Guillaume Boutard and Catherine Guastavino
Centre for Interdisciplinary Research in Music Media and Technology
(CIRMMT) and School of Information Studies
McGill University
3661 Peel Street
Montreal, Quebec, Canada H3A 1X1
guillaume.boutard@mail.mcgill.ca,
catherine.guastavino@mcgill.ca

Following Gesture Following: Grounding the Documentation of a Multi-Agent Music Creation Process

Abstract: The documentation of electroacoustic and mixed musical works typically relies on a posteriori data collection. In this article, we argue that the preservation of musical works having technological components should be grounded in a thorough documentation of the creative process that accounts for both human and nonhuman agents of creation. The present research aims at providing a ground for documentation policies that account for the creative process and provide relevant information for performance, migration, and analysis. To do so, we analyzed secondary ethnographic data from a two-year creation and production process of a musical work having a focus on gesture following. Using grounded theory, we developed a conceptual framework with different levels of abstraction and consequent levels of transferability to other creative contexts. Finally, we propose several paths for grounding a subsequent documentation framework in this conceptual framework.

The preservation of musical works involving electroacoustic technologies requires preserving the means to re-perform the work. As Bernardini and Vidolin (2005) stated, "live electro–acoustic music currently possesses notational conventions and practices that can be compared at best to [medieval] tablatures." In this context, the relationship between the preservation of musical works involving electroacoustic technologies and their documentation is long established (e.g., Battier and Landy 2004; Bernardini and Vidolin 2005; Wetzel 2006). But on which documentation basis should we address their preservation? A posteriori documentation is a standard process for institutions dealing with music archives (e.g., the archive database at the Institut de Recherche et Coordination Acoustique/Musique [IRCAM] in Paris), but it may be insufficient for preservation purposes. Indeed, "[software] programs are often developed over time through the collaborative imaginative labor of several authors. Because of this inherent temporal and social mediation, the resultant baroque totality is extremely difficult to decode after the event and is thus opaque to the reconstruction of its total logic—the necessary prerequisite for documenting it" (Born 1995, p. 276). Born refers primarily to IRCAM's specific artistic production, but the importance of the process of artistic creation has also been emphasized in other contexts. Zattra (2007) reconstructs the compositional process in electroacoustic music using a combination of "philological and historical analyses" (p. 39). She considers that without the composer's "comments, recollections, feedback, and supervision, this research [the analysis of the creative process of John Chowning's work *Stria*] could often have encountered a 'dead end'" (p. 39). Saaze (2011) emphasizes that installation art cannot be understood separately from actors and museum practices, and advocates for an ethnographic approach to curation. In the context of the preservation of video games, Winget (2011) considers that "each piece of hardware and software has a history of creation of its own, as does the design of the game as a whole" (p. 1879) and also advocates for ethnographic studies of stakeholders involved in creation and use. As a consequence, we argue that the preservation of musical works involving electroacoustic technologies should be grounded in a thorough documentation of creative processes.

Theoretically, the relationship between technology and the processes of its creation is a fundamental research question in science and technology studies, since "technology does not develop according to an inner technical logic but is instead a social product, patterned by the conditions of its creation and use" (Williams and Edge 1996, p. 2). This social process is further emphasized by the context

Computer Music Journal, 36:4, pp. 59–80, Winter 2012

of preservation of electroacoustic technologies, whose best practices rely on a constant effort of migration (Polfreman, Sheppard, and Dearden 2006; Yong 2006). Specifically, the black-boxing process, i.e., "a process that makes the joint production of actors and artifacts entirely opaque" (Latour 1999, p. 183), is relevant to preservation issues of art installations (Saaze 2009), and we argue that it is also relevant for preserving musical works involving electroacoustic technologies. Magnusson (2009) raised the question of knowledge inscription processes within new digital musical instruments. He described these new digital musical instruments as black-boxed instruments containing the knowledge of their inventors (p. 171). Because the more successful the technology is, the more opaque and obscure it becomes (Latour 1999, p. 304), exposing the creative process and knowledge embedded in these black-boxed instruments becomes a challenging issue of a musical work's preservation, especially for works using electroacoustic technologies.

Specifically, creative processes in electroacoustic and mixed music involve numerous agents. Teamwork in the performing arts has received research attention (e.g., Rouse and Rouse 2004). But our contribution is to extend this line of inquiry by having documentation methodologies further include nonhuman agents as an integral part of the music creation process, as "nonhumans also act, displace goals, and contribute to their redefinition" (Latour 1994, p. 38). Zattra (2006) already identified six agents in electroacoustic music creation: composers, listeners, computer music designers (a.k.a. musical assistants), performers, performance devices, and instruments for sound generation. Gurevich and Treviño (2007) further theorized an ecological view of music creation that accounts for "the complex interrelation of human and non-human agents" (p. 106) involved in the creative process. In terms of human agents, artistic creative processes challenge the specification of precise roles (Benghozi 1995). Menger and Cullinane (1989) specifically emphasized the complexity of the relationship between the computer music designer and the composer whose success "depends on the full and entire cooperation of the assistant" (p. 99). Whereas Boulez (1986) considers that "research/invention individual/collective, the multiple resources of this double dialectic are capable of engendering infinite possibilities" (p. 494), composer Marco Stroppa specifies that interactions between composers and researchers occur in several ways: the composer as the absolute master (exemplified by Pierre Boulez); the composer as a "super-consultant" acknowledging the potential musical use of technology; and finally, composers and researchers as partners (Stroppa et al. 2010). In a similar vein, Delalande (2009) suggests investigating social practices during production and reception of electroacoustic music for analysis purposes.

Consequently, the present study investigates the multi-agent creative process of a mixed music work in order to provide new insights for documentation practice. This research departs from a strictly formal and technological approach to technology preservation, broadening the scope by offering a sociological approach where technology is just one agent among others.

Toward a Case Study on Gesture Following

In this context of multi-agent creative processes, we focus on an interactive composition involving gesture following, which was the object of an ethnographic data collection (hence this article's title).

Interaction and Gesture Following

Our study aims to include all potential agents of the creative process of musical works involving electroacoustic technologies. For this repertoire, we selected the paradigm of interactivity, because it involves performers, as well as other agents, throughout the creative process. As such, it accounts for all agents described by Zattra (2006) and for the link between agents and context identified by Gurevich and Treviño (2007), who state, "an ecological model of musical creation prohibits the isolation of musical interfaces from their artistic contexts" (p. 110). From a typological point of view, Tiffon (2005) considers that interactivity represents a situation on the fringes of his classification system for mixed music but acknowledges that it has become a central preoccupation of mixed music. Ungeheuer (in press) emphasizes interactivity in her theorization of music with live electronics. According to her, interactivity is one of the three conceptual approaches to live electronics and is especially quintessential. Interactivity therefore provides a relevant compositional approach for studying musical works involving electroacoustic technologies. On theoretical grounds, Rowe (1993) distinguishes between two interactivity paradigms: the instrumental paradigm and the player paradigm. The instrumental paradigm implies that "gestures from a human player are analyzed by the computer and guide an elaborated output exceeding normal instrumental response" (p. 8)—which is closely related to the *instrument augmenté* (Manoury 2007)—and the player paradigm relates to "an artificial player, a musical presence with a personality and behavior of its own" (p. 8). Both paradigms involve black-boxing processes and, therefore, are relevant to the preservation issues under study.

Specifically, we focus on gesture following, because it epitomizes interactivity in the creation of electroacoustic and mixed music (Bevilacqua, Rasamimanana, and Schnell 2006). Following the creative process of a work that focuses on gesture following provides us with a situation whose level of complexity is well suited to our concerns about preservation and our goal to inform documentation frameworks. In this sense, the current study, although grounded in a specific approach to interactivity, aims at being transferable to other creative contexts.

Florence Baschet's *StreicherKreis*

In 2006 Donin, Goldszmidt, and Theureau started a study at IRCAM on the creative process of Florence Baschet's string quartet augmented with electroacoustic processes, *StreicherKrei*s. Their goal was to inform cognitive ergonomics as well as music research with a focus on creative processes (Donin, Goldszmidt, and Theureau 2009). Our study will rely on a formal analysis of the data set they collected between 2006 and 2008, but our aim is to inform documentation practices.

During the research phase (six work sessions in the studio, from February 2007 to July 2007), Donin and colleagues collected ethnographic data about experiments and gesture-control technological system development with one or several performers. During the production phase (five work sessions in the studio, from September 2007 to October 2008) they collected further ethnographic data about the process of music creation. Both phases involved the composer, as well as the computer music designer (a.k.a. musical assistant), the scientific team and its leader, and different engineering teams (sound and electronics). This augmented string quartet project built upon a previous project on gesture following with the same composer: *Bogenlied*, a composition by Florence Baschet for augmented violin (Bevilacqua et al. 2006). For *StreicherKreis*, the gesture-following technological environment is composed, in particular, of the IRCAM Max/MSP library MnM and a module combining a three-axis accelerometer (Analog Device ADXL335) and a dual-axis gyroscope (InvenSense IDG500) (Bevilacqua, Baschet, and Lemouton 2012).

