Solo works of mixed music with live electronics:

A qualitative enquiry in timbre and gesture from the performer's perspective

Guillaume Boutard
University at Buffalo, 534 Baldy Hall, Buffalo, NY 14260-1020, USA.

Abstract

The performance of mixed music with live electronics is challenging for performers. In this context, idiosyncratic sound processing and synthesis tools are developed specifically for each work, inclined to technological obsolescence, and thus creating transmission and preservation issues. Still, performers, especially in the case of solo works, develop an expertise over time and over multiple performances by multiple performers. From this perspective, the question of co-construction of meaning in relation to performance is especially relevant. We designed an experiment to study this process of co-construction of expertise and appropriation of live electronics from the perspective of instrumentalists. We commissioned four solo works (each one for a different instrument) and asked two instrumentalists (for each work) to play the piece during a concert. We used qualitative methods stemming from psychology of work to study the performance activity in relation to gesture and timbre from the point of view of instrumentalists. For each work, the instrumentalists were confronted with the traces of their own activity, that is to say, the video and audio recordings of their performance and, subsequently, with those of the other instrumentalist in his/her presence. The data was then compared to conceptual frameworks designed mainly in relation to instrumental music. This study provides us with a better understanding of the appropriation of live electronics by instrumentalists, the strategies for transmitting an expertise, and proposes theoretical and practical grounds for new frameworks for documenting and disseminating mixed music with live electronics.

Keywords

documentation methodology, gesture, mixed music, multimodal, performance, timbre, transmission

The question of the sustainability of music with live electronics is discussed widely in the literature, especially since the early 2000s (e.g., Canazza & Vidolin, 2001; Chadabe, 2001; Polfreman, Sheppard, & Dearden, 2006; Yong, 2006; Zattra, De Poli, & Vidolin, 2001). Except for some considerations in a broader context (see Bernardini & Vidolin, 2005; Wetzel, 2006), few projects have focused on the instrumentalist's perspective[1] and, from this specific perspective, have tackled the questions of what defines and qualifies the instrument and the instrumentalist in relation to live electronics, and how. In the specific context of solo work, we argue that documenting the performer's point of view is critical and requires an enquiry into the modalities of verbal and non-verbal strategies of communication of a professional activity. How does one document a professional activity in a context where boundaries are constantly challenged by technological obsolescence? Which dimensions and strategies do performers use when transmitting and simultaneously constructing this expertise in a collaborative process? And how does this expertise relate to other musical practices? These questions grounded our research.

In this article we propose a qualitative enquiry in the modalities of expression of performance practice and expertise related to solo works of mixed music with live electronics. Using methods stemming from psychology of work to collect data, we applied instruments from linguistics and conceptual frameworks in music technology literature to identify strategies used by performers in order to make sense of their activity.

Investigation of mixed music performance: A qualitative method

Co-construction

Rink (2002) argues that "the interpretation of music requires decisions – conscious or otherwise – about the contextual functions of particular musical features and the means of projecting them" (p. 35). In this context, the use of audio or video traces has long been acknowledged: "perhaps the firmest ground on which to conduct the debate is a recording of performance, which lays the performer's conception open to inspection more fully than the expression marks given by the composer or the comments by the listener" (Shaffer, 1995, p. 31). Recordings convey a broad range of information according to Clarke (2002a):

> *The sounds of a performance have the potential to convey a wealth of information to a listener, ranging from physical characteristics related to the space in which the performance is taking place and the nature of the instrument, to less palpable properties such as the performance ideology of the performer.* (p. 190)

But traces are not limited to performance recordings; prior activities such as rehearsals may also be included: "another tactic is to study the evolution of a performance during its rehearsal (Miklaszewski, 1989), getting the musician to comment on the use of expression at different stages" (Shaffer, 1995, p. 31).

Clarke (2004) also reviewed methods for empirical research in performance studies; he states:

> *A method which owes a lot to work in psychotherapy is to get performers to speak about their own performances, and then to analyze both what they say and what they do. As a research method this "talking analysis" is aimed at discovering the intentions,*

[1] An exception, outside the scientific research domain, is the 2005 edition of the score of Luigi Nono's Das Atmende Klarsein (1981), which contains a commented performance by Roberto Fabbriciani.

> *motivations, and evaluations of one or more performers in relation to their own (or another's) performance. The data for this kind of approach are usually of two kinds: first, a sound recording of one or more performances, and second, a sound recording of the commentary by one or more of the original performers, or another commentator. The commentary is often made by a person who listens to the original sound recording of the performance, stopping the recording as often as he or she likes to make whatever comments are appropriate, and possibly doing so on more than one occasion. In this way a detailed account can be built up outside of the pressure of "real-time" performance.* (p. 91)

Clot's (2008) qualitative research in work psychology emphasizes a convergent point of view in terms of implementation, but with a specific theoretical focus, building notably on Vygotsky: the performed behaviour is just one tiny part of what is possible. The work activity is not limited to what is done: what was not done or could have been done needs to be included in the analysis, forming what Clot (2008, p. 129) refers to as the *thickness* of the activity. This *thickness* cannot be accessed directly and thus Clot advocates for 'indirect' methodologies (pp. 170-171), notably with his method of *cross self-confrontations*: "in the framework of his clinical approach to activity, inspired by the work of Vygotsky, Yves Clot uses dialogical exchanges and the possibility of eliciting controversies as tools (Vygotsky, 1978; Clot, 1999)" (Cahour & Licoppe, 2010). We will detail this method in the following section in relation to our research. The focus on the *thickness* of the activity is also a method to avoid what Dunsby (2002) refers to as the thin edge of the wedge:

> *Yet the performers who do tell us about performance tend to record their views, as we have seen, at the thin end of the wedge, naturally preferring to concentrate on the fleeting goal, the product, rather than on the journey, the substantial process by which they arrive at the goal. (p. 234)*

According to Clarke (2002b),

> *performance research has mostly adopted a thoroughly individualistic view of the performer and his or her mind. The social context of performance (including co-performers, the audience and the influence of teachers and mentors, as well as recordings and performances by others, social attitudes to performance and performance "fashions") is of paramount importance. (p. 68)*

In our research we have focused on the aspect of "co-performance" informed by an interactionist perspective. From this point of view, meaning arises in the process of interaction between people (Blumer, 1969, p. 4; see Denzin, 1992, for an historical review of the evolution of interactionism); the co-construction of meaning, through verbal and non-verbal negotiations, is thus critical. In music research, Cook (2001, n.p.) provides us with a converging view when he states that "signification is constructed through the very act of performance, and generally through acts of negotiation between performers, or between them and the audience". This negotiation between performers is synchronic but also diachronic (i.e., historically situated) between subsequent performers.

Instruments and intrumentalists

In the context of new musical instruments' categorization, taxonomies have been proposed. Davies (2001) reminds us that "several attempts have been made since then [his own attempt] to add electrophones to their [von Hornbostel and Sachs] four categories of idiophones, membranophones, chordophones and aerophones" (p. 296). A more recent example is provided by

Vine (2010). From an interactionist linguistics perspective, Mondada and Dubois (1995, p. 269) remind us that categories are fundamentally unstable; their construction may be observed in negotiations comprising verbal and non-verbal activities. Cance, Genevois, and Dubois (2013) provide us with an example, in the context of new digital instruments and musical interface, during their investigation of users' perception of the instruments developed by the group Puce Muse. They observed that "regular marks of negotiation concerning boundaries of what is considered as an instrument are frequently produced." Cance and Genevois (2009, p. 141) emphasize the need to consider the co-construction of the identity of the instrument and the instrumentalist, and the multimodal experience including gesture, sound, and vision. This necessity has grounded our research position.

The qualitative research of Féron and Boutard (in press) on performers' appropriation of live electronics in solo works of mixed music relied on interviews submitted to inductive analysis based on grounded theory. One of the appropriation strategies to emerge from their analysis relates to the relevance of sound explorations in the process of live electronics' appropriation. A specific paradigm in mixed music is the one of the augmented instrument; that is to say, a traditional acoustic instrument whose possibilities are extended technologically and compositionally by live electronics. Ungeheuer (2013) refers to this paradigm (in the context of her categorization of live electronics music) as the spatial and temporal transgression of the instrument. She further states that this concept encompasses also the triggering of pre-recorded sequences and live transformation through instrumental gesture control. In this paper, we question the co-constructed multimodal identity and quality of the augmented instrument (as a paradigm of mixed music, following Ungeheuer's conceptualization) in relation to two dimensions, namely, timbre and gesture (control). These dimensions, critical to the development of our methodology, are widely discussed in the literature.

Timbre and gesture in mixed music

The relation between timbre and instrument is critical: "timbre research has traditionally been centred on distinguishing types of instruments from one another" (Bellemare & Traube, 2005). Castellengo and Dubois (2005) emphasize two aspects of the definition of timbre: the identification of the source and the qualification of its properties. Lavoie (2013) distinguishes between inter-instrumental and intra-instrumental timbre. Several authors, such as Chion (2009, p. 93), have restricted the use of the notion of timbre to well-established instruments. Castellengo and Dubois (2005) argue that the use of the notion of timbre, in relation to its qualification, requires the long development of an auditory expertise, which entails its application to a specific instrument (such as a flute, a guitar, and so on and so forth).

