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ORIGINAL ARTICLE

Theoretical and methodological issues related to long term creative cognition: the case of musical composition

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Abstract The theme of large temporal span of cognition is emerging as a key issue in cognitive anthropology and ergonomics. We will consider it through the analysis of a musical composition process, that of *Voi(rex)* by Philippe Leroux, in which sketches and score writing are articulated through the use of different kinds of computer software. After presenting the data collecting method, we will consider the analysis of the resulting data concerning the writing of two movements of *Voi(rex)*. Such an analysis will allow us: (1) to draw methodological conclusions about the time and mode of inquiry; (2) to specify the notion of situated cognition in situations essentially pre-established by the actor; (3) to set out two families of theoretical results relating to large temporal span cognitive phenomena: the first concerns the notion of an *idea* and its role in the development of the creative process; the second deals with the notion of the *appropriation* of tools and the making of situated individual cognition.

Keywords Large temporal span of cognition · Activity analysis · Musical composition · Situation simulation · Cognition theory

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1 Introduction

Time is a problem for cognitive analysis. At its very origin, Newell and Simon (1972) proposed ''to try to represent in some detail a particular man at work on a particular task'' and to search for ''a process theory'' of the ''human system'' according to ''three dimensions of variation'': ''tasks'', ''individual differences'' and ''time scales in behavioural acts'' (Newell and Simon, pp. 2–3). It is clear, some 30 years later that this last dimension has been insufficiently explored. However, many activities can be described and explained only if several time horizons are considered. Among them are creative activities, for example, the activity of musical composition that we will consider here: just as the creative instant counts, so does the composition of some meaningful part of the work, as well as the composition of the entire work, and even more, its place as part of the composition of a set of works, or as part of the composer's intervention in the artistic debates of the time-period. Although there has been a host of speculations about these creative activities, very few empirical studies of them exist. Concerning real life musical composition, since the study by Mion et al. in semiotics (1982) and by Marmaras in cognitive ergonomics (1984), as far as we know, no empirical studies exist until we arrive at Hervé's study in the theory of musical composition (1999), and Nuhn et al. (2002) and McAdams (2004) in the field of cognitive psychology.

The analysis which we will present here of the activity of composition of the third and fifth movements of *Voi(rex)* (composed in 2002, premiered in 2003) by Philippe Leroux reveals some constraints which a cognitive theory and methodology interested in the large temporal span of human creative cognition as involving multiple and embedded time spans should take into account. This theme also emerges in other recent empirical and technological research in

cognitive ergonomics, for example with regards to appropriation processes of technical devices (Haué 2003) as well as e-learning activity (Dieumegard 2004), management activity in the industrial field (Dieumegard et al. 2004) or the activity of consultants in ergonomics (Lamonde 2000). Hutchins (1994) may be regarded as having opened up the question in cognitive anthropology, by proposing to study cognition as the dynamics of a ''cultural symbolic system''. This view contrasts both with approaches used in cognitive anthropology, which consider cognition as static, following the cognitive definition of culture proposed by Goodenough (1981) (e.g., Dougherty 1985, d'Andrade 1995) as well as with approaches used in cognitive psychology which consider cognition as cultural, but which are not equipped for the documentation of the real world. Since Fleck's seminal work (1979), social studies of science have also approached this theme through the history of scientific discovery (e.g., Knorr Cetina 1983), the description of scientific activity (e.g., Garfinkel et al. 1981), as well as in cognitive research itself (e.g., Grison 1998 on the cognitive activity of a research team in biology over a 3-year period).

Throughout this article, we will contrast our findings, as we did above, with Newell and Simon (1972), which is taken to be one of the main historical landmarks in the formulation and the study of cognitive issues. For Newell and Simon (1972), the phenomena of human problem solving in the laboratory require a methodology that is ''empirical, not experimental'' as well as ''non-statistical'': ''Because of the strong history-dependence of the phenomena under study, the focus on the individual, and the fact that much goes on within a single problem solving encounter, experiments of the classical sort are only rarely useful. [1/4] Thus, the analysis of verbal protocols is a typical technique for verifying the theory [1/4]'' (Newell and Simon, p. 12). Following these authors, what kind of methodological consequences do the characteristics of large temporal span creative cognition phenomena have? In order to answer this first question, that is, to present the data collecting method which we used and advocate, we will proceed in two steps: Sect. 2—the situation simulation interview; then, after presenting some of the results of the analysis, we return to Sect. 7 for the situation simulation interview in light of this analysis.