During the project's presentation meeting, on 6 February 2007, Florence Baschet stated, "this quartet is a real challenge, I would like it to really be 'augmented.' When I got involved with the gesture working group [at IRCAM], when I composed *Bogenlied*, I already had in mind the idea of this quartet, but it was not possible to start before we validated the possibility of using gesture as a real compositional parameter" (our translation; see Appendix, row 1). Based on this statement, we first note that the collaboration between Florence Baschet and the scientific team started as a super-consultant relationship during *Bogenlied* and later evolved into a planned true partnership for the quartet (to use the classification of Stroppa et al. 2010). Second, interactivity in *StreicherKreis* fits Rowe's player paradigm as much as his instrumental paradigm, a goal presented by the scientific team leader, who stated

Table 1. Video Data Captured During Work Sessions, Debriefings, and Interviews

	Work sessions		*Debriefing sessions*		*Interviews*	
	Video (min)	*Transcriptions (words)*	*Video (min)*	*Transcriptions (words)*	*Video (min)*	*Transcriptions (words)*
Project's presentation meeting (6 February 2007)			150	9,457		
Research phase (February–July 2007)	1,130	13,511	321	11,089	175	9,859
Production phase (September 2007–October 2008)	1,710	60,994	70	4,981	544	20,087
Final debriefing (19 November 2008)			136	9,088		
Total	2,840	74,505	677	34,984	719	29,946

at an early stage of the research phase, "the electronic part will emerge as a fifth performer" (our translation; see Appendix, row 2). As a consequence, this creation process provides us with a unique opportunity to analyze interactions between all agents involved in a context relevant to the preservation of musical works dealing with electroacoustic technologies.

Methodology

In this section, we present the data set and the challenges of its methodological analysis.

Data Review

Our large data set consists of video recordings of all work sessions (involving all participants) and debriefing sessions (with all participants but the performers) over two years, as well as video interviews (with several participants including the composer, the computer music designer, and the scientific team leader), scores, software, emails, notes, and reports (Donin, Goldszmidt, and Theureau 2009). We were also provided with transcriptions of video recordings. Table 1 summarizes the data set recorded during work sessions, debriefing sessions, and interviews, in terms of video duration and transcription length.

Secondary Data Analysis

Our analysis relies on grounded theory, an inductive method of theory development (Glaser and Strauss 1967), i.e., a way of producing a theory that is grounded in data, in contrast to the typical approach of starting from a hypothesis. Grounded theory consists of: (1) a method of formalization based on constant comparison at every level of analysis; (2) a specific sampling method; and (3) a specification of the saturation point, named *theoretical saturation*. The process is summarized by Strauss and Corbin (1998) as "data gathering driven by concepts derived from the evolving theory and based on the concept of 'making comparisons,' whose purpose is to go to places, people, or events that will maximize opportunities to discover variations among concepts and to densify categories in terms of their properties and dimensions" (p. 201). Grounded theory was developed for qualitative data and fieldwork but applies to different data-collection techniques (Glaser 1978). Strauss and Corbin (1998) consider that "researchers should approach already collected data and secondary or archival materials exactly as they would their own data" (p. 281). Szabo and Strang (1997) emphasize the need for large data sets for secondary data analysis. In our data set, we focused on data relevant to the documentation process of the technological part of the composition. We first reviewed the entire data set, with the support of a data index provided by IRCAM's Analyse des Pratiques Musicales (APM) team, in order to implement a strategy based on grounded theory's theoretical sampling, i.e., the way the analyst "decides what data to collect next and where to find them, in order to develop [her or] his theory as it emerges" (Glaser and Strauss 1967, p. 45). Consequently we started our analysis with data out of the project's presentation meeting, together with studio sessions and debriefing from the research phase. During the analysis we established relationships between statements from the debriefing sessions and corresponding work sessions. Then we extended the analysis to work sessions and interviews of the production phase, until we reached theoretical saturation (25,000 words out of a transcription corpus of about 140,000 words).

Not included in the analysis are interviews and work sessions that focused on instrumental practice or composition per se (with no link to electroacoustic aspects), or any discussions outside of the project context. We coded verbal data transcribed from the videos or written material (notes, reports, and emails), but not nonverbal information (such as behavior or facial expressions). Because transcriptions were often incomplete or sketchy, we reviewed all videos and completed the transcriptions for relevant incidents, i.e., the unit of analysis in grounded theory.

Analysis

We analyzed about 650 incidents (with 38 words per incident on average) using grounded theory's constant comparison analysis. Each incident could be classified into one or more categories.

Four main categories emerged from the data analysis: *organological specifications*, *knowledge lifecycle*, *production process lifecycle*, and *electroacoustic composition*, each one of them leading to a hierarchical structure of sub-categories. The inductive analysis principle of grounded theory tends to generate categories starting from low levels to reach, a posteriori, more abstract categories. But for the sake of argumentation we will instead discuss these categories from the more generic to the more specific. In this article's four figures, each of which depicts a categorization scheme, the most generic categories are displayed on the left side and the most specific sub-categories are displayed on the right. The following scheme is used for differentiation purposes: first-level categories are formatted in **CAPITAL LETTERS AND BOLD STYLE**; second-level categories in *CAPITAL LETTERS AND ITALIC STYLE*; third-level categories in ***bold and italic style***; and subsequent categories in *italic style*. The quotations in Tables 2, 3, 4, and 5 are our translations; please refer to the Appendix for the original quotations. The composer is referred to as COM, the computer music designer as CMD, and the scientific team leader as STL.

ORGANOLOGICAL SPECIFICATIONS

ORGANOLOGICAL SPECIFICATIONS (see Figure 1) refer to statements that define the project's specific organological setup. Organology is not restricted here to the musical instrument taxonomy but also includes computers, software, sensors, etc. (Stiegler 2003). It can be divided into two subcategories: *LOGICAL FUNCTIONALITIES* and *SYSTEMIC DEPENDENCIES*.

LOGICAL FUNCTIONALITIES

LOGICAL FUNCTIONALITIES describe the technological system in terms of logical entities involved in the specific goal of the project, namely (in the case of *StreicherKreis*), to produce an electroacoustic processing in relation to gesture. Three entities emerged from the analysis: ***data production***, ***data pre-processing***, and ***data processing***. Interestingly, this categorization can be related to Rowe's (1993) theorization of the processing stages of interactive computer music systems: "the first is the sensing stage, when data is collected from controllers reading gestural information from the human performers on stage. Second is the processing stage, in which a computer reads and interprets information coming from the sensors and prepares data for the third, or response stage, when the computer and some collection of sound-producing devices share in realizing a musical output" (p. 9). Our analysis,

Figure 1. Organological specifications.

ORGANOLOGICAL SPECIFICATIONS	LOGICAL FUNCTIONALITIES	***Data production***	*Typological specifications*	
			Contextualization	
		Data pre-processing	*Calibration*	
			Modification	
		Data processing	*Modeling*	*Extraction principles and procedures*
				Differentiation and segmentation principles
			Operationalizing	*Comparison and recognition principles*
				Comparison procedures
			Mapping	*Mapping principles*
				Entities
	SYSTEMIC DEPENDENCIES	***Reliability / Adaptability***	*To compositional properties and variations*	
			To organological properties and variations	
			To intra/inter-individual characteristics and differences	
			To performance context properties and variations	
		Engineering	*Architecture*	
			Libraries and versions	

however, revealed an additional pre-processing category, referring to issues of data *calibration* (see Table 2, quotation 6) and *modification* (see Table 2, quotation 7) mentioned recurrently throughout the whole creative process. *Modification* refers to various processes of data cleaning.

Within ***data production*** we distinguish between *typological specifications* and *contextualization*. *Typological specifications* refer to data-production systems' specifications that are not context-related. For example, the kind of measurements provided by sensors (see Table 2, quotation 3), characteristics of the signal (see Table 2, quotation 4), and data formats. *Contextualization* provides the link between the data production system and its organological context (see Table 2, quotation 5).

Data processing may be considered the core issue of the organological specification framework. It is a major goal of the project (see Table 2, quotation 8), specifically for the scientific team, whose leader is involved in other projects involving gesture following (Donin, Goldszmidt, and Theureau 2009). The relevance of this involvement relates to the link discussed later between **PRODUCTION PROCESS LIFECYCLE** and *KNOWLEDGE RANGE*. *Data processing* emerged as a threefold categorization that is not function-related and therefore is less work-specific. It describes broader concepts that refer to logical entities. This is not surprising, because the process of categorization tends to move toward greater levels of abstraction. For example, a distinction between gesture following and gesture recognition could account for more concrete levels of explanation, but this proved less relevant according to the method of analysis.

Modeling refers to the part of the process that builds up models needed for performance. On one side, this *modeling* activity is defined by *extraction principles and procedures*, i.e., theories and implementations that relate models' specifications to the signal (see Table 2, quotation 9), and, on the other side, by *differentiation and segmentation principles*, i.e., specification processes for models' boundaries (see Table 2, quotation 10).

Operationalizing is about using modeling outcomes within the real-time framework. It directly relates to performance. Within *operationalizing,* we distinguish *comparison and recognition principles*—that is to say, principles that relate the performance data to models—from *comparison procedures* that refer to actual processes. For instance, the composer at the beginning of the project emphasizes a non-Boolean comparison method (see Table 2, quotation 11) whereas the scientific team leader emphasizes a specific procedure (see Table 2, quotation 12).