In our context, where new instruments are constantly produced for each work, the co-construction of identity described by Cance and Genevois (2009, p. 141) becomes critical. Alluri and Toiviainen (2010) state:

> *On a more general note, an interesting development is that of contemporary music, which appears to be deviating from the well-known theories of Western melodic, harmonic, and rhythmic progressions. This music seems to move towards creating new sounds and textures by focusing on the blending of varied timbres. These results simply emphasize the importance of delving into the realm of polyphonic timbre perception. (p. 225)*

Similarly, Bellemare and Traube (2005) argue that, in the context of piano performance, "complex timbres, where at least two sonic elements create one resulting sound object, can be examined from the point of view of their vertical makeup or from that of their temporal evolution". We may apply these statements to mixed music, especially in relation to augmented instruments, where the

extension of the timbre possibilities of the acoustic instrument is part of its definition. Indeed, Ungeheuer (2013) states that real-time transformation of an acoustic instrument enables an extension of the timbre diversity.
The relation between timbre and gesture has received significant research attention (specifically at the intra-instrumental level; see Lavoie, 2013, p. 14; see also Cance & Genevois, 2009, about the multisensoriality or "holisensoriality" of the instrument), in relation to specific acoustic instruments (e.g., the piano, Bernays & Traube, 2013). The notion of gesture is as polysemic as that of timbre; Rink, Spiro, and Gold (2013) define their use of the word gesture:

> *We regard the gestures created in and through performance as potentially having motivic functions within the performed music. Such "motives" are defined not in terms of pitch, harmony or rhythm, however, but as expressive patterns in timing, dynamics, articulation, timbre and/or other performative parameters that maintain their identity upon literal or varied repetition. (p. 267)*

In relation to its pure physicality, "the body is not only essential to the physical manipulation of the instrument for the accurate execution of music, but it is also vital in the generation of expressive ideas about the music" (Davidson & Correia, 2002, p. 237). From a music technology perspective, Wanderley and Depalle (2004) define "performer gestures as performer actions produced by the instrumentalist during a performance, meaning both actions such as prehension and manipulation, and noncontact movements" (p. 633). Wanderley and Depalle (2001) remind us of the distinction between gestures directly and indirectly related to sound production: "these gestures have been called *expressive, accompanist, ancillary or non-obvious*". Cadoz (2009) distinguishes between ergotic interactions, where "forces, displacements, exchanges of energy between a human body and material objects or a material environment are involved" (p. 217), and non-ergotic interactions, where the same forces only involve the human body. From this perspective, the musical instrument is defined as "a physical object that produces acoustical phenomena when we have a gestural (and ergotic) interaction with it, while an energy continuum is assumed from the gesture to the sound" (Cadoz, 2009, p. 219). Digital instruments introduce a discrepancy in the energy continuum, leading Magnusson (2009) to state that "although we interact in an embodied manner with the computer using physical interfaces (moving our mouse on a two-dimensional plane, touching screens, or swinging Wiimotes) the interaction always takes place through symbolic channels of varied bandwidths" (p. 174). He further defines the digital instrument as "an epistemic tool (a conveyor of knowledge used by an extended mind) and its symbolic nature was described as a designed artefact that affords cognitive offloading by the thinker or the performer" (Magnusson, 2009, p. 175).
Timbre and gesture are intricately related and both are brought under question by the introduction of live electronics in relation to performance in mixed music as well as the core notion of instrument. In this context where categories are not firmly established, there is a need to investigate the processes of co-construction of meaning by performers in relation to their appropriation of live electronics and the modalities of this co-construction. The goal is to provide theoretical tools for the dissemination of an expertise that is constructed by different performers during the multiple interpretations of a work.

Study design

Theoretical background

Licoppe (2008) discusses and compares multiple methods for the investigation of the activity: the ethnographic approach of distributed cognition (see Hutchins, 1995); enquiries in science and technology studies, especially following Latour's (2005) actor network theory; and

several approaches in relation to activity theory and psychology of work, specifically with the work of Vermersch (2009), Theureau (2010), and Clot (2008). According to Licoppe, both actor network theory and distributed cognition propose a strong model for the inclusion of non-human agents in the activity as compared to the other approaches, which emphasize intentionality. Thus, they differ with regard to the observation of the activity in activity theory and work psychology where observations are, specifically, completed by verbalizations from participants. Rix-Lièvre (2010) also points to these similarities in the methods proposed by Vermersch, Theureau, and Clot, notably the need for observations of an activity during its realization in a valid context, and the ability of agents to reflect on this activity. The use of traces of the activity, such as video recordings (see Mondada, 2012, for a discussion about choices in recording technique), is thus critical in the work of both Theureau and Clot. Rix-Lièvre (2010) reminds us that the confrontation of agents with the traces of their activity helps in focusing on the activity while avoiding generalizations.
Our study is based on Clot's method of cross self-confrontations (Clot, 2008). From this perspective, participants share the process of data analysis. The core of the methodology consists of three stages: 1) the capture of the activity; 2) the self-confrontation with the recording of the activity; 3) the cross self-confrontation with the recordings of the activity (see Clot, 2008; Duboscq & Clot, 2010). In phase two, the participants comment on their own activity. In phase three, the cross self-confrontation, a participant (who previously commented on her/his own recorded activity) comments on the other participant's recorded activity in her/his presence, grounding the interaction between both of them in relation to their expertise. Thus, cross self-confrontations invite peers to co-analyze their activity, which fosters the process of making explicit the *thickness* of their activity.

The workshop

The first author commissioned four studies of mixed music with live electronics from four different composers (three solo composers and one pair). The rationale for commissioning new works stems from the following: 1) the emphasis on the study of timbre and gesture rather than the historicity of the performance of a specific work; and 2) the existence of short studies of mixed music that fit our requirements; 3) the scope of the research, i.e. the sustainability of the repertoire, including the question of documentation methodologies for mixed music works, which entails the need to include the whole creative process. The composers were instructed to write a study of mixed music for solo instrument with the duration between 1 minute and 3 minutes. No instrument was specified but we requested diversity among compositions. The live electronics was to be designed for a stereo setup. Two works were to focus on timbre, relating closely to the idea of augmented instrument in reference to the conceptualization of Ungeheuer (whose text was provided to the composer in order to avoid a different use of the term, focusing on the technological side of augmentation in relation to sensors). These two works are: *Piano rim* for piano and live electronics by composer Jean-Emmanuel Filet; and *Up and Down* for double bass and live electronics by composer Brice Gatinet. The other two works were to focus on gesture control, namely: *Âpre teinte* for alto saxophone and live electronics by composers Analia Llugdar and Cédric Camier; and *NoControl* for percussion and live electronics by composer Sylvain Pohu. Composers had to include electronics in the score (i.e. a representational score, according to Fennelly, 1974). They were free to seek the help of a computer music designer, but the composers required prior experience with mixed music composition. In this context, composer Jean-Emmanuel Filet worked with computer music designer (and composer) Ana Dall'Ara Majek. Each composer selected two performers for their work for solo instrument. At least one rehearsal with live electronics was requested prior to the concert date. Composers had to work with performers independently and performers had to have experience with mixed music performance. The performers were: 1) on piano, Daniel Áñez García (DAG) and Romain Pollet (RP); 2) on double bass, Pierre-Alexandre Maranda (PAM) and Graham Isaak (GI); 3) on alto saxophone, Marie-Chantal Leclair (MCL) and

Jean-Marc Bouchard (JMB); 4) on percussion, Kristie Ibrahim (KI) and João Catalão (JC). All performers are fluent in French (except for GI, see the discussion section; French is the first language for RP, PAM, MCL, and JMB) and accustomed to working professionally in French. Both composers and performers received a small compensation fee.

For ecological validity reasons (see Guastavino, 2009, for a discussion about the criteria which posits, notably, the dependency between the environment and the subject in relation to a task), we organized a live concert in the presence of a public audience at the Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT) in the Music Multimedia Room (MMR). The argument for the duration of the work followed the same logic of ecological validity (most composers asked for a small extension of the duration of the maximum length from 2 minutes to 3 minutes to be able to develop a musical idea) and prior reflections on segmentation. Garnier, Dubois, Poitevineau, Henrich, and Castellengo (2004), in the context of vocal quality description, conclude that qualification criteria relate as much to global aspects of the musical phrase (articulations, dynamics, etc.) as to local aspects (attacks, etc.). In the context of the study, participants were thus provided with the possibility during the verbalization to focus on multiple levels of segmentation according to their needs for making explicit a specific aspect of the interpretation.

The schedule of the event that we organized was: 1) first performance of each work; 2) presentation of the live electronics setup; 3) second performance of each work. The concert was followed by the "Roundtable on mixed music: Notation and performance of live electronics" with the composers and performers, moderated by Caroline Traube (Université de Montréal) and Pierre Michaud (Université de Montréal), both invited by the first author.

The composer Sylvain Pohu served as production manager for the concert as well as sound engineer for the audio recording of the performances. Performances were video and audio recorded (durations are provided in Table 1). Microphones used for sound recording comprised: two AKG C 414 B-XLS/ST; four DPA 4088-F; three DPA 4099VIO; one Neumann KM100-MS; and four Schoeps CMC62U/MK4. Three cameras (Sony PMW-EX3) were used at different angles for a better selection choice for the research phase. Composer Sylvain Pohu provided this next phase with the final mix of each performance. Mixes were sent to each composer prior to the data collection for potential feedback. The subsequent research phase took place where the mix was carried out, in the same studio and with the same rendering system: Dynaudio BM-15A speakers (stereo) and a 65-inch Panasonic Plasma display.