For Newell and Simon, these phenomena require a theory that is ''dynamically oriented'': ''The natural formalism of the theory is the program, which plays a role directly analogous to systems of differential equations in theories with continuous state spaces'' (Newell and Simon, p. 11). What kind of a theory is then called for by phenomena of large temporal span creative cognition? Today, there is no available formalism to replace the program, which proves evidently irrelevant in the case of creative cognition. Moreover, the dynamics of composition are too complex to be captured by the dynamical systems approach, which is used in a growing number of developmental psychology studies (see e.g., Smith and Thelen 1993, Thelen and Smith 1995). Hence, we will offer a much more modest response to this second question, by exploring a few cognitive notions and their related empirical hypotheses: in Sects. 3 and 4, the notion of ''situated composition''; in Sect. 5, the notion of ''idea'' and the development of the creative process; in Sect. 6, the notion of ''appropriation'' and the making of situated individual cognition.

2 Background and methodology of study

2.1 The composition of *Voi(rex)*

Over the course of 2002, French composer Philippe Leroux composed his work called *Voi(rex)*, for soprano, six instruments and electronics, which was commissioned by IRCAM[1] (France). What traces were left of his compositional activity?

- A printed score, along with an electronic part composed of sound files and a concert patch using Max/MSP (a software created and widely used at IRCAM, used for real-time electronic transformation of sound in a concert situation or sound installation).
- The score manuscript (entirely written out by hand in pencil by the composer, and which, in the weeks leading up to the work's premiere, was recopied by a copyist into a music editing program, in view of the score's publication).
- Sketches, plans and other manuscripts produced and used during the compositional process.
- Various files and software environments left in the composer's laptop computer, especially:
  - *Patchwork* [software for computer-assisted music composition, designed and disseminated at IRCAM] and *OpenMusic* [a newer version of this program][2].

[1] Our institution, IRCAM (Institut de Recherche et Coordination Acoustique/Musique), includes both a music studio (including production capacity, a nation-wide concert season and concert tours) and a laboratory for research and development (computer music tools and the musical sciences).

[2] A few more details could be of use to the reader of what follows: these two programs were inspired by a formalizing approach to musical composition which was a result of practical and theoretical research in contemporary music from the 1940s through the 1980s, and with which IRCAM has in turn orchestrated an encounter with the technological possibilities of computers. Through its graphic interface, *OpenMusic* allows a user to execute operations of complex calculations on MIDI information (that is musical parameters encoded according to the protocol of Musical Instruments Digital Interfaces (established in 1983) which allows for musical data to be circulated between different machines and electronic instruments). A patch is a combination of algorithmic operators, equipped with one or several inputs and one or several outputs, and fabricated by a user as a way to realise any given compositional or pre-compositional procedure.

- *ProTools* [a digital audio sequencer, a program for sound editing commonly used by professional sound engineers and musicians][3].
- *Max/MSP*.
- *Patchwork* patches.
- *ProTools* sessions.

– Screenshots of various stages of the patches and work sessions of the computer work listed above.
– E-mail exchanges with the singer, etc.

The composer conserved all of these elements, and had sorted those which were on paper into folders bearing various titles (e.g., ''I'', ''II'', etc., for the different movements of the work, ''rhythm'', ''harmony'', ''ideas of all kinds for vocal pieces'', etc.) in order, on the one hand, to be able to retrieve upon request by a musicologist studying the work, but also as a source of inspiration for a future work which revisits *Voi(rex)* on a different level, by taking up those possibilities which were not exploited in it, but for which traces exist in the materials used during its composition.

2.2 Recreating the compositional situation through the use of material traces and questioning

Our collaboration with the composer concerning the composition of *Voi(rex)* took place between the concert première of the work (in early 2003) and the beginning of his work (end of 2004) on the new piece connected to it, *Apocalypsis*. This collaboration had several goals. The composer would benefit from having other people analyse the processes at work in the genesis of *Voi(rex)*—and, more generally, from an analysis of his method of composition, which he felt to be evolving—in the development of the project for the new work. For the researchers, it would be a way to reconstruct the compositional activity of *Voi(rex)* by questioning the composer about the detailed existing data concerning the genesis of the work. The elaboration and realisation of this collaboration therefore depended on the very particular situation of this composer at that particular period of his artistic development.

After a preliminary methodological study, we chose to focus on the period of score writing. This period can be distinguished from the composition of the piece as a whole, which was preceded by an extensive preparation phase (end of 2001 to February 2002: collection of loose notes, writing up idea sheets, recording of preliminary sounds, etc.), and was followed by a period of finalization (end of 2002 to 20 January 2003) of both the score (re-reading, correction of proofs) and the electronic component (sound levels, settings for live sound transformation), until the evening of the concert, and including the rehearsals.