Table 2. **Translated Quotations in the Category ORGANOLOGICAL SPECIFICATIONS**

ID	*Date*	*Session*	*Agent*	*Translation*
3	6 February 2007	Project's Presentation Meeting	STL	". . . the sensor, which is a three-axis accelerometer and a two-axis gyroscope. So the accelerometer measures accelerations according to three potential axes, and the gyroscope measures angular velocity according to two axes"
4	6 February 2007	Project's Presentation Meeting	STL	"in a way, it means that the work could be re-performed with something else. It could be re-performed with something other than accelerometers if we are ever able to provide the same kind of information"
5	19 September 2007	Interview COM+CMD	COM	"there is a small ring that goes in [. . .], which adapts to each bow, since each bow is different"
6	6 March 2007	Interview COM	COM	"sensor number two is poorly calibrated, it may provide more significant information in the future"
7	6 February 2008	Work Session (afternoon)	STL	"we should use a gate on sound again [. . .]"
8	19 September 2007	Interview COM+CMD	COM	"[. . .] gesture following, since it is . . . one of the main electroacoustic goals of this work, that is to say on the software side"
9	6 February 2007	Project's Presentation Meeting	STL	"we try to extract parameters by comparing these different [signal] units"
10	22 May 2007	Interview STL	STL	"what we do actually is listen to the whole work and specify 'here we switch to the next model'. For example there is this part where *écrasé* bow strokes chain up very fast with *martelé* bow strokes; we may even consider this a whole section"
11	6 February 2007	Project's Presentation Meeting	COM	"and the third interesting point is to recognize it [gesture] in context, out of context, played by a performer in two different ways, but also to be able to assess these differences between the way it was defined and the way it is performed. This is more interesting than simply saying 'I recognized it, I won,' which is poor"
12	22 May 2007	Interview STL	STL	"if this is the referenced played and if this is what is realigned with a margin of error, we draw a function between this and this to obtain that, then we calculate the slope, and it provides us with the difference mean"
13	19 November 2008	Project's Debriefing Meeting	CMD	"[. . .] at which point are there too many of them [sensors], When is it not worth it anymore since we cannot perceive anything? Indeed when each performer simultaneously controls only one synthesis parameter, [. . .], it works [. . .]"
14	2 April 2007	Work Session	COM	"I'd like to map his gesture on electroacoustic transformations, I receive very little gesture signal and I'd like to map it to bass frequency density"
15	6 March 2007	Interview COM	COM	"transposing up a sixth is no problem for gesture recognition"
16	15 January 2008	Work Session	CMD	"we have to adjust pressure a little bit, we changed potentiometers, now they are easier to calibrate"
17	22 May 2007	Interview STL	STL	"It is going to work better because there will be less variation in the way they play"

Table 2. Continued

ID	Date	Session	Agent	Translation
18	19 November 2008	Project's Debriefing Meeting	CMD	"whenever you play [. . .] in different concert halls [. . .], you need a fast adaptive system, you cannot do everything all over again each time. Now that is what you've got: a fast adaptive system"
19	19 September 2007	Interview COM+CMD	CMD	"you know it's not stable, even between a dress rehearsal and a concert. The follower has to have the widest possible variety, from almost good to not good at all."
20	26 September 2007	Interview STL	STL	"one machine will carry out everything related to sound processing, and another one will carry out the analysis"
21	30 October 2007	Work Session	COM	"B: and it's lib and. . . ? A: lib, snd, and FTM [. . .] B: OK, and which patch? A: October 30th, 2001"

Mapping, finally, is the arbitrary setting of relationships, *mapping principles* (see Table 2, quotation 13), between two *entities* (see Table 2, quotation 14). In our context, it refers predominantly to the relationship between the outcomes of the comparison, such as the one previously described, and electroacoustic transformations (a filter, a reverb, etc.).

SYSTEMIC DEPENDENCIES

SYSTEMIC DEPENDENCIES are twofold, either dealing with ***reliability and adaptability*** of the technological system, or with ***engineering*** dependencies. Within the category of ***reliability and adaptability*** we refer to four topics: *Compositional properties and variations* (see Table 2, quotation 15), *organological properties and variations* that describe the system's own capability to address variability (see Table 2, quotation 16), *intra-/inter-individual characteristics and differences* (see Table 2, quotation 17), and *performance context properties and variations*, a broad sub-category that relates to different kinds of performance context (see Table 2, quotation 18), as well as different kinds of performances (see Table 2, quotation 19).

On the other hand, ***engineering*** dependencies relate to usual technological dependencies in terms of *architecture* (see Table 2, quotation 20), and *libraries and versions* (see Table 2, quotation 21).

KNOWLEDGE LIFECYCLE

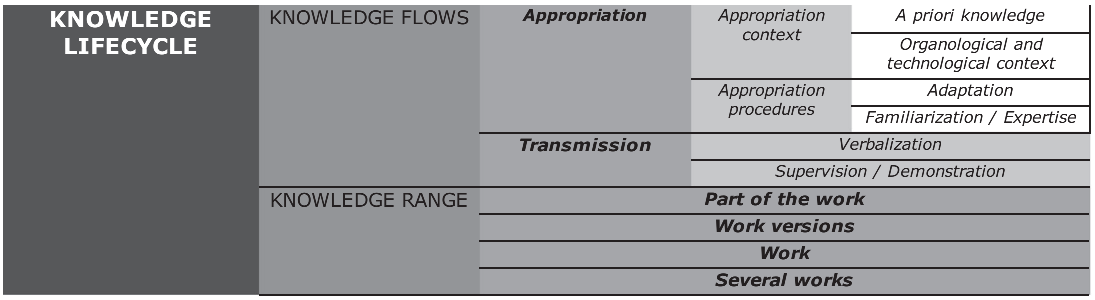
The **KNOWLEDGE LIFECYCLE** category (see Figure 2), which emerged from analysis, is a specific topic of interest for our research, as it relates to the notion of black-boxed instruments (Magnusson 2009).

KNOWLEDGE FLOWS

KNOWLEDGE FLOWS is the first sub-category of **KNOWLEDGE LIFECYCLE**. It describes knowledge processes involved in the creative process through two different types of process: ***appropriation*** and ***transmission***.

Appropriation is a complex process. As we will see, it involves far more agents than anticipated and is not limited to embodiment issues by performers. It can be divided into *appropriation context* and *appropriation procedures*. *Appropriation context* refers to external factors affecting the appropriation process. It involves both *a priori knowledge* (see Table 3, quotation 22), a broad category that also involves ***transmission*** between actors (see Table 3, quotation 23), and *organological and technological context,* which often refers to constraints imposed by the system (see Table 3, quotation 24). Generally speaking, this category is in direct relationship with **ORGANOLOGICAL SPECIFICATIONS** but also with other constraints such as the recurring discussion during the creative process about sound

Figure 2. Knowledge lifecycle.



feedback for performers (Donin, Goldszmidt, and Theureau 2009). On the other hand, *appropriation procedures* refer to *adaptation* (i.e., practice modification for this specific project; see Table 3, quotation 25), and *familiarization / expertise* (i.e., appropriation procedures which do not imply any specific prerequisites). These procedures are not limited to performers. Indeed, the computer music designer as much as the scientific team is involved in *appropriation procedures*, especially within *familiarization / expertise* procedures (see Table 3, quotation 26).

Transmission, on the other hand, is purposive, in the sense that it is a knowledge flow whose goal can be articulated but whose process is more or less tacit. It emerged through two sub-categories, namely, *verbalization*, which can be affirmative (see Table 3, quotation 27) or interrogative (see Table 3, quotation 28), and *supervision / demonstration,* which differs from *verbalization* because it implies more-tacit modes of transmission (see Table 3, quotation 29).

KNOWLEDGE RANGE

KNOWLEDGE RANGE, the second sub-category of **KNOWLEDGE LIFECYCLE**, places knowledge significance within a context. It answers the question, "What does it apply to?" The analysis revealed four contexts. ***Part of the work*** refers to knowledge that is related to a specific part of the composition (see Table 3, quotation 30). ***Work versions*** emerged from the analysis of the project debriefing session on 19 November 2008 (see Table 3, quotation 31). ***Work*** is about knowledge impacting the whole work (see Table 3, quotation 32). Because the work is the scope of this case study, these kinds of incidents are likely not to occur in the verbal data. Finally, ***several works*** refers to knowledge that is relevant to multiple compositions, either from the same composer, for instance, *Bogenlied* (see Table 3, quotation 33), or other composers.

PRODUCTION PROCESS LIFECYCLE

The **PRODUCTION PROCESS LIFECYCLE** (see Figure 3) specifies the project framework in terms of *PRODUCTION STEPS* and *WORKFLOWS*. It addresses critical aspects of the creative process.

PRODUCTION STEPS

PRODUCTION STEPS is a category that emerged from three sub-categories, namely, ***evaluation (test / validation)***; ***development***; and ***discussion, negotiation, and decision-making***.

Evaluation (test / validation) is a category often referred to because the whole creative process is punctuated by these processes. It is characterized by its goals (see Table 4, quotation 34) and its procedures (see Table 4, quotation 35).