TABLE 1. Duration of performances for each instrumentalist

Concert: March 13, 2014		
Instrument	Performer	Performance duration
2*Double bass	GI	3’40”
	PAM	3’30”
2*Vibraphone	JC	2’50”
	KI	3’40”
2*Piano	DAG	4’20”
	RP	3’30”
2*Alto saxophone	MCL	5’15”
	JMB	5’10”

Confrontations and cross confrontations

During the confrontations with the recorded videos of the performances, we asked performers

to propose an a posteriori analysis of the performance – that is to say, a descriptive analysis (see Rink, 2002). We asked the participants to describe the relation between their performance and the live electronics, especially in relation to either timbre (for the pieces by Jean-Emmanuel Filet and Brice Gatinet) or gesture control (for the pieces by Analia Llugdar and Cédric Camier, and Sylvain Pohu). They were free to play the recording as many times as they wanted, to come back, stop, and comment at any time of the study. In the context of cross self-confrontations, the non-performing participant had the control of the recording.
The confrontations have been audio and video recorded and subsequently transcribed. The level of transcription is related to the object of research. Mondada (2011) argues that:

> *Understanding is constantly actively managed by the participants along with the emergent, incremental, sequential organization of turns moment by moment; in the way in which they respond, they allow the speaker to go on with a continuer, or repair the previous bit of talk. Moreover, understanding is constantly displayed in a multimodal way: participants manifest their current understanding in their gesture, gaze, facial expression, body position, etc. (p. 545)*

Bernays and Traube (2013) echo this question of multimodality of experience and transmission in their study of piano timbre control:

> *Timbre happens to be a meaningful and well-defined parameter amongst high level performers, who have developed over the years of practice a precise and refined motor control of the instrument, as well as an acute perceptive sensibility to slight sonic variations. This multimodal perception of timbre results in an extensive vocabulary developed to describe the nuances a performer can detect. However, the terms commonly used remain intuitive and directly linked to the sensation level. During the learning process, timbre is empirically transmitted from master to student through analogies and metaphorical verbal descriptions. (p. 207)*

Lavoie (2013, p. 143) describes three modalities of communication for the control of instrumental sound in her qualitative study of guitar master classes: verbalization, instrumental demonstration, and vocal imitation. In order to be able to capture these potential modalities, we included them in the transcription principles. The transcription codes (grounded in Mondada, 2004) are provided in Appendix A, and the translation of the Tables are provided in Appendix B. Duboscq and Clot (2010), who pose a functional relation between dialog and action (p. 255), previously used similar methodological instruments in the context of the study of building construction activity. They conducted a conversation analysis of cross self-confrontation data (see also the work of Brassac and Gregori, 2003, using discourse analysis and conversation analysis). Mondada (2012) reminds us that "from its very beginnings, Conversation analysis has been a pioneering movement that has explicitly recognized the use of recorded data" (p. 52). Because of conversational analysis's focus on speech (historically with telephone conversations, according to Schmitt, 2006, and in comparison to its grounds in Garfinkel's *ethnomethodology*, see Kvale & Brinkmann, 2009, p. 221), Duboscq and Clot did not include gesture in the transcription principles.

Analysis

Timbre

Multimodalities.

Davidson and Correia (2002) argue that "a wide range of verbal metaphors – especially for situations where the expression has to do with inner motions or reactions (like contraction or tenderness) can be used by teachers to stimulate the student's imagination and bodily meaning" (p. 247). In the context of our study, several metaphors are used in relation either to 1) the augmentation of the instrument (e.g., RP states "comme si notre piano se retrouvait complètement dans l'eau"[2] and "qui sort des doigts"[3]), or 2) the notion of control (see Table 2 in relation to the score excerpt provided in Figure 1), which will be discussed further in the following section. These last two examples emphasize the gesture-timbre relation.

TABLE 2. Use of metaphors for the description of live electronics control.

RP:	C'est ça c'est que là on est moins acteur de la création du son, je trouvais.
DAG:	Oui, §ici§, disons,
	§pointe à la mesure 3 (corresponding to the notated effect of delay and reverb)§,
DAG:	§on jette des pierres dans l'eau§,
	§geste doux d'imitation du lancer vers l'avant avec la main droite, index et pouce pincés§,
DAG:	puis on créé des petits dessins [avec les vagues qu'on fait,
RP:	[((rires))
DAG:	alors §qu'ici§…
	§pointe à la mesure 12 (see Figure 1)§,
RP:	Bonne métaphore ça.
DAG:	vraiment on modèle la pâte

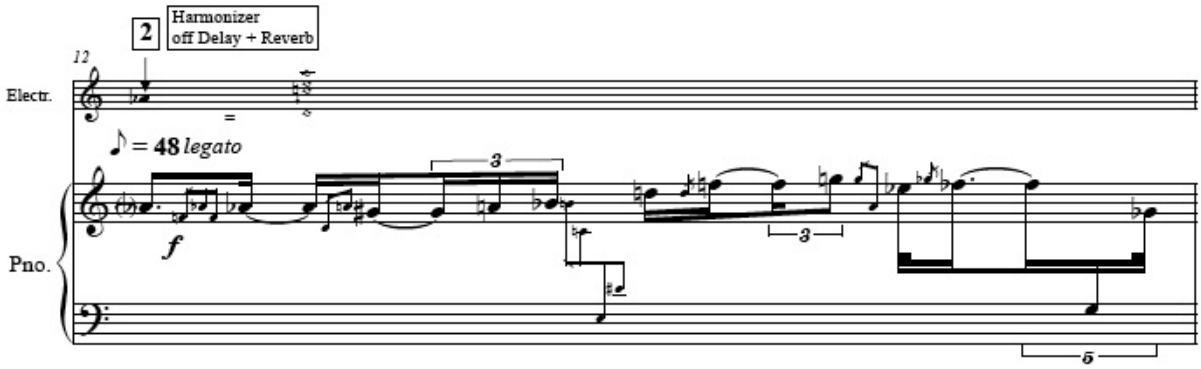

Figure 1. Piano rim's score, measure 12

[2] "as if the piano was completely under water".
[3] "coming out of our fingers".

Onomatopoeias and sound imitations have also been documented in the literature in relation to instrumental timbre verbalization (see Faure, 2010; Lavoie, 2013). In our data, they are often used in relation to live electronics, sometimes in combination with gestures, for example, in Table 3 (the transcription of the onomatopoeias is very approximate and should be considered as an example).

TABLE 3. Description of differences in the flanger effect with gesture and onomatopoeias

DAG:	Ça c'est très différent entre… parce que tu jouais la section du flanger.. très "clean".
RP:	† OUI, [oui †
	† acquiesce †,
DAG:	[et puis l'effet est assez intéressant, §((onomatopée: preubeleu))§, c'est très subtil, c'est très différent
	§la main positionnée à droite à hauteur du visage à l'horizontale pointant vers l'avant qui fait des mouvements de pincements désynchronisés des différents doigts contre le pouce§
RP:	Au niveau de la pédale ? ou euh…
DAG:	Au niveau de ce qu'on entend du flanger, parce que le flanger va réagir par rapport à combien il y a de résonance à l'intérieur…, puis cette section dit *poco pedale*, alors qu'est-ce que ça veut dire *poco* ? [Ben oui, t'as mis peu, moi j'ai mis peu, mais toi t'as mis peu à ta façon et moi j'ai mis peu à ma façon, puis ça donne des résultats…
RP:	[† ((rires))† Ben oui
	† acquiesce †
RP:	xxx. Oui c'est ça, mais ça fait des effets très différents, je trouve ça intéressant la couleur que ça donne comme ça.

The analysis shows that the different modalities – sound imitation and onomatopoeias, verbalization including metaphors and gestural description – documented in the literature in relation to instrumental timbre form the core of the verbal and non-verbal strategies used by the performers for making sense of the performance, in the context of mixed music. As presented in the examples, these modalities are often used in combination (e.g., Table 3).

TABLE 4. Identification: Comparison to other sound sources (number of occurrences in square brackets).

DAG	RP
Clavecin (*Harpsichord*) [2]	Cloche (*Bell*) [2]
Synthetiseur (*Synthesizer*)	Casserole (*Pan*)
Hyperinstrument	
Autre instrument (*Another instrument*)	

Identification and qualification.

Several verbalizations refer to the notion of identification, proposed by Castellengo and Dubois (2005). Both RP and DAG use strategies of identification by similarity. DAG relates to other instruments, both acoustic and electronic (see Table 4). RP relates to non-instrumental objects (i.e., the bell and the pan), with a negative connotation:

> RP: c'est comme si on avait plus de capacités avec notre instrument que d'habitude, euh.. à travers la partie, ºdonc ça c'est intéressant de ce point de vue làº ; puis un timbre un peu euh.. ça peut sonner/ casserole de même, sur le piano.[4]

Bellemare and Traube (2005) state that

> *piano pedagogy is an elaborate discipline wherein these gesture parameters are often discussed but without necessarily referring to their outcome in a direct fashion. Nonetheless, performers call upon a vast vocabulary to describe the nature of their sound; examples of adjectives include bright, champagne, metallic, plush, round, veiled.*

In terms of qualification, RP uses a variety of adjectives in relation to timbre (see Table 5). Some of them are related to the live electronics algorithms, e.g., *Harmonisé* [*Harmonized*] (according to Cance et al., 2009, -é suffixes denote an accomplished process resulting in a specific state), or the live electronics effect, e.g., *aquatique [aquatic]*, while others relate to documented descriptive terms for piano timbre, e.g., *métallique [metallic]*, *sec [abrupt]* (see also Bernays & Traube, 2013). For example, RP states:

> parce que là c'est assez métallique, c'est assez.. ça nous rapproche du timbre métallique du piano qu'on a tendance à oublier.[5]

Most of these adjectival forms are non-axiological evaluative (without value judgment), according to the categorization presented by Cheminée, Gherghinoiu and Besnainou (2005). Still, there are traces of axiological evaluative (implying a value judgment): RP uses the adjective *intéressant [interesting]*, and affective adjectives such as *cool* and *fun*. In terms of non-axiological categorization, DAG, on the other side, does not use adjectival forms to describe the timbre except for the description of the time or amplitude characteristics of signal processing (see Table 5).

