonic masses, noise-oriented sonorities, and syntaxes and vocabularies stemming from the instrument’s extended playing techniques. In the era marked by a generalisation of live-electronic praxes, the electric guitar present a significative case study of an augmented instrumental environment and its musical implications.

References

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1 For examples of this field of study, see S. Waksman, Instruments of Desire: The Electric Guitar and the Shaping of Musical Experience and A. J. Millard The electric guitar: a history of an American icon.
2 www.cicm.mshparisnord. For video material of the augmented guitar, see: http://lahdeoja.org/fplaahdeoja/augmented_guitar
3 Audio recordings of the five movements of 5 fragments for Electric Guitar are available in JIMS webpage: www.musicstudies.org
4 Tapping is a guitar playing technique where the fingers of both hands are used to “tap” the strings against the fretboard, producing legato notes.

Biographies

Otso Lähdeoja. Guitarist, composer and music researcher specialised in augmented instruments. Currently a PhD candidate at the CICM, Université Paris 8, France. Masters degree in musicology in the domain of improvised music studies. Conservatory diploma in electric guitar and electronic music. Otso Lähdeoja participates in and directs numerous live electronic and multimedia projects.

Benoît Navarret. Doctoral Student – CICM University of Paris 8 / LAM University of Paris 6. After studies of economic sciences and computer music at the Universities of Pau and Paris, Benoît Navarret studied musical acoustics at the Conservatoire National Supérieur de Musique et de Danse de Paris (CNSMDP). Doctoral student in CICM/Paris8 and LAM/Paris6 teams, he works on the organology of the electric guitar, the influence of the lutherie parts on the sound produced by musicians and their expectations. The main goal of these researches is to define and characterize the feeling of guitarists both with a perceptive and an acoustic approaches. He works at the Musée de la musique and makes reviews for musical press.

Santiago Quintans. Guitarist, composer. Santiago holds a Bachelor's Degree in Jazz guitar and a Master's Degree in Jazz composition form the University of Miami (USA), and a Master's Degree in Musicology (with a focus on the electric guitar in modern music) from Paris 8 University, France. As a guitarist, Santiago has performed alongside some of today's top Jazz musicians (Kenny Wheeler, Maria Schneider), and conductors (Mark Foster) and has toured extensively in Europe and North and South America. After moving to Paris in 2003, Santiago has devoted himself to contemporary and experimental music. Santiago was a teacher at the University of Miami from 1999 to 2001, and he is currently head of the Jazz Department at the conservatoire of the city of Le mans, France.