Development is the logical counterpart of ***evaluation (test / validation)***. It relates to both software and hardware, and accounts for standard engineering practices in terms of features. It divides into *add /remove* (see Table 4, quotation 36) and *evolution / modification* (see Table 4, quotation 37).

Discussion, negotiation, and decision-making, the last category within *PRODUCTION STEPS,* relates to events that are usually of a shorter time span. Decision-making reflects the evolution of the

Table 3. Translated Quotations in the Category KNOWLEDGE LIFECYCLE

ID	*Date*	*Session*	*Agent*	*Translation*
22	6 February 2007	Project's Presentation Meeting	COM	"it implies instrumental practice because she worked her gesture eight hours a day at the conservatory; the repertoire implies being used to contemporary music [. . .] and then it implies note accuracy in a specific situation that relates to the instrument... and then it implies oral tradition [. . .]"
23	30 October 2007	Work Session	COM	"[Performer] and how do we know... or is this not important? [Composer] yes, you know it, [. . .]. So the one with the lead has the frequency shifter control with the pressure sensor. So actually you'll hear that these events work, [. . .]"
24	6 February 2007	Project's Presentation Meeting	CMD	"[. . .] we abandoned [the sensor's position] since it was too constraining"
25	2 April 2007	Work Session	COM	"to adapt his technique to this, we felt he had to play flautendos for a longer time so that it works"
26	6 February 2007	Project's Presentation Meeting	STL	"if something is not working and we clearly see why, [. . .] and the system reacts as expected because of this error, it still makes us move forward because we get familiar with the system [. . .]"
27	15 January 2008	Debriefing Session	COM	"I explained electroacoustic to them, what I wanted to do here and there"
28	12 February 2007	E-mail	COM	"1 I need details about the flautendo capture. 2 Does the accelerometer operate in 3D? [. . .]"
29	30 October 2007	Work Session	COM	"for example here is the violin 1 that... wait, I'm transferring it [sound effect] to violin 2, go ahead, play whatever you want and you will hear the frequency shifter that..."
30	19 September 2007	Interview COM+CMD	CMD	"in the first section there are comparisons between individual or inter-individual models, but it is not necessarily a conscious gesture control"
31	19 November 2008	Project's Debriefing Meeting	STL	"basically, if we were to perform it again in a month, I think I would move a marker to the beginning of a section and eventually restart the training of one section, or nothing... "
32	21 February 2008	Interview COM+CMD	CMD	"she used this experiment's outcomes again and it's true, since there is no need to do it all over again, and now you know what works and what doesn't work"
33	21 February 2008	Interview COM+CMD	CMD	"the granular synthesis, which is the same as the one in *Bogenlied*"

global project, and may provide accounts for critical steps of the process (see Table 4, quotation 38).

WORKFLOWS

WORKFLOWS refer to project management practices. It involves agents and the different ways they work together within the project framework, either in a direct ***collaborative*** way or in an ***independent*** way.

Collaborative processes emerged in two different ways: strict *teamwork,* which refers to the work conducted by several agents (usually at the same time and place; see Table 4, quotation 39) and *parallel processes and convergence* (see Table 4, quotation 40).

Independent, on the other hand, relates to processes that are, broadly speaking, sequential, either *round trips* (see Table 4, quotation 41) or in a strict *sequential and transitions* way, which describes

Figure 3. Production process lifecycle.

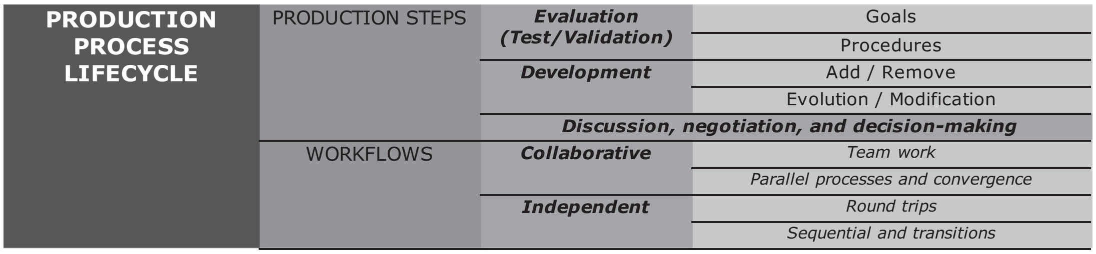


Table 4. Translated Quotations in the Category PRODUCTION PROCESS LIFECYCLE

ID	*Date*	*Session*	*Agent*	*Translation*
34	19 November 2008	Project's Debriefing Meeting	CMD	"we tested it, and we understood that the speed parameter wasn't doing anything"
35	26 September 2007	Interview STL	STL	"Florence usually started with Plot [. . .] we can view the data, we can see differences to some extent [. . .] and then we check how the system analyzes... and we can go back to Plot when things surprised us; when we can't recognize or follow something, we go back to Plot and carefully look at the details [. . .]."
36	12 April 2008	Interview COM	COM	"I removed some modules and work only on harmonizer, granular synthesis, frequency shifter, distortion, reverberation [. . .]"
37	26 September 2007	Interview STL	STL	"Things will change over here. Here we selected only one instrument and this is going to disappear... instead we will be able to select a group of sensors from any instrument"
38	19 November 2008	Project's Debriefing Meeting	COM	"then we fiercely negotiated with [the computer music designer], he told me that we wouldn't come back to real-time mode if ever we did that, we would stay in fake real-time mode. I said 'no way, we stay in fake real-time mode as long as the system is down and then we come back to real time mode"
39	19 November 2008	Project's Debriefing Meeting	COM	"We did a fine job with [the sound engineer], we played it in full, he listened to it, he understood perfectly, he took notes, etc."
40	21 February 2008	Interview COM+CMD	CMD	"I think Florence should work on events [Florence Baschet agrees], I should move forward too, and then converge before... in 15 days [. . .]"
41	6 February 2007	Project's Presentation Meeting	STL	"there were many round trips, you [Florence Baschet] were bringing parts of the score, and we would tell whether or not it was likely to work"
42	6 February 2007	Project's Presentation Meeting	STL	"for the time being we do things in batches [. . .] We are going to record all these phrases and then we'll check the system's behavior"

Figure 4. Electroacoustic composition.

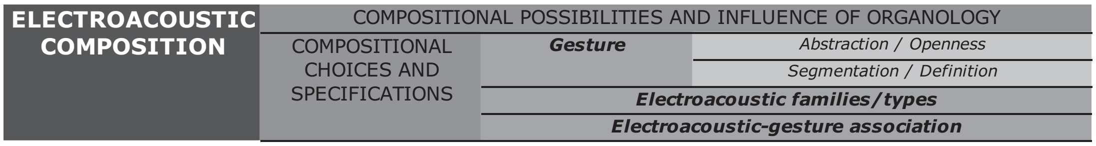


Table 5. Translated Quotations in the Category ELECTROACOUSTIC COMPOSITION

ID	*Date*	*Session*	*Agent*	*Translation*
43	21 February 2008	Interview COM+CMD	CMD	"the part we didn't talk about is the way we store events. So we are using Patter, and everything is here [pointing at the array of data], so this is the score"
44	40 October 2007	Interview COM+STL	COM	"the gyroscope 1 [first axis] is pretty interesting, I personally look a lot at gyroscope 1"
45	26 September 2007	Interview STL	STL	"[the Plot software] was very useful to Florence [. . .] she built up a representation, an intuition about the musical outcome of the sensors."
46	6 February 2007	Project's Presentation Meeting	COM	"I thought about [. . .] having another staff below the score and writing exactly... I didn't do it [. . .] because I wanted the performer to be involved in gesture [. . .]"
47	9 July 2007	Debriefing Session	COM	"[points at the crenel] these are trajectories, I switch between the violin et the cello. [. . .] [points at the diamond] these are complex forms made out of several gestures"
48	12 April 2008	Interview COM	COM	"And in terms of space, I conceived five different spaces."
49	11 July 2008	Interview COM	COM	"I tried this writing 2 by 2, with these thirty-second notes, really thinking about an electroacoustic transformation [. . .]"

sequential work but also the way an activity follows a previous one (see Table 4, quotation 42).

ELECTROACOUSTIC COMPOSITION

The last broad category, **ELECTROACOUSTIC COMPOSITION** (see Figure 4) may stand on the fringes of our research focus, namely, the inscription of knowledge in electroacoustic technologies. Indeed, this categorization is the most work-related and therefore the least likely to be transferable to other creative contexts. Still, composition-related statements were included whenever they referred to electroacoustic aspects. The **ELECTROACOUSTIC COMPOSITION** category is not a theorization of what electroacoustic composition is or should be. It is an account, grounded in data, of relationships between compositional questions related to electroacoustic concerns either theoretical or organological. In this sense, this category is relevant to our research. Indeed, there is a close relationship between sub-categories from **ELECTROACOUSTIC COMPOSITION** and categories previously described. It is composed of two sub-categories: *COMPOSITIONAL POSSIBILITIES AND INFLUENCE OF ORGANOLOGY* and *COMPOSITIONAL CHOICES AND SPECIFICATIONS*.