TABLE 5. Qualification: Non-axiological adjectival forms (number of occurrences in square brackets).

DAG	RP
"Timé" ("*Timed"*)	Harmonisé (*Harmonized*)
Carré (*Square*)	Rythmé (*With Rhythm*)
Continu (*Continuous*)	Métallique (*Metallic*) [2]
Grand (*Big*)	Aquatique (*Aquatic*)
Puissant (*Powerful*)	Sec (*Sharp*) [2]

[4] RP: it is like we had more opportunities with our instrument, hum.. through the part, ºso this is interesting from this point of viewº; then a timbre that is slightly hum.. it can sound/ "like a pan", with the piano.

[5] "because here, it is pretty metallic, it's quite.. it gets closer to the metallic timbre of the piano, which we usually try to forget".

In their study, Castellengo and Dubois (2005) presented participants with audio samples manipulated in relation to time while keeping the frequency content constant; specifically, they reversed the samples. In doing so, they introduced a timbral ambiguity, which they analyzed in participants' descriptive verbalizations. In our study, we find multiple traces, on the one hand, of this relation to "incongruity" (see Castellengo & Dubois, 2005) and, on the other hand, to the notion of complex timbre, introduced previously (see Bellemare & Traube, 2005), that mixed music creates in specific cases by "augmenting" the instrument. The "incongruous" character is visible in the identification (see above, Table 4) and the qualification (see Table 6) of timbre.

TABLE 6. Incongruity and complex timbre reference in adjectival forms (number of occurrences in square brackets).

DAG	RP
Opaque	(relation) Dichotomique (*Dichotomic*)
Équilibré (*Well-balanced*)	(relation) Ambigüe (*Ambiguous*)
	Transformé (*Transformed*)
	Élargi (*Enlarged*) [2]
	Accumulé (*Accumulated*)
	Bizarre
	(pas) Juste (*Out of tune*)

The notion of complex timbre is often related to the idea of balance between acoustic and electronic sounds, e.g., *équilibré [well-balanced]*, *accumulé [accumulated]*, and *dichotomique [dichotomic]*. DAG talks about “mélange de timbres.” Similar to previous descriptions, multiple strategies operate in relation to the “incongruity” of the augmented instrument and the complex timbre construction, as exemplified in DAG’s confrontation excerpt in Table 7. The verbal relation to incongruity for RP relates both to the qualification and identification dimension with a predominance of qualification, while for DAG it relates essentially to identification. A noteworthy dimension of qualification for mixed music that emerges from the analysis is the spatial characteristic of the instrument that relates to the electroacoustic setting. DAG, on the one hand, states:

> j’essayais de faire un phrasé puis de garder le phrasé avec cet instrument qui apparaissait comme derrière moi mais je pense qu’au niveau de l’extérieur c’est un hyperinstrument, c’est un synthétiseur, c’est une autre chose, c’est une construction.[6]

RP, on the other hand, states:

> on est forcé d’écouter ce timbre qui nous sort des doigts. Parce qu’il y a vraiMENT/ l’impression de sortir des doigts.. pas d’un haut-parleur.[7]

This dimension is to be contextualized in relation to the work, following the discussion expressed previously about control (see Table 2).

TABLE 7. Multiple strategies to describe the relation between acoustic and electronic sounds.

[6] "I was trying to phrase it and then to keep the phrasing with this instrument that appeared behind me but I think that for the public, it's more like a hyperinstrument, a synthesizer, it's something else, it's a construct".

[7] "We have to listen to this timbre that comes out of our fingers. Because there is reaLLY/ the feeling that it comes out of our fingers.. not from the speakers".

DAG: Le besoin que j'avais dans cette section, § c'était de me cacher derrière, d'une certaine façon §.

§ mouvement de balancier lent des deux mains à l'horizontale, les doigts pincés avec un léger mouvement désynchronisé se transforme en jeu virtuel au piano §

DAG: Puis.. je trouvais que.. cette section, la douzième, de l'harmonizer correspondait plus à mes idéaux.. de me cacher derrière l'harmonizer.

The vocabulary that relates to live electronics is predominantly based on verbs: *transformé [transformed]*, *élargi [enlarged]*, *accumulé [accumulated]*, *harmonisé [harmonized]*, *rythmé [with rhythm]*, and *équilibré [well-balanced]*. Dubois (2002) argued that these adjectival forms represent an effect on the subject rather than an objective entity independent from the observer (e.g., with simple adjectival forms such as loud). Both participants use these forms, but in general there are strong differences in strategies between them. DAG, whose first language is not French but who is fluent, uses fewer adjectives and more gestures, onomatopoeias, and metaphors than RP. RP, who also uses all these strategies, is the only one to use documented timbre adjectives such as *métallique [metal]ic]* and *sec[abrupt*. Although the range of possibilities explored to transmit their expertise of the performance of the piece is constant, the forms vary greatly between them, generating a rich construction of meaning in relation to the augmented instrument performance.

Gesture

Multimodalities.

Similar to that of timbre, the description of gesture control mobilizes several modalities. These modalities parallel those described in the previous section for timbre. To collect the expertise of our participants in relation to gesture control – KI and JC for the vibraphone, MCL and JMB for the saxophone – we requested that they bring the instrumental and electronic setup to the interview studio. In terms of electronics setup, MCL and JMB brought the mute, constructed by Cédric Camier, that sent the light to a sensor (the E.L.S.A. system – Extension Lumineuse pour Saxophone Augmenté – developed by Cédric Camier) according to the position inside the bell; KI and JC used a laptop that simulated the one used on stage, the electronics control being triggered by the laptop camera. In this context, they were free to describe the content of the concert recording and to exemplify it using the full augmented instrument setup, if necessary.
Gesture is an important part of the description of their interaction; however, gestures are divided into two categories. First, some gestures are the direct replication of the control gesture (see Table 8), sometimes in relation to onomatopoeias and vocal imitations (see Table 9), while others are sound description. The latter relates to what we described in the previous section, and may also be accompanied by onomatopoeias (see Table 10)

Table 8. Gestural description of gesture.

KI: surtout je voulais entendre le son de l'électronique ‡ avec le geste acoustique ‡ sur le vibraphone.

‡ frappe virtuelle du vibraphone, tandis que la main gauche est placée à distance fixe de la camera du laptop, paume vers l'instrumentiste. ‡

TABLE 9. Combined use of onomatopoeias and gestures.

JC: Et là je fais la même chose, $ quand je fais huuuuuuououuuuuu-poum $ j'essaie de le fermer et quand je le ferme j'enlève ma note tu vois.
$ la main droite tient la baguette au dessus du vibraphone, la main gauche se déplace vers la camera paume en avant à moitié serrée jusqu'à un arrêt sec accompagné d'un coup de mailloche sec sur le vibraphone. $

TABLE 10. Gestural description of live electronics output.

JMB: Non comme là, à la fin, c'est exactement le même effet, ¶ brrrrrrrr ¶ le bruit de fond que j'aime beaucoup.
¶ les mains, formant un cercle à l'horizontale, s'écartent ¶

Gestures are used also in situations of comparison, for example between MCL and JMB in Table 11.

TABLE 11. Comparisons of gestures.

MCL: Ça, tu trouves que £ finalement ça faisait £
£ la main droite tenant virtuellement la sourdine fait un mouvement ample d'aller retour haut bas. £
MCL: l'équivalent de £ ça ? £
£ la main gauche, index pointé en avant fait un mouvement d'aller retour horizontaux £
JMB: Oui. Mais peut-être qu'en tournant comme ça on envoie de la lumière sur le …

In this context, the explicit verbalization of ancillary gestures is provided by the participants; the saxophonist MCL states:

> C'est un des passages où c'était le plus en nuance. Ça, ça ne fait rien à la fin mais ça fait joli c'est pour le spectacle, ça fait partie de la performance mais au niveau du son ça ne faisait rien surtout qu'on ne claquait pas.[8]

Similarly, the percussionist KI states:

> la tension dans le bras n'est pas nécessaire du tout techniquement, mais pour moi, musicalement, physiquement, dans la pièce si.[9]

Following the functional classification of Jensenius, Wanderley, Godøy, and Leman (2010) into communicative gestures, sound-producing gestures, sound-facilitating gestures, sound-accompanying gestures, although the case of MCL relates closely to a communicative gesture, the case of KI relates also to a sound-facilitating gesture. Indeed, the categories of Jensenius et al., 2010, are not exclusive; gestures may have multiple functions, especially sound-facilitating gestures: "the unique contribution of such sound-facilitating gestures may be hard to isolate as they are

[8] "This was a more nuanced part. This doesn't do anything in the end, but it looks nice, it's for the show, it's part of the performance but in relation to the sound, it doesn't do anything".
[9] "The tension in the arm is not necessary technically, but for me, musically, physically, in this piece, it is".

overlapping with, and bridging between, the sound-producing and communicative gestures" (Dahl et al., 2010, p. 53).
In terms of verbalization, participants either describe the gesture or the goal of the gesture (Figure 2 shows the notation of the electronic part in Sylvain Pohu's work). For example, KI describes JC's gesture in Table 12.