COMPOSITIONAL POSSIBILITIES AND INFLUENCE OF ORGANOLOGY

This category is, in the first place, a counterpart of the **ORGANOLOGICAL SPECIFICATIONS**' ***reliability / adaptability***, specifically the sub-category *compositional properties and variations*, from the composition point of view. An example is the use of technology to register events that constitute a kind of score (see Table 5, quotation 43). This specific point refers to what Schnell and Battier (2002) call a "composed instrument";

it "underlines the fact that computer systems used in musical performance carry as much the notion of an instrument as that of a score, in the sense of determining various aspects of a musical work." Furthermore, statements about the specific influence of organology on composition are included in this category. For example, the composer emphasizes a specific sensor property that appeals to her in relation to the compositional process (see Table 5, quotation 44). This is also a natural complement to *appropriation procedures* (Figure 2) on the part of the composer, for instance when the composer uses new software for compositional purposes, which implies *familiarization / expertise* (see Table 5, quotation 45).

COMPOSITIONAL CHOICES AND SPECIFICATIONS

COMPOSITIONAL CHOICES AND SPECIFICATIONS relates to the process of building a compositional discourse about gesture and its relationship to electroacoustic sounds. It is a compositional counterpart of *LOGICAL FUNCTIONALITIES*, especially ***data processing*** (see Figure 1). It can be divided into ***gesture***, ***electroacoustic families/types***, and ***electroacoustic-gesture association***.

Gesture contains two sub-categories: *abstraction/openness*, which refers to the level of specification of gesture from a compositional perspective (see Table 5, quotation 46), and the *segmentation / definition* of gesture, e.g., the different schemes defined and displayed with pictograms (see Table 5, quotation 47). ***Electroacoustic families/types*** refer to the compositional specification of electroacoustic aspects as regards the current musical work, e.g., the definition of different spaces by the composer (see Table 5, quotation 48). ***Electroacoustic-gesture association*** refers to compositional aspects of the established relation between electroacoustic aspects and gesture (see for instance Table 5, quotation 49).

Documentation Relevance

The outcome of our analysis is a complex categorization that portrays a creative process from four perspectives, each one of them bringing up relevant documentation issues. Considering the state of the art of documentation for musical works dealing with electroacoustic technologies, we are able to provide improvements in terms of the documentation of the knowledge involved in the creative process, its inscription within technological agents, and the ways nonhuman agents interact with human agents. Each of our four broader categories is of potential interest for future documentation frameworks and will be discussed independently.

ORGANOLOGICAL SPECIFICATIONS (see Figure 1) are typically addressed by existing documentation frameworks; still, our analysis revealed the importance of topics that are not traditionally covered. First, the significance of ***data preprocessing***, especially *calibration* processes, should be addressed. Indeed, any documentation framework relying on Rowe's (1993) classification might have overlooked this category that proved to be relevant in the analysis. Second, the network of *SYSTEMIC DEPENDENCIES* is of particular interest. As much as *LOGICAL FUNCTIONALITIES* deal with lists of features, characteristics, etc.—that is, the kind of data structure that documentation traditionally deals with—*SYSTEMIC DEPENDENCIES* relate to maps and networks. Indeed, this category portrays a complex network of relationships. If ***engineering*** seems straightforward, and potentially accessible through reverse engineering, the complex set of ***reliability / adaptability*** relationships appears to be a critical documentation issue for future performance (especially for *performance context properties and variations* and *intra-/inter- individual characteristics and differences*) and migration purposes (especially for *organological properties and variations*).

KNOWLEDGE LIFECYCLE (see Figure 2) is of specific interest to the question of nonhuman agents' involvement in the process of interaction. *KNOWLEDGE RANGE* relates to issues of cognitive relevance studied by Donin and Theureau (2007). On the other hand, *KNOWLEDGE FLOWS* points at essential documentation issues. First, ***appropriation*** should be documented both in terms of *appropriation context* and in terms of *appropriation procedures*. It is relevant for performers, therefore important for preservation for reuse, ensuring the sustainability of the repertoire. The scientific team leader provides us with a striking example of *appropriation procedures* on the performers' side: "I like the fact that they overplayed with the system . . . they get familiar with what is possible, before working in a more subtle way" (our translation; see Appendix, row 50). Furthermore, the analysis indicates that this category is also relevant for other agents, namely, for the engineers and researchers, therefore relevant for migration purposes. It also applies to composers and therefore is potentially interesting for music research; a shining example of appropriation by the composer is the use of Plot, a very generic plotting software provided but not used by the scientific team that the composer used in order to visually evaluate the compositional potential of gestural data in terms of data curves and their relationship to the electroacoustic composition (see Table 5, quotation 46). ***Transmission*** involves issues of tacit knowledge flows, an issue also relevant to ***appropriation***. If *verbalization* refers to knowledge made explicit, *supervision / demonstration* leans toward more tacit communication modes, which suggest that specific methodologies of data collection should be proposed for *KNOWLEDGE FLOWS*.

The category **PRODUCTION PROCESS LIFECYCLE** (see Figure 3) may at first sound irrelevant to documentation frameworks, but we argue quite the contrary. Creation is a process, and our analysis shows that all categories previously described are embedded in a temporal framework. First, categories within *PRODUCTION STEPS,* such as ***evaluation (test/validation)*** and ***development***, support **ORGANOLOGICAL SPECIFICATIONS** (see Figure 1), especially the ***engineering*** sub-category but also ***data processing***, whose principles and procedures evolved during the project. Second, the general lifecycle described with *WORKFLOWS* supports the **KNOWLEDGE LIFECYCLE** (see Figure 2) and accounts for the diversity and variability of roles (Benghozi 1995) within the creative process. Evolutions are critical. ***Reliability / adaptability***, for instance, changed over the lifetime of the project, and so did *appropriation procedures*. **PRODUCTION PROCESS LIFECYCLE** (see Figure 3) together with *KNOWLEDGE RANGE* account for interconnections of different lifecycles. As an example, the scientific team has its own agenda and produces knowledge that may be relevant for ***several works***, independently of the composer, as highlighted in this statement from its leader: "[things] we put aside temporarily . . . may come back later during other projects . . . according to the specific case of each composer" (our translation; see Appendix, row 51). Together with **KNOWLEDGE LIFECYCLE** (see Figure 2), this category questions documentation frameworks. Integrating lifecycles in documentation frameworks is relevant to account for the question of the visibility of the object's action, this is emphasized by Latour (2005) who considers that "when objects have receded into the background for good, it is always possible—but more difficult—to bring them back to light by using archives, documents, memoirs, museum collections, etc., to artificially produce, through historians' accounts, the state of crisis in which machines, devices, and implements were born" (p. 81).

The category **ELECTROACOUSTIC COMPOSITION** (see Figure 4), although more idiosyncratic, has close relationships with the other three, specifically with *KNOWLEDGE RANGE*. Furthermore, COMPOSITIONAL POSSIBILITIES AND INFLUENCE OF ORGANOLOGY and *abstraction / openness* relate to *compositional properties and variations* in ***reliability / adaptability***. *Segmentation / definition* provides a compositional counterpoint to *modeling* in ***data processing***, and *electroacoustic families/types* and *electroacoustic-gesture association* provide a counterpart to *entities* of *mapping*, as emphasized by composer Florence Baschet: "I prefer to choose it [the transformation type]; this is a compositional choice" (our translation; see Appendix, row 52).

As a consequence, in comparison to current documentation practice, the outcomes of the analysis provide a theoretical ground for a documentation framework. Each one of the four broad categories brings up a relevant point of view on documentation issues to further address.

Toward a Documentation Framework

The provision of this conceptual account of creative processes in the context of musical works with electroacoustic technologies aims to provide the basis for an unobtrusive documentation framework, that is to say, a framework that does not enforce a specific context of production. Nevertheless, unobtrusive does not necessarily mean transparent; the level of transparency should be specified whenever defining documentation policies.

Still, the outcomes of the analysis we presented are not documentation guidelines, but rather a conceptual framework grounded in data specifically relevant to preservation issues. Although it is beyond the scope of this article to implement a documentation framework informed by this conceptualization, several paths for future research are presented in order to highlight the impact of this study on documentation practice.

The focus on controversies, an object of study in science and technologies studies, is the first trail we propose to follow. Venturini (2009) states, "controversies begin when actors discover that they cannot ignore each other and controversies end when actors manage to work out a solid compromise to live together. Anything between these two extremes can be called a controversy" (p. 26). In our conceptual framework the category *PRODUCTION STEPS* and, specifically, the subcategory ***discussion, negotiation and decision-making***, provide us with the possibility to document the emergence and conclusion of some relevant controversies. A substantial part of this information could be embedded in a more generic software production–tracking tool, which could account for other relevant categories included in the broad category **PRODUCTION PROCESS LIFECYCLE**. Similarly, specific categories such as *LOGICAL FUNCTIONALITIES* can be enforced in a documentation methodology, controlling, for instance, the presence of specific ***data pre-processing*** documentation when an agent provides a technological setup at any point of the creative process. Furthermore, following Callon (1981), who studied the process of generalizing a solution to a broader context, this focus on controversies should be related to subcategories of *KNOWLEDGE RANGE* as part of the documentation methodology. That way, we may incorporate a specific subset of the conceptual framework into a documentary framework.

In order to account for knowledge that is more tacit, we can refer to previous methodologies developed in other contexts. Although the current study relied on the analysis of observational data and interviews collected during the creative process, less intrusive methods should be considered in order to minimize potential interferences with the creative process. In this view, a potential solution for documentation would be to follow the work of Donin and Theureau (2007), using what they call an *interview within situation simulation through material traces*, that is, by recreating a situation (in their case, the compositional situation) through the use of material traces and interviews. A convergent approach in a different domain, namely, the documentation of computer-mediated activity, is the semi-automatic approach of story-telling presented by Yahiaoui et al. (2011), which is also based on traces of activity. This data collection could take place at any relevant time in the course of the creative process with minimum interference.

Reliability and adaptability concerns should be documented with every version submitted during the process. The responsibility for providing a prototype for documentation at multiple stages of the creative process is delegated to the agents of the creative process. The involvement of human agents in the preservation of their work is necessary, but with such a documentation framework, the content becomes acknowledgeable, open to validation, and potentially with automated support.

A documentation framework may benefit from other research that specifically focuses on the ***appropriation*** of electronics by performers for further elaboration purposes. In a similar vein, Féron and Boutard (2012) conducted semi-structured interviews with performers about context, personal skills, notation of electronics, and collaboration with composers and engineers during the preparation process of mixed music with live electronics. On the basis of the current study, we may want to relate structured interviews in the domain of live electronics to data-collection methodologies proposed in previous research in the domain of video-game archiving, such as the player-produced walkthroughs used by Newman (2011). This approach expands the proposition Canazza and Vidolin advocated for in 2001 for handing down the performance praxis (Canazza and Vidolin 2001). Overall, interviews with participants, structured according to our findings, should be planned for data collection during relevant steps of the creative process, namely, in association with the **PRODUCTION PROCESS LIFECYCLE**.

Further research is needed to test the impact of such a documentation framework on digital preservation theory and on the preservation of musical works involving electroacoustic technologies. Specifically, different levels of implementation could be compared.

Discussion

Donin, Goldszmidt, and Theureau (2009) remind us of the fundamental fact that the creative process of *StreicherKreis* is historically situated. It is unlikely to be defined as a paradigmatic creative process that we could generalize to all musical works dealing with electroacoustic technologies. Donin and Theureau (2007) conducted a methodologically similar study on compositional processes with composer Philippe Leroux. Leroux (2010, p. 55), reflecting on this study, stated: "ils ont compris que la création artistique était un phénomène extrêmement riche, et qu'il serait tout à fait inintelligent de chercher à l'enfermer dans quelques lois qui ne pourraient être que réductrices" [they understood the extreme complexity of the artistic creation phenomenon, and that any attempt to define it in necessarily simplistic laws would be unreasonable (our translation)]. Therefore, our analysis is in no way an attempt to implement a formal system that would account for creative processes in music, an attempt likely to fail, but rather an attempt to identify abstract principles grounded in specific cases. The more abstract the principles, the greater potential they have to be relevant to other cases (Strauss and Corbin 1998).

This complexity of the artistic creative process stressed by Leroux was indeed a key component of Florence Baschet's creative process in *StreicherKreis*. Although idiosyncratic, this project, thanks to its extraordinary setup, provides us with a unique situation where interaction processes between agents are emphasized, captured, and therefore made observable. The availability of interactions between all agents of the creative process, along with the complexity and time span of the process, enabled us to zoom in on specific practices while situating them in a larger longitudinal perspective, which is highly relevant to documentation issues.

Although it is likely that some of these issues will not generalize to other, different creative process, a documentation framework should address their potential relevance. In this view, further investigations could enrich the analysis with case studies likely to address specific areas of concern, such as the one discussed in this section.

Regarding the data set, it should be noted that the technical setting varied during the process. Indeed, the video camera setup became complex during the production phase when the data-collection team decided to use three video cameras instead of one. There is a possibility that some data were not captured during the research phase with a single camera. In terms of completeness of the work process, we have to note that the recordings of rehearsals in the performance hall (before the premiere) were limited, because fixed cameras and microphones were unable to capture all interactions. Consequently, transcriptions were incomplete for the last two work sessions, which could account for limited interactions with sound engineers, present at the rehearsals, in our analysis. Lastly, the lack of performers' interviews tends to lessen their point of view in the analysis.

Nevertheless, the categorization, grounded in data, which emerged from the analysis process is an account of the specific situation of the creative processes under investigation. Its trustworthiness was controlled at different stages of development. The results were presented twice to the participants for validation at different stages of the research—first during the coding process and again at the end of the analysis process. In addition, we circulated a written report to all participants.

Conclusion

Heydenreich (2011) posits that documentation of installation art "is the basis for developing preservation strategies, planning loans and presentation, [and] determining environmental conditions and risk assessment" (p. 159). We argue that the situation is quite similar for musical works involving electroacoustic technologies. Specifically, documentation policies and preservation strategies are closely related, especially as migration is the current best practice in this field whenever an actual preservation strategy is endorsed.

The documentation basis we advocate for, in order to preserve music works with electroacoustic technologies, is informed by processes and lifecycles. Our analysis reveals the limitations of a posteriori documentation in accounting for the knowledge involved in the creative process of a musical work involving electroacoustic technologies and interaction between agents. It implies that the documentation has to be closely related to the process of developing the musical work. At the same time, the documentation methodology should be implemented in a non-obtrusive way without imposing technological and lifecycle constraints on the artistic workflow.

A documentation framework based on our categorization implies the need to address the question of data-collection methodologies, which have to reflect tacit knowledge as well as active participation of nonhuman agents, and to define what can be automated and what cannot. In the context of film preservation, Cherchi Usai et al. (2008) noticed that the amount of extra work that documentation policies imply may be too high, because "[articles and essays] assume that an archive would have the time to precisely collect the information about preservation, in a way which is clearly not applicable to archives that preserve a large amount of films" (p. 166). It is up to institutions (or individuals) to define their policy in terms of completeness of their documentation process. It is a question of negotiation, and in this view our study serves as the basis for accountable, informed documentation policies. These policies will have to account for what is and what is not part of their process according to their goals: re-performance, migration, and/or analysis.

Acknowledgments

This research was supported by Guillaume Boutard's doctoral fellowship from the Fonds québécois de recherche sur la société et la culture and was specifically funded by the CIRMMT Inter-Centre Exchange program. We would like to thank the composer Florence Baschet, the Quatuor Danel, and all participants of the production process of *StreicherKreis*. We would also like to thank Nicolas Donin and the APM team at IRCAM for hosting this research, providing both a challenging research environment and delicious tea.

References

Battier, M., and L. Landy. 2004. "Electroacoustic Musics: A Century of Innovation Involving Sound and Technology. Resources, Discourse, Analytical Tools." *Organised Sound* 9(1):1–2.

Benghozi, P.-J. 1995. "Les sentiers de la gloire: savoir gérer pour savoir créer." In Florence Charue-Duboc, ed. *Des savoirs en action*. Paris: L'Harmattan, pp. 51–87.

Bernardini, N., and A. Vidolin. 2005. "Sustainable Live Electro-Acoustic Music." In *Proceedings of the International Sound and Music Computing Conference.* Available online at smcnetwork.org/files/proceedings/2005/Bernardini-Vidolin-SMC05-0.8-FINAL.pdf. Accessed September 2012.

Bevilacqua, F., F. Baschet, and S. Lemouton. 2012. "The Augmented String Quartet: Experiments and Gesture Following." *Journal of New Music Research* 41(1):103–119.

Bevilacqua, F., et al. 2006. "The Augmented Violin Project: Research, Composition and Performance Report." In *Proceedings of the 2006 Conference on New Interfaces for Musical Expression*, pp. 402–406.

Bevilacqua, F., Rasamimanana, N., and Schnell, N. 2006. "Interfaces gestuelles, captation du mouvement et création artistique." *L'inouï* 2:101–111.

Born, G. 1995. *Rationalizing Culture: IRCAM, Boulez, and the Institutionalization of the Musical Avant-Garde*. Berkeley: University of California Press.

Boulez, P. 1986. "Technology and the Composer." In J.-J.Nattiez, ed. *Orientations: Collected Writings*, trans. M. Cooper. Cambridge, Massachusetts: Harvard University Press, pp. 486–495.

Callon, M. 1981. "Pour une sociologie des controverses technologiques." *Fundamenta Scientiae* 12(4):381–399.

Canazza, S., and A. Vidolin. 2001. "Introduction: Preserving Electroacoustic Music." *Journal of New Music Research* 30(4):289–293.

Cherchi Usai, P., et al., eds. 2008. *Film Curatorship: Archives, Museums, and the Digital Marketplace*. Vienna: Österreichisches Filmmuseum.

Delalande, F. 2009. "Pratiques et objectifs des transcriptions des musiques electroacoustiques." In R. Campos and N. Donin, eds. *L'Analyse musicale: une pratique et son histoire.* Geneva: Droz-HEM pp. 131–153.