TABLE 12. Goal description

KI:	C'est un super réflexe que tu as… « Oh non, ‡ il faut vraiment que je ne laisse pas passer plus de lumière » ‡. ‡ le poing gauche vient boucher le champs de la caméra ‡

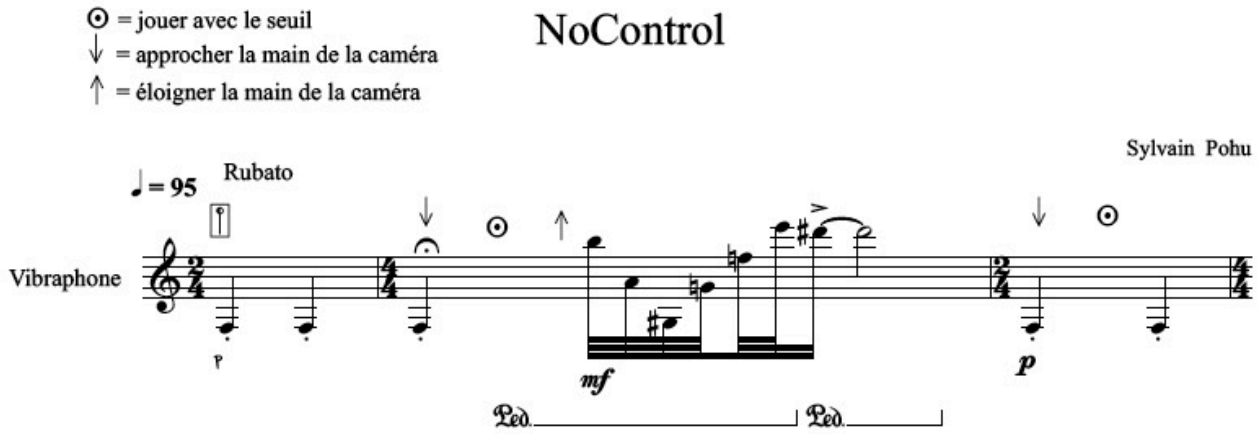

Figure 2. *NoControl*'s score excerpt. Live electronics notation.

Qualification.

Adjectival forms are used to qualify both the gesture and the relation between gesture and live electronics. The qualification relates either to the general form or specific gestures. A vivid example is provided by KI who proposes a generalization (without any request from the interviewer):

> KI: Je trouve que pour moi, si j'avais besoin d'utiliser un adjectif.. la forme de mon interprétation c'est vraiment rond et donc tous les moments d'improvisation, tous les départs, les gestes, les longueurs sont vraiment ronds, celle de João sont plus abrupts. Mais je dis agressif, mais juste dans un sens qualitatif.[10]

The example of the adjective *rond [round]* is especially interesting because of its use in relation to timbre for multiple acoustic instruments (see Bernays & Traube, 2013; Cheminée, 2009; Fritz, Blackwell, Cross, Moore, & Woodhouse, 2008; Lavoie, 2013). The use of *rond [round]* is not as much related to the spatial properties of gesture as to its dynamics, which is emphasized by its opposition to *abrupt* and *agressif [aggressive]*. The relation to timbre vocabulary also brings to light the "holisensoriality" aspect of the construction of the experience of the senses (see Cance, 2008; Cance & Genevois, 2009).

[10] KI: I think that for me, if I did need to use an adjective.. the style of my interpretation, it's really round. So all the improvisation, the departures, the gestures, are really round, those from João are more abrupt. I am saying aggressive, but in a qualitative way.

In terms of adjectives (see Table 13), we find the same categories as with timbre – axiological forms such as *joli [nice]* and *dramatique [dramatic]*, and non axiological forms such as *rond [round]* and *fluide [fluid]* – but with a different emphasis (especially in relation to axiological forms, which are more present in the verbalizations in relation to gesture) and for some participants, such as MCL, a more limited use. Some adjectives refer to other artistic practices, i.e. *choréographique [choreographic]*, *théatral [theatrical]*, and *dramatique [dramatic]*, while adjectives such as *legato* and *tenuto* come directly from the musical vocabulary. Similarly to DAG in the previous context, JC uses adjectival forms to describe the electronics effect in relation to gesture and, in this context, the -é form emerges: *saccadé [jerky]*, *"timé" [timed]*. The use of the adjective *clair [clear]*, often used in relation to timbre (see Cheminée, 2009), describes, in this context, the relation between gesture and live electronics (in addition to the adjectives *lié [bound]*, and é*vident [obvious]*), i.e. meaning "obvious" rather than "bright." It supports a claim about energy and mappings discussed in the literature, notably by Cadoz (2009): "we claim here that the status of representation of energy in the models must be explicit since it has a direct consequence on whether the models can or cannot be experienced with reference to our previous enactive knowledge" (p. 225)[11]. KI and JC discuss this question using different adjectives such as *naturel [natural]*, *organique [organic]*, and *mécanique [mechanic]*, *ergonomique [ergonomic]*. This focus takes a large part of the qualitative evaluation of gesture in relation to electronics (as opposed to the quantitative part represented by adjectives such as *petit [small]*, *rapide [fast]*, and so on), from the perspective of performers.

TABLE 13. Adjectival forms for gesture and gesture-electronics relationship in verbalizations (number of occurrences in square brackets)

KI	JC	MCL	JMB
Naturel (Natural)	Legato	Clair (Clear) [4]	Graduel (Gradual) [2]
Ergonomique (Ergonomic)	Organique (Organic) [2]	Lié (Bound)	Evident (Obvious)
Organique (Organic)	"Timé" ("Timed")	Joli (Nice)	Clair (Clear)
Rond (Round) [2]	Rond (Round) [2]		Intéressant (Interesting)
Abrupt [2]	Rapide (Fast)		Dramatique (Dramatic) [2]
Agressif (Aggressive)	(electronics) Saccadé (Jerky) [2]		Théatral (Theatrical)
Petit (Small)			Joli (Nice)
Minuscule (Tiny)			
Droit (Straight)			
Choréographique (Choreographic)			
(plus) Court (Shorter)			
(plus) Long (Longer)			
(plus) Lent (Slower)			
Fluide (Fluid) [2]			

[11] Some authors, on the contrary, support this discrepancy: "a significant implication of using electronic technology to create a new instrument is that its playing methods is decoupled from its sound production method. The design constraints of acoustic instruments are intimately tied to acoustical physics, and this impacts the ways a player must play and what timbres can be produced. With digital instruments, these limitations disappear" (Singer, 2008, p. 208).

Cool
Tenuto
Mécanique (Mechanic)

Control.

The verbalization of mappings brings to light the question of control and embodiment in relation to the augmented instrument. As KI declares:

> C'est intéressant parce que des fois j'ai du mal à séparer le.. parce que je passe tellement de temps à essayer de fusionner les deux [the instrumental and the electronic part] donc c'est drôle de penser juste depuis la perspective de l'électronique.[12]

The notion of control in relation to live electronics has been widely discussed in the scientific literature (see Cadoz, 2009; Dodge & Jerse, 1997; Rowe, 1993; Wanderley & Depalle, 2004). Two works involve gesture control with a technical setup described previously. In relation to mapping, Cadoz and Wanderley (2000) provide us with an instrumental gesture typology consisting of three categories: excitation gestures (providing the energy for the sound production); modification gestures (impacting the instrument's properties); and selection gestures. In both works exemplifying gesture control, we have a combination of modification and selection gestures. Rowe (1993) famously described three dimensions of interaction. The third makes explicit the distinction between instrument paradigm systems (closely related to the augmented instrument) and player paradigm systems (related to artificial players). The first dimension, such as from score driven programs (i.e. with predetermined event collections) to performance driven programs (without a stored representation of the music used as input), reflects verbalizations of the participants from the opposite perspective (the performance); see for example in Table 14. Indeed, we have already encountered such parallel distinctions in the context of the piano piece (see Table 2).

TABLE 14. Levels of gesture control.

KI:	C'était pas le même geste où on avait besoin de garder et éloigner, c'était plutôt ‡ on ou off ‡
	‡ la paume parallèlement au buste se projette vers l'avant puis revient ‡

Similarly to the convergence from timbre to gesture, exemplified metaphorically, the opposite movement can be traced back in this statement by KI:

> Pour moi dans ma tête le patch, les sons, sont comme lâchés, ou relâchés. Donc pour moi, c'était moins une question de coordination d'attaque, c'était plus une question de changer les couleurs.[13]

Issues of hardware specificities also emerge in relation to the performance as much as the appropriation during rehearsal time

> KI: Et ce qu'on a trouvé aussi.. moi j'ai travaillé avec un autre ordinateur et on pensait que peut-être la caméra était moins sensible. Donc ça c'est intéressant aussi.. c'est d'avoir accès au matériel avec lequel on va jouer l'interprétation.[14]

[12] "It's interesting, because sometimes I have trouble separating the.. because I spend so much time to blend them together, so it's hard to think only from the perspective of the electronics".