Donin, N., S. Goldszmidt, and J. Theureau. 2009. "Organiser l'invention technologique et artistique? L'activité collective de conception conjointe d'une oeuvre et d'un dispositif informatique pour quatuor à cordes." *Activités* 6(2):24–43.

Donin, N., and J. Theureau. 2007. "Theoretical and Methodological Issues Related to Long Term Creative Cognition: The Case of Musical Composition." *Cognition, Technology and Work* 9(4):233–251.

Féron, F. X., and G. Boutard. 2012. "L'(a)perception de l'électronique par les interprètes dans les œuvres mixtes en temps réel pour instrument seul." Paper presented at Analyser la musique mixte / Analysing Mixed Music, April, Paris.

Glaser, B. G. 1978. *Theoretical Sensitivity: Advances in the Methodology of Grounded Theory*. Mill Valley, California: Sociology Press.

Glaser, B. G., and A. L. Strauss. 1967. *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago, Illinois: Aldine Publishing.

Gurevich, M., and J. Treviño. 2007. "Expression and its Discontents: Toward an Ecology of Musical Creation." In *Proceedings of the 2007 Conference on New Interfaces for Musical Expression*. pp. 106–111.

Heydenreich, G. 2011. "Documentation of Change—Change of Documentation." In T. Scholte and G. Wharton, eds. *Inside Installations: Theory and Practice in the Care of Complex Artworks*. Amsterdam: Amsterdam University Press, pp. 155–171.

Latour, B. 1994. "On Technical Mediation—Philosophy, Sociology, Genealogy." *Common Knowledge* 3:29–64.

Latour, B. 1999. *Pandora's Hope: Essays on the Reality of Science Studies*. Cambridge, Massachusetts: Harvard University Press.

Latour, B. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. New York: Oxford University Press.

Leroux, P. 2010. "Question de faire. La génétique musicale in vivo vue du côté du créateur." *Genesis* 31:55–63.

Magnusson, T. 2009. "Of Epistemic Tools: Musical Instruments as Cognitive Extensions." *Organised Sound* 14(2):168–176.

Manoury, P. 2007. *Considérations toujours actuelles sur l'état de la musique en temps réel.* Paris: IRCAM.

Menger, P., and D. Cullinane. 1989. "Technological Innovations in Contemporary Music." *Journal of the Royal Musical Association* 114(1):92–101.

Newman, J. 2011. "(Not) Playing Games: Player-Produced Walkthroughs as Archival Documents of Digital Gameplay." *International Journal of Digital Curation* 6(2):109–127.

Polfreman, R., D. Sheppard, and I. Dearden. 2006. "Time to Re-wire? Problems and Strategies for the Maintenance of Live Electronics." *Organised Sound* 11(3):229–242.

Rouse, W. B., and R. K. Rouse. 2004. "Teamwork in the Performing Arts." In *Proceedings of the Congrès Workshop "Human Supervision and Control in Engineering and Music,"* pp. 606–615.

Rowe, R. 1993. *Interactive Music Systems: Machine Listening and Composing*. Cambridge, Massachusetts: MIT Press.

Saaze, V. van. 2009. "Doing Artworks: An Ethnographic Account of the Acquisition and Conservation of No Ghost Just a Shell." *Krisis* 1:20–32.

Saaze, V. van. 2011. "Acknowledging Differences: a Manifold of Museum Practices." In T. Scholte and G. Wharton, eds. *Inside Installations: Theory and Practice in the Care of Complex Artworks*. Amsterdam: Amsterdam University Press, pp. 249–255.

Schnell, N., and M. Battier. 2002. "Introducing Composed Instruments, Technical and Musicological Implications." In *Proceedings of the 2002 Conference on New Interfaces for Musical Expression*. pp. 1–5.

Stiegler, B. 2003. "Bouillonnements organologiques et enseignement musical." In *Des outils pour la musique*. Chasseneuil du Poitou: CNDP, pp. 11–15.

Strauss, A. L., and J. M. Corbin. 1998. *Basics of Qualitative Research: Techniques and Procedures For Developing Grounded Theory* (2nd ed.). Thousand Oaks, California: Sage Publications.

Stroppa, M., et al. 2010. "Pensée conceptuelle pensée sensible en musique." In J. Dautrey, ed. *La recherche en art(s)*. Paris: Éditions MF, pp. 165–188.

Szabo, V., and V. R. Strang. 1997. "Secondary Analysis of Qualitative Data." *Advances in Nursing Science* 20(2):66–74.

Tiffon, V. 2005. "Les musiques mixtes: entre pérennité et obsolescence." *Musurgia* 12(3):23–45.

Ungeheuer, E. in press. "La musique électronique *live*. Vers une topologie de l'interaction interprète-machine." In N. Donin and L. Feneyrou, eds. *Théories de la composition musicale au XXe siècle*. Lyon: Symétrie.

Venturini, T. 2009. "Diving in Magma: How To Explore Controversies With Actor-Network Theory." *Public Understanding of Science* 19(3):258–273.

Wetzel, D. B. 2006. "A Model for the Conservation of Interactive Electroacoustic Repertoire: Analysis, Reconstruction, and Performance in the Face of Technological Obsolescence." *Organised Sound* 11(3):273–284.

Williams, R., and D. Edge. 1996. "The Social Shaping of Technology." *Research Policy* 25:865–899.

Winget, M. A. 2011. "Videogame Preservation and Massively Multiplayer Online Role-Playing Games: A Review of the Literature." *Journal of the American Society for Information Science and Technology* 62(10):1869–1883.

Yahiaoui, L., et al. 2011. "Redocumenting Computer-Mediated Activity from Its Traces: A Model-Based Approach for Narrative Construction." *Journal of Digital Information* 12(3). Available online at journals.tdl.org/jodi/article/view/2088/1756. Accessed September 2012.

Yong, K. 2006. "Electroacoustic Adaptation as a Mode of Survival: Arranging Giacinto Scelsi's *Aitsi Pour Piano Amplifié* (1974) for Piano and Computer." *Organised Sound* 11(03):243–254.

Zattra, L. 2006. "The Identity of the Work: Agents and Processes of Electroacoustic Music." *Organised Sound* 11(2):113–118.

Zattra, L. 2007. "The Assembling of *Stria* by John Chowning: A Philological Investigation." *Computer Music Journal* 31(3):38–64.

Appendix: Original Quotations

ID	*Date*	*Session*	*Agent*	*Original quote*
1	6 February 2007	Project's Presentation Meeting	COM	"[. . .] ce quatuor est un vrai challenge, je voudrais qu'il soit vraiment augmenté. Quand j'ai commencé à participer au groupe geste [à l'IRCAM], quand j'ai écrit *Bogenlied*, j'avais déjà en tête l'idée du quatuor mais c'était impossible de s'y attaquer tant qu'on n'avait pas validé la possibilité de travailler avec le geste comme un paramètre compositionnel à part entière"
2	22 May 2007	Debriefing Session	STL	"la partie électronique va devenir comme le cinquième instrumentiste"
3	6 February 2007	Project's Presentation Meeting	STL	"le capteur, qui est un accéléromètre trois axes et un gyroscope deux axes. Donc l'accéléromètre mesure les accélérations selon trois axes possibles et le gyroscope mesure les vitesses angulaires et les vitesses de rotation suivant deux axes"
4	6 February 2007	Project's Presentation Meeting	STL	"et dans une certaine mesure en fait ça veut dire que la pièce pourrait être refaite avec même autre chose en fait. Ca pourrait être refait avec peut-être pas des accéléromètres mais autre chose si on arrive après à déduire les mêmes types d'information"
5	19 September 2007	Interview COM+CMD	COM	"y'a une petite bague qui rentre sur la [. . .] qui est adaptée à chaque archet parce qu'il y a pas deux archets pareils"
6	6 March 2007	Interview COM	COM	"le capteur 2 est mal étalonné, et pourra donner des infos plus significatives à l'avenir"
7	6 February 2008	Work Session (afternoon)	STL	"faudrait remettre un gate sur le son [. . .]"
8	19 September 2007	Interview COM+CMD	COM	"[. . .] le suivi de geste, parce que c'est quand même... une des grandes finalités au niveau électroacoustique, enfin informatique de cette pièce"
9	6 February 2007	Project's Presentation Meeting	STL	"c'est en comparant ces différentes unités [de signal] entre elles... qu'on cherche à extraire des paramètres"

Appendix: Continued

ID	Date	Session	Agent	Original quote
10	22 May 2007	Interview STL	STL	"En fait ce qu'on fait, c'est qu'on écoute toute la pièce et on donne juste des indications 'là on peut passer à la détection suivante'. Par exemple y'a un exemple ou c'est les écrasés qui s'enchainent très très rapidement avec les martelés; à la limite on peut tout ça les prendre comme une section en entière"
11	6 February 2007	Project's Presentation Meeting	COM	"et il y a la 3ème chose qui est intéressante, c'est non seulement de le reconnaître, en contexte, hors contexte, joué par une interprétation, joué par le même avec une autre interprétation, mais aussi de pouvoir en apprécier, justement, les différences, entre la façon dont il a été élaboré et la façon dont il est interprété. Qui est plus intéressant que le simple fait de dire 'j'ai reconnu', j'ai gagné quoi, qui va rester pauvre"
12	22 May 2007	Interview STL	STL	"si ça c'est la référence ce qui est joué, et si ça c'est ce qui est réaligné avec erreur d'alignement, on met ça en fonction de ça et on obtient ça, puis on calcul la pente, et ça me donne la moyenne de cette différence [. . .]"
13	19 November 2008	Project's Debriefing Meeting	CMD	"[. . .] et à quel moment il y en à trop et c'est plus la peine parce qu'on perçoit plus? Et en fait que chaque instrumentiste contrôle un paramètre de la synthèse simultanément, [. . .] ça fonctionne [. . .]"
14	2 April 2007	Work Session	COM	"je voudrais régler son geste sur l'électroacoustique, je reçois très peu de gestes et je voudrais l'affecter à la densité des graves"
15	6 March 2007	Interview COM	COM	"la reconnaissance de geste n'a pas de problème si on transpose jusqu'à la sixte"
16	15 January 2008	Work Session	CMD	"on réajuste juste un petit peu les pressions, tu sais on a changé les potentiomètres, maintenant on arrive mieux à les calibrer"
17	22 May 2007	Interview STL	STL	"Ça va de mieux en mieux marcher parce que leur jeu va moins varier"
18	19 November 2008	Project's Debriefing Meeting	CMD	"quand tu joues [. . .] dans des salles différentes [. . .], il faut un système pour s'adapter vite, tu ne peux pas tout refaire à chaque fois. Là, tu avais un système où tu pouvais t'adapter vite"
19	19 September 2007	Interview COM+CMD	CMD	"tu sais bien que c'est instable, même entre une générale et un concert. Il faut au suiveur le plus de variété possible, entre le truc presque bien, et le truc pas bien du tout"
20	26 September 2007	Interview STL	STL	"y'a une machine qui fera tout ce qui est processus sonore et une machine qui fera tout ce qui est analyse"
21	30 October 2007	Work Session	COM	"B : et c'est lib et. . . ? A : lib, snd et FTM [. . .] B : OK, et ton patch c'est ? A : 30 octobre 001"
22	6 February 2007	Project's Presentation Meeting	COM	"ça passe par la culture instrumentale parce qu'elle a bossé pendant huit heures par jour au conservatoire pour faire son geste, le répertoire, ça passe par l'habitude de la musique contemporaine [. . .] et puis ça passe par la précision de la note dans telle situation liée à l'instrument... et puis ça passe par la tradition orale [. . .]"

Appendix: Continued

ID	Date	Session	Agent	Original quote
23	30 October 2007	Work Session	COM	"[Instrumentiste] et nous on le sait ou... c'est pas important ? [Compositrice] si, vous le savez, [. . .]. Donc celui qui a la ligne a le capteur de pression en temps réel sur le frequencyshifter. Donc en fait vous verrez que les événements fonctionnent, [. . .]"
24	6 February 2007	Project's Presentation Meeting	CMD	"[. . .] on a abandonné [la position du capteur] en cours de route, parce que c'était assez contraignant"
25	2 April 2007	Work Session	COM	"d'adapter son jeu à ça, on avait vu qu'il fallait qu'il tienne plus longtemps les flautendo pour que ça fonctionne"
26	6 February 2007	Project's Presentation Meeting	STL	"si quelque chose ne marche pas mais qu'on voit très bien pourquoi, [. . .] et que le système réagit exactement comme attendu parce que y'a cette erreur et tout ca, ca nous permet quand même d'avancer parce qu'on se familiarise avec le système [. . .]"
27	15 January 2008	Debriefing Session	COM	"je leur ai expliqué l'électroacoustique, ce que je voulais faire ici, ce que je voulais faire là"
28	12 February 2007	E-mail	COM	"1 j'ai besoin de précisions sur la captation du flautendo. 2 L'accéléromètre est-il en 3D ? [. . .]"
29	30 October 2007	Work Session	COM	"par exemple là c'est le violon 1 qui... attends je le [transformation du son] mets au violon 2, va y joue ce que tu veux, joue une ligne et tu vas entendre le frequencyshifter qui..."
30	19 September 2007	Interview COM+CMD	CMD	"dans la première section, c'est vraiment des comparaisons entre des modèles individuels ou interindividuels, mais ça c'est pas quelque chose qui est forcément contrôlé de façon consciente par le geste"
31	19 November 2008	Project's Debriefing Meeting	STL	"en gros, si on reprenait la pièce dans un mois, je crois qu'il y a un marqueur que j'avancerais au début d'une section et refaire éventuellement l'apprentissage d'une section, ou rien..."
32	21 February 2008	Interview COM+CMD	CMD	"elle a réutilisé les résultats de cette expérience là et c'est vrai, parce que c'est pas la peine de refaire, et maintenant tu sais les choses qui marchent, les choses qui marchent pas"
33	21 February 2008	Interview COM+CMD	CMD	"[. . .] synthèse granulaire qui est la même que *Bogenlied*"
34	19 November 2008	Project's Debriefing Meeting	CMD	"on a fait des tests là-dessus, on s'est rendu compte, du coup, le paramètre de vitesse faisait rien quoi"
35	26 September 2007	Interview STL	STL	"Florence commençait plutôt par Plot [. . .] on peut visualiser donc on voit déjà a peu près les différences [. . .] et on regarde comment la machine analyse... et on peut retourner vers plot quand y avait des choses qui nous étonnait , là il arrive vraiment pas à reconnaître ou suivre , on retourne dans Plot et on regarde vraiment en détail les données [. . .]"
36	12 April 2008	Interview COM	COM	"j'ai éliminé des modules et je me restreint à harmonizer, granulaire, flute euh frequencyshifter, la disto, reverb [. . .]"

Appendix: Continued

ID	Date	Session	Agent	Original quote
37	26 September 2007	Interview STL	STL	"C'est à dire qu'il y a des choses qui vont changer ici. Ici on sélectionnait un instrument à la fois et ça, c'est en train de disparaître. . . on va plutôt choisir un groupe de capteurs mais qui peut provenir de chaque instrument"
38	19 November 2008	Project's Debriefing Meeting	COM	"après, il y a eu une négociation terrible avec [le réalisateur en informatique musicale], [il] m'a dit si tu fais ça on ne revient pas au mode réel, on reste au mode fictif. Je lui ai dit 'pas question, je reste en mode fictif le temps de la panne et je repasse en mode réel ensuite"'
39	19 November 2008	Project's Debriefing Meeting	COM	"Mais on a fait un très beau travail avec [l'ingénieur du son], on a fait tourner toute la pièce, il l'a entendue, il a très bien compris, il prenait des notes, etc."
40	21 February 2008	Interview COM+CMD	CMD	"je pense qu'il faut que Florence avance sur ses évènements [Florence Baschet acquiesce] que moi j'avance bien aussi , qu'on arrive à converger avant. . . dans quinze jours quoi. [. . .]"
41	6 February 2007	Project's Presentation Meeting	STL	"il y a eu beaucoup d'allers-retours, toi [Florence Baschet] tu venais avec des bouts de partitions, et nous, on te disait si on pensait que ça allait marcher ou pas"
42	6 February 2007	Project's Presentation Meeting	STL	"pour l'instant, on fait les choses en série. [. . .] On va enregistrer toutes ces phrases, après on va regarder comment le système se comporte."
43	21 February 2008	Interview COM+CMD	CMD	"ce qu'on a pas vu c'est la façon de stoquer les évènements. Donc on utilise Patter, et tout est là [montre tableau de données] donc la partition de ? C'est ca"
44	30 October 2007	Interview COM+STL	COM	"le gyro 1 est assez intéressant, moi je regarde beaucoup le gyro 1"
45	26 September 2007	Interview STL	STL	"[le logiciel Plot] a servi énormément à Florence, [. . .] elle s'est construit une représentation, enfin une intuition par rapport à ce que donnent les capteurs par rapport à la musique"
46	6 February 2007	Project's Presentation Meeting	COM	"j'ai pensé, [. . .] en dessous de la partition, d'avoir un autre pentagramme et écrire exactement... Je ne l'ai pas fait [. . .] car je voulais associer l'instrumentiste dans le geste [. . .]"
47	9 July 2007	Debriefing Session	COM	"[montre le créneau] ca c'est des trajectoires ca passe du violon au violoncelle. [. . .] [montre le losange] c'est vraiment des complexes de gestes cumulés"
48	12 April 2008	Interview COM	COM	"Et au niveau de l'espace , j'ai fait 5 espaces différents"
49	11 July 2008	Interview COM	COM	"J'avais essayé cette écriture 2 à 2, avec ces triples croches, en pensant vraiment à une transformation électro [. . .]"
50	22 May 2007	Debriefing Session	STL	"c'est bien qu'ils aient joué de façon excessive avec le dispositif [. . .] ils se familiarisent avec les bornes de ce qui est possible, en attendant de travailler plus dans la nuance [. . .]"
51	6 February 2007	Project's Presentation Meeting	STL	"[les choses] qu'on abandonne c'est pas définitif [. . .], ca peut revenir après dans d'autres projets... suivant les compositeurs on est dans des cas différents"
52	6 February 2007	Project's Presentation Meeting	COM	"je préfère le decider [le type de transformation], ca c'est compositionnel"