[13] "For me, in my head, the patch, the sounds, are set loose. So for me, it was less an attack coordination and more a question of color change".

[14] KI: And what we found also.. Me, I worked with another computer and we thought that maybe the

Another critical point is the different strategies for performance and the level of appropriation established by participants (see Table 15). In the context of MCL and JMB it is interesting to note that Analia Llugdar and Cédric Camier provided in the score a prescriptive and descriptive part for live electronics (see Figure 3). These differences bring us to the notion of *thickness* previously introduced.

TABLE 15. Appropriation of live electronics.

MCL:	J'ai une question : toi, tu essayais de la garder bien stable la sourdine ? Admettons que tu étais à moitié sorti, tu faisais attention de ne pas bouger pour que … si tu essayais de rester bien immobile, est-ce que t'avais l'impression que ça avait un impact ?
JMB:	Moi je respectais ce qui était écrit. Si je restais immobile ? tu veux dire si le traitement était statique ? Ça, mon questionnement ne s'est pas rendu là. Mais j'essayais de regarder la boîte noire et quand je la voyais éclairée j'essayais de garder la même intensité.

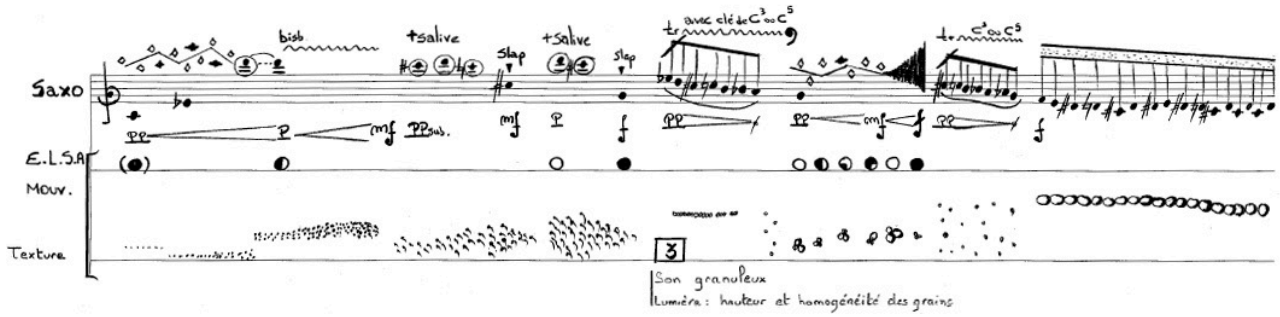

Figure 3. *Âpre teinte*'s score excerpt. Prescriptive and descriptive notation for the electronics part.

Thickness of the performance activity

The main objective of this study is to bring to light the *thickness* of the activity of the performance of mixed music with live electronics (for analytical as well as transmission, and potentially pedagogical, purposes) across the different modalities of transmission of the expertise (developed in relation to a specific work). Examples of this *thickness* are numerous in the interviews for each group; they emphasize similarities (e.g., Table 16) and differences (see Table 3), and they also include previous discussions about ancillary gestures.

camera was less sensitive. So that was also interesting.. to have access to the same hardware as for the performance.

TABLE 16. Similarities in performance.

KI : Là, par exemple, je pense que là, on avait vraiment la même idée. Je le vois dans son geste, ‡ c'est vraiment de ‡ …
‡ la main droite est pincée au dessus de la paume gauche ‡
KI: suivre le ‡ crescendo ‡ de l'électronique.
‡ la main droite s'écarte vivement de la main gauche en ouvrant les doigts en éventail ‡
KI: Même ‡ le geste lui-même était plus lent, ‡
‡ la paume de la main gauche vient se positionner vivement devant la camera, verticalement, les doigts vers le haut et s'immobilise ‡
KI: par ‡ rapport à tous ses autres gestes c'était plus lent, ‡
‡ la paume de la main gauche dans la même position se retire très lentement de devant la camera ‡
KI: ‡ ça suivait, ça suivait et après c'était tout fluide ‡
‡ poursuivant le mouvement, rotation du buste en direction du vibraphone ‡
KI: et après ‡ $ je pense que, je sais pas, j'ai l'impression qu'on partageait ‡ $ cette [idée,
‡ KI se tourne vers JC puis fait un mouvement de va et vient en opposition de phase des mains devant le buste, paumes verticales ‡
$ JC acquiesce $
JC:
[ouais, ouais.
KI: ‡ l'idée que ça doit être totalement fluide, un geste, ‡ le geste,
‡ les deux paumes relevées à angle droit se déplacent lentement depuis la camera du laptop vers le vibraphone puis prenant un peu de vitesse décrivent un arc de cercle vers le haut qui revient à l'ordinateur ‡
KI: ou ‡soit deux, mais qui […‡ étaient liés,
‡ les deux mains écartées et ouvertes se rapproche rapidement les doigts s'entrelacant lègerement ‡
JC: [tout à fait
KI: ‡ vraiment qu'il y ait une connexion ‡
‡ mouvement rotatif du buste et des bras, les paumes des mains tendues, passant de l'ordinateur au vibraphone avec une légère montée puis plongée en prenant de la vitesse des paumes à l'horizontale sur le vibraphone ‡
KI: pour que justement on ‡ arrive à cet accord ‡. Voilà. Ce qui est…
‡ montée et écartement des mains doigts écartés, la main droite à hauteur du cuir chevelu, la main gauche à hauteur de la poitrine ‡
KI: [oui…
JC: [C'est tout à fait ça.

TABLE 17. Possibilities in interpretation.

JC: Alors j'avais le choix de faire $ … $
$ pédale enfoncée, joue de la main droite pendant que la main gauche est accrochée sur l'écran du laptop bloquant la caméra, relève la pédale pour la dernière note $
JC: finir…, $ lâcher la main $, et laisser la prochaine partie qui commençait sur un grave, ((onomatopoeia: doooooouuu)).
$ relève la pédale pour la dernière note $

JC: Ou, tout jouer, $ …$,
$ pedale enfoncée, joue de la main droite pendant que la main est accrochée sur l'écran du laptop bloquant la caméra $
JC: $ lâcher ma main,$
$ retire la main doucement de devant la caméra alors que la pédale est toujours enfoncée $

Differences arise in relation to technological affordances. JC provides a fine example of the questioning of the unit of analysis that has been famously discussed by Bateson (1987) in his conceptualization of "cybernetic epistemology"[15]. Indeed, JC decided to use the mallet in front of the camera at times (according to him, he initiated this strategy during the dress rehearsal for the first time), rather than the hand like KI:

> JC: Et là je le fais avec la baguette, parce que je trouvais que je pouvais faire des changements plus brusques de rentrée de lumière avec un objet plus pointu.[16]

KI further comments on this difference:

> KI: Oui donc là il utilise sa baguette au lieu de sa main, c'est le fun, je n'aurais vraiment pas pensé mais ça n'aurait pas marché pour moi, c'est l'avantage de son set up, de la configuration qu'il a, il a peut-être d'autres options.
> Researcher: Pourquoi penses-tu que ça n'aurait pas marché pour toi ?
> KI: Juste à cause du niveau où c'est placé. Ou peut-être, je ne sais pas.. Je sais pas, pour moi c'était même pas dans ma tête.[17]

What could have been done is not limited to one individual (see, table 17); rather, it involves all performers. JMB reflects on both performances:

> JMB: Si c'était à recommencer je ne le ferais pas comme je l'ai fait, je ne le ferais pas comme tu [MCL] l'as fait. J'essayerais de trouver une troisième alternative.
> Researcher: Ce serait quoi ?
> JMB: Ce serait … il est sorti des sons très aigus mais ça avait l'air un peu hors de contrôle, je pense. J'essaierais d'amener quelque chose de plus graduel, aussi fort que je peux, mais plus graduel. Essentiellement faire mieux.[18]

It is also possible to relate the *thickness* to the work with the composer and, generally speaking, the creative processes (some performers provide explicit references to qualitative or quantitative

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[15] "The cybernetic epistemology which I have offered you would suggest a new approach. The individual mind is immanent but not only in the body. It is immanent also in pathways and messages outside the body; and there is a larger Mind of which the individual mind is only a subsystem" (Bateson, 1987, p. 467).

[16] JC: And there, I do it with the mallet, because I could do fastest lighting change with a pointier object.

[17] KI: Yes, so here, he uses his mallet instead of his hand, it's fun, I wouldn't have thought about that but it wouldn't have worked for me, it's the benefit of his setup, his configuration, maybe he has more options.
Researcher: Why do you think it wouldn't have worked for you?
KI: Just because of the placement. Or maybe, I don't know.. I don't know, for me, I didn't even think about it.

[18] JMB: If I had to do it again, I wouldn't do it this way, I wouldn't do it the way you did. I would think about a third way.
Researcher: What would it be?
JMB: It would be.. there were some real high sounds but it sounded a little bit out of control, I think. I would try something more gradual, as loud as I can. Essentially, do it better.

differences in work done with the composer as compared to the other performer). RP discusses interaction with the composer Jean-Emmanuel Filet:

> RP: Oui c'est ça, mais je ne sais pas ce que t'en pensais mais je trouvais que c'était le fun de mélanger des fois, les harmonies de ça. Je sais que Manu voulait pas mais …
> DAG: Oui je l'ai essayé une fois puis ils m'ont dit de ne pas le faire donc je ne l'ai pas fait, donc je n'ai pas eu l'expérience d'expérimenter avec ça.[19]

On a more theoretical level, some differences arise between KI and JC, which relates to the process of appropriation. JC describes a conceptual approach,

> JC: Je fais le geste et musicalement j'entendais et je faisais un rapport de ce que musicalement j'entendais et je faisais un rapport de ce que je faisais avec la musique aussi. Ma façon de jouer est toujours basée là-dessus. J'essaie toujours de transformer tous mes concepts en son. Alors je ne pense pas au geste de ma main mais je pense au son que ça va faire.[20]

while KI, in Table 18, describes a fundamentally inductive empirical approach, emphasized by the exemplification with gestures.

TABLE 18. Description of the appropriation process.

KI:	Pour moi c'était plus une question de sensation ; si je bouge ‡ ces doigts ‡ qu'est-ce qu'il se passe ? ‡ paume tendue devant la camera, les doigts bougent imperceptiblement vers le buste ‡
KI:	si je bouge ‡ ça ‡ qu'est-ce qu'il se passe ? ‡ paume tendue devant la camera, les doigts bougent vers la camera ‡
KI:	et donc tu sais.. je sais logiquement que c'est à cause du montant de lumière ; mais pour moi c'était plus ‡ dans le geste et vraiment dans la sensation‡ que j'ai pris mes décisions. Est-ce que ça fait du sens ? ‡ main droite en pince vient heurter plusieurs fois la paume de la main gauche ‡
JC:	OK, je comprends ca. Mais on se rejoint là-dessus parce que ‡ comme je te disais avant ‡, j'essayais toujours de, même si je connaissais, de, ok je fais ça, mais c'est mon oreille qui guidait à la fin là. ‡ le regard se tourne vers le chercheur puis revient vers KI ‡

Discussion

During the rehearsal process, performers develop practice ability in relation to live electronics for a specific work. The context of rehearsal is thus critical:

> JC: C'est ça la preuve, c'est important d'écouter ce qu'on fait, de travailler tes gestes sans avoir ton résultat sonore c'est pas… quand tu fais une musique mixte il faut avoir

[19] RP: Yes, that's it, I don't know what you think, but I think it was fun to mix sometimes, these harmonies. I know that Manu didn't want it, but..
DAG: Yes, I tried once and they told me not to do it so I didn't, so I didn't experiment with it.
[20] JC: Here I do the gesture and musically, I was hearing and I related it to what I was hearing and I related it to what I was doing with the music too. My way of playing is always grounded in that. I always try to transform my concepts into sounds. So I don't think about the gesture of my hand instead I think about the sound it will make.

ton dispositif le plus tôt possible dans la mesure du possible parce que ça change comment tu travailles énormément.
K: Oui énormément.. ça changeait énormément tout le timing de la dernière section.[21]

These statements converge with Berweck's (2012) position: "since the performer has to be intimately acquainted with the machinery used on stage, it is paramount to rehearse with the exact same devices" (p. 217)[22]. The opposite is exemplified by the case of the piece by Brice Gatinet. The composer neglected several important requirements of the process. First of all, the performers, PAM and GI, never rehearsed with the electronic part before the day of the concert; PAM states that "on a commencé à travailler avec l'électronique très très tard. Donc y'a pas eu une grande periode d'adaptation. Dans le fond la première fois qu'on l'a essayé dans un setup de concert, c'était le jour même"[23]. According to Furniss and Dudas (2014),

> *it has been all too common for performers to be confronted with the electronics for the first time at the dress rehearsal stage of an event. By contrast, a more embedded learning practice, in which a musician has been able to adjust, rehearse with, and interact with the computer at home, is an entirely different experience" (p. 458)*

Second, the notation of electronics was primarily provided as a waveform. Third, GI is not fluent in French, which is a particular hindrance in the context of a discussion focusing on timbre, limiting the verbal interaction between the two performers in the context of the cross self-confrontation. For these reasons the data was not analyzed. PAM comments largely on the lack of work with the electronics, a situation significantly different from that of the other works. For example, MCL describes the work process in Table 19. This last example also depicts a situation where one of the performers worked more closely with the composer than the other (but nevertheless following the requirements), which is also true in the case of JC (as compared to KI). Still, the data shows no relation of lead (in terms of turn taking) in the discussion in relation to this fact.

TABLE 19. Appropriation of live electronics.

JMB:	Oui. Moi j'ai répété uniquement ici. Je pense qu'on y a passé 3 heures.
MCL:	Moi j'ai fait quelque chose de plus que lui. J'ai fait la première grande session où on a définit le matériau musical, on a décidé quels genres de modes de jeu, tous les trucs très doux, où on entend comme une espèce [de balayage… Non, pas les sons de nuages, les balayages harmoniques au début, où on entend juste le sax résonner, puis ¶ les petits aigus qui sortent ¶, ça on a fait ça 10 mn avant la fin de la séance puis ils ont aimé ça alors on a décidé qu'on allait travailler ça. ¶ la main droite pointée vers l'avant au dessus du niveau de la tête fait un mouvement d'ondulation horizontale ¶
JMB:	[les sons de nuages ?
MCL:	Ce n'était pas supposé être dans la pièce, mais c'est arrivé. C'est pour ça qu'il faut passer du temps, les accidents fertiles, les surprises ça arrive juste quand il y a du temps puis finalement.

[21] JC: That's the proof, it's important to listen to what you are doing; to practice your gestures without the sound rendering is not.. whenever you play mixed music, you need the setup as soon as possible. Because it changes the way you work enormously.
KI: Yes, enormously.. it changed all the timing from the last section enormously.

[22] Berweck (2012) then adds: "since it is only possible to be acquainted with a limited range of devices, they must be flexible enough to be used in a wide range of settings" (p. 217).

[23] "We started with the electronics very very late. So there wasn't a period of adaptation. In the end the first time we tried the setup was the day of the concert".

The linguistic analysis of this research is based on methodological instruments already used in the musical domain, consistent with research that is fundamentally interdisciplinary. A deeper linguistic analysis would require larger multidisciplinary projects with researchers in each domain grounding the interdisciplinary study presented in this paper. Similarly, the transcription of onomatopoeias and vocal imitations could benefit from a phonetic transcription (see Bellemare & Traube, 2006).

Our study proposed a fundamentally qualitative enquiry in mixed music with live electronics performance. This research could be extended with a mixed-methods perspective, that is to say, using quantitative instruments for triangulation and complementarity (see Greene, 2008). In the context of gesture, Leman (2010) advocates for such an approach: "the study of gestures cannot be reduced to merely objective measurements of sounds and body movements, nor to simply descriptions of personal experiences and interpretations thereof " (p. 149). He encourages the use of three complementary perspectives: 1) phenomenal self-observation; 2) intentionality and social interaction in gesture (including the question of empathy); and 3) the purely quantitative perspective of gesture tracking. Our research paralleled the first two perspectives, with 1) self-confrontations and 2) cross self-confrontations. The inclusion of the third perspective is thus a logical extension of this research. Fritz and Dubois (2015) also assess the relevance of mixed methods in the context of musical acoustics: "this search for correlations between 'subjective' (psychological/perceptual) and 'objective' (physical/acoustical) properties of musical instruments is nowadays a general issue in musical acoustics" (p. 369).

In terms of limitations, the decision to rely on new works limits the scope of the research, taking into account that it does not include the whole range of the professional activity under investigation. Another limitation of this research is the focus on French, a potential extension of this research would be to address other languages used in similar professional environments. Finally, this research could benefit from a more extensive range of gesture control paradigms, following Cadoz and Wanderley's (2000) typology.

Another direction of research would be to include live electronics musicians (LEMs)[24] into the same methodological framework. The role of the LEM was indeed critical in some of the works studied in this paper. Specifically, in the case of the work by Analia Llugdar and Cédric Camier, the co-composer Camier acted also as LEM, as discussed by MCL:

> je pense aussi que Cédric était quand même là, comme par exemple dans le passage qu'on a vu tantôt je sais qu'il ajustait des petites choses live.[25]

Finally, the methodology we proposed may benefit the pedagogy of mixed music with a converging interest in transmission of expertise using multiple modalities. As Reid (2002) reminds us: "both the pedagogical and the psychological literature suggests that listening to the performance of others is the most effective means of developing interpretative skill" (p. 107). In the context of our study, several participants gave spontaneous feedback, emphasizing the fact that while they were not used to this activity of analysis and co-analysis, they found it enriching.

[24] Plessas and Boutard (2015) propose the term *live electronic musician* (LEM), as a distinction from the computer music designer, emphasizing the activity of performing the electronics of mixed music during the concert. They further describe their professional role in relation to the adaptation of the system for the needs of the performance.

[25] "I think also that Cédric was present, for example during the part we just saw, I know he was controlling small things in real time".

Conclusion

This interdisciplinary qualitative research proposed a method for the investigation of performance in mixed music with live electronics with a specific purpose, namely, questioning the transmission of an expertise developed for a specific piece. In this context, we compared the case of mixed music with live electronics to previous research focusing mainly on instrumental music and demonstrated that the conceptual frameworks they propose, with regard to timbre and gesture description, are relevant in this new context. We conducted cross self-confrontations for the investigation of performance knowledge in relation to live electronics. We applied a series of analysis instruments stemming from research in linguistics, psychology, and music technology (human computer interaction) conceptualization. We shed light on the thickness of the performance practice for the repertoire and the co-construction of the performance activity in relation to a specific work and a specific technological setup. We described the multimodal strategies – including multiple types of verbalizations, gestures, onomatopoeias and sound imitations – for this co-construction in comparison with the literature on instrumental music and new instruments. In this context, the research presented some intricate relationships between gesture and timbre in the context of mixed music with live electronics, and discussed the variety and complementarity of the experience-sharing strategies of each performer.

The multimodality of the expression of the experience, the intra-personal and inter-personal variety of these modalities, and the cross-fertilization between timbre and gesture are visible in the data we collected. These dimensions of the research advocate for a holistic strategy of transmission and documentation, that is to say in a mixed-methods, multimodal, multi-expertise (including all agents of the creative processes), and distributed environment (building on the research and practice communities). From this perspective, the theoretical and practical tools to be proposed are critical. We advocate for new frameworks building on the methodology grounding our research in terms of data collection as well as analysis, that is, cross self-confrontations and multimodal conceptual frameworks. As a qualitative study, we investigated the variety in the data; we do not seek or claim to generalize our outcomes. The goal is rather the generalization of the method in order to account for the whole range of expressive modalities in transmission, documentation, and potentially pedagogical strategies for solo works of mixed music with live electronics. As discussed in the previous section, future directions in terms of research and practice should seek to investigate the convergence of this type of qualitative methods with quantitative methods to help further disseminate the repertoire in relation to performance expertise, an expertise that is always in the process of co-construction.

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Appendix A: Transcription codes

[	Overlap	. .. ...	Pauses
/	Ascending tone		
\	Descending tone	ºtextº	Whispered
xxx	Indistinct	TEXT	Accentuated

§ §	Indication of the beginning/end of a gesture for DAG, described on the following line
† †	Indication of the beginning/end of a gesture for RP, described on the following line
$ $	Indication of the beginning/end of a gesture for JC, described on the following line
‡ ‡	Indication of the beginning/end of a gesture for KI, described on the following line
£ £	Indication of the beginning/end of a gesture for MCL, described on the following line

APPENDIX B: Translation of tables

Table B2

RP: Exactly, here we are not so much the agents of the sound production, I think.
DAG Yes, § here §, let's say,
:
§ point at measure 3 (corresponding to the notated effect of delay and reverb) §,
DAG § we throw pebbles in the water §,
:
§ gentle gesture mimicking the action of throwing something in front of oneself with the index and thumb pinched of the right hand §,
DAG Then we create small patterns [with the waves we created,
:
RP: [((laughs))
DAG But § here §…
:
§ points at measure 12 (see Figure 1) §,
RP: That's a good metaphor.
DAG Really, we are modeling the clay
:

Table B3

DAG That is very different, between… because the flanger section… very "clean".
:
RP: † YES, [yes †
† approves †,
DAG [and the result is rather interesting, § ((onomatopoeia: preubeleu)) §, it's real
: subtle, really different
§ the hand placed horizontally on the right at the face level, and pointing forward, the fingers making non-synchronized pinching movements against the thumb §
RP: In relation to the pedal ? or hum…
DAG In relation to the flanger, because the flanger reacts to the amount of resonance…, and
: this section is *poco pedale*, so what does that mean *poco* ? [you played poco, I played poco, but in different ways and the results are…
RP: [† ((laugh)) † Yes right
† approves †
RP: xxx. Yes, that's it, but the results are very different, I find it interesting the color it brings this way.

Table B7

DAG: The need I had in this section, § it was to hide behind, in a certain way §.

§ slow balance movement with both hand horizontal and fingers pinched with a slight desynchronized movement, transforming into virtual piano playing. §

DAG: And then.. I thought that.. in this section, section 12, the harmonizer matched my idea better.. to hide behind the harmonizer.

Table B8

KI: Especially, I wanted to listen to the sound of the electronics ‡ with the acoustic gesture ‡ on the vibraphone.
‡ virtual hit on a vibraphone, while the left hand stays at a fixed distance from the laptop camera, palm facing the instrumentalist. ‡

Table B9

JC: And here I do the same, $ when I do huuuuuuououuuuuu-pam $ I try to close it and when I close it, I remove my note, you see.
$ the right hand hold the mallet above the vibraphone, the left hand moves toward the camera, palm forward and half-closed, and stops abruptly as the mallet in the right hand hits the vibraphone. $

Table B10

JMB: No, like here, at the end, it's exactly the same effect, ¶ brrrrrrrr ¶ the background noise that I like very much.
¶ hands, forming a horizontal circle, spread apart. ¶

Table B11

MCL: This, do you think that £ finally, it was doing £
£ the right hand holding a virtual mute, does a vertical back and forth wide movement. £

MCL: the same as £ that? £
£ the left hand, index finger pointing forward, does an horizontal back and forth movement £

JMB: Yes. But maybe, moving this way, we send some light on the…

Table B12

KI: That is a great reflex that you have here… "Oh no, ‡ I really should not let more light come through ‡.

‡ the left fist comes to block the field-of-view of the camera ‡

Table B14

KI: That was not the same gesture, where we had to keep it still and then move away, it was more like ‡ on or off ‡

‡ the palm parallel to the chest is projected forward and back ‡

Table B15

MCL: I have a question: did you try to keep the mute stable? Let's say that you were half way, were you careful not to move, so that… If you stayed still, did you feel that it had an impact?

JMB: Me, I was respecting and doing was written. Did I stand still? You mean, was the stable? I did not think about that, but I tried to look at the black box and when the light was on, I tried to keep the same intensity.

Table B16

KI: Here, for example, I think that here, we had exactly the same idea. I see it in his gesture, ‡ it's really to ‡ …

‡ right hand, fingers pinched, is placed above the left palm ‡

KI: Follow the ‡ crescendo ‡ of the electronics.

‡ the right hand moves quickly away from the left hand, fingers spreading apart in a fan shape ‡

KI: Even ‡ the gesture itself was slower, ‡

‡ the left palm moves swiftly to the front of the camera, in a vertical position with fingers pointing up, and comes to a standstill ‡

KI: in ‡ comparison to every other gesture, it was slower, ‡

‡ the left palm in the same position moves away very slowly from the camera ‡

KI: ‡ it was following, following, and then it was very fluid ‡

‡ continuing the same gesture, the chest rotates towards the vibraphone ‡

KI: and then ‡ $ I think that, I don't know, I feel like we shared ‡ $ this [idea,

‡ KI turns to JC and the hands, palms vertical in front of the bust, move back and forth, in opposition of phase, towards JC‡

$ JC approves $

JC: [yeah, yeah.

KI: ‡ the idea that it should be absolutely fluid, a gesture, ‡ this gesture,

‡ palms, forming a right angle, move slowly from the camera of the laptop towards the vibraphone, then accelerating circle back up to the laptop ‡

KI: or ‡ two of them, but […‡ bound together,

‡ both hands opened with spread fingers converge and join quickly, fingers slightly interlacing each other ‡

JC: [quite true
KI: ‡ so that there is a real connection ‡
‡ rotation of the chest and arms, hands opened, moving from the laptop to the vibraphone with a slight upward direction and then an accelerating fall towards the vibraphone, palms horizontal on the vibraphone ‡
KI: So that, effectively, we ‡ come to this chord ‡. There it is. That is…
‡ hands raise up et spread apart, the right hand at the level of the hair, the left hand at the level of the chest‡
KI: [yes…
JC: [Absolutely right.

Table B17

JC: So I had the choice to do $ … $
$ pressing on the pedal, plays with the right hand while the left hand sticks to the screen of the laptop, blocking the camera, releases the pedal for the last note $
JC: to end…, $ release the hand $, and wait for the next part that started with a low note, ((onomatopoeia: doooooouuu)).
$ release the pedal for the last note $
JC: Or, to play everything, $ …$,
$ pedal pressed, plays with the right hand while the left hand rests on the laptop screen blocking the camera $
JC: $ release the hand,$
$ slowly removes the hand from the camera while the pedal is still pressed $

Table B18

KI: From my point of view, it was more a question of sensation. If I move ‡ these fingers, ‡ what happens?
‡ palm facing the camera, while the fingers move slightly toward the chest ‡
KI: if I move ‡ this ‡ what happens?
‡ palm facing the camera, the fingers move towards it ‡
KI: so you know.. I know, logically, that it relates to the quantity of light, but for me, it was more ‡ in relation to the gesture and the sensation ‡ that I was making decisions. Does it make sense?

‡ right hand with pinched fingers bumps several times into the left palm ‡
JC: OK, I understand that. But we converge on that, because ‡ as I said before ‡, I always tried to, even though I knew, to, ok I do that, but in the end it was my ear that was directing.
‡ looks towards the researcher then back to KI ‡,

Table B19

JMB: Yes, I rehearsed only in this space. I think we spent 3 hours.

MCL: Me, I did something more. I took part in the first long session where we defined the music material, we decided which playing modes, all the very soft things when we hear some sort [of a sweeping… No, not the cloud sounds, the harmonic sweepings at the beginning, where we just hear the sax resonating, then ¶ the small bright notes coming out ¶, we did that 10 minutes before the end of the session, then they liked it so we decided to work with that.

¶ the right hand pointing forward, above the head, undulates horizontally ¶

JMB: [the cloud sounds ?

MCL: It was not meant to be in the piece, but it happened. That is the reason why we need to spend some time, the fertile accidents, the surprises, finally, it happens only when we have time.