Data were collected over the course of eleven interviews of approximately 3-h duration each, distributed over six months. The interviews took place in a room where the composer's personal computer, his sketches and other documents listed above, were put on a table simulating the composer's familiar space when he's working. Our chronological reconstruction of this activity followed its own segmentation into five phases of writing (corresponding to the five movements of the work), so that there were approximately two interviews per movement.

For each interview, we proceeded in three steps:

– Selection and laying out of the materials needed for the reconstruction of the movement's compositional activity.
– Reconstruction of the composer's anticipations[4] at a precisely defined moment (which corresponded to the beginning of the movement or of a significant part of it).
– Verbal and gestural expression over the course of score writing in the simulated past situation.

During this interview, we constantly used the different materials to contradict or support the reconstruction by the composer of his own activity and to help him both to retrieve his past situation of score writing and to quit his present situation of a composer involved in other compositional problems, commenting his piece for his students in composition class or giving interviews for music journals. Every interview was recorded on video. The term we give to this type of interview is ''interview within situation simulation through material traces'' Theureau and Donin (2006).

We will consider here the analysis of the resulting data concerning the writing of two movements: the third, and the fifth and final movement[5]. There are several reasons for this choice as pertains to the subject of this article. First of all, during the composition of the third movement, many surprises emerged while using previously prepared material; secondly, the use of previous material while writing the last movement was dramatic; finally, many elements were brought forward from one movement to the other.

Through such an analysis of the composer's writing activity concerning these two movements, presented here with a focus on the issues related to the large temporal span of creative cognition, we will illustrate both the efficacy of

[3] See Fig. 3 and footnote 11.

[4] [Trans. note] The word « anticipation » in French connotes both the passive expectation with regards to a future event as well as an active project for a future action. Throughout I use the word ''anticipation'', even if the passive connotation dominates in the English cognate.

[5] The question of whether the data analysis of the writing of the piece as a whole and its full temporal deployment would support the results presented here, would be impossible to address in the space of a single paper. It will be tackled in a forthcoming book.

the data collecting method just described, and a number of constraints the empirical phenomena just described set upon cognition theory. Unless otherwise specified, all of the passages quoting the composer are derived from the interviews of compositional situation simulation of the third and fifth movements, which took place respectively on April 2 and 29, 2004, and June 3 and 22, 2004.

3 The situated composition of the third movement: situation preparation and re-reading

3.1 Characterization of situated (musical) composition

In this section, we will begin by considering the effects of a re-reading of material prepared for the third movement. In the next section, we will look at the effects of re-reading of other material prepared for the fifth movement, inasmuch as the writing of the score is constrained by the conclusive nature of this movement.

Through a description of the composer's activity, we will see that composer's cognition must be considered as situated in the strong sense: there is a constant embedding in the dynamic situation at hand of the materials prepared previously, either in and of themselves, or as reminders for future use. Secondly, a central place must be given to the perception–action loop and to its development into a discovery–creation loop; this applies just as much to the realisation of a work (surprises arising from inner and auditory hearing which take place both during the score writing and the electroacoustic signal processing) as to the procedures of composition. Also, the notion of the preparation of a situation must be developed, rather than simply that of plan: in the preparation to the writing of the work as a whole, the composer is not so much planning as *preparing* situations which will only become defined at the moment of writing, thus taking into account all that has been written up to that point through re-reading; in the score-writing itself, the goal is at the same time to write the given passage of the score and to pursue the preparation of future writing situations. This writing entails a constant redefinition of the past: if there is a separation for the composer between the preparation to writing and the writing itself, certain operations of preparation can be redefined by him afterwards as having constituted the beginnings of writing. Finally, an essential role must also be given to memorization (anticipated or aimed at by the totality of operations of inscription), to remembering and forgetting (in the re-reading and in the writing). Related to this last point, a particular skill of Philippe Leroux must also be considered, which consists of a technique of self-listening which allows him to let a musical impression that could be potentially productive to his compositional work just ''come to him'', and to note its essential features as rapidly as possible.

These characteristics of composer's cognition demonstrate that it must be considered not only as situated in the strong sense, but also as situated in a specific sense. With regards to the notion of situated action as it has been proposed by Suchman (1987), the particularity of situated music composition is that many important elements of the composition situation have been constructed in the past by the composer himself. This explains the essential role of memorisation, inscription, and re-reading and their corresponding techniques, which participate in the construction of an ensemble of which the realized work is only one of its most obvious manifestations. This also explains, from a methodological point of view, why it is so easy to undertake the situation simulation of the composer described in Sect. 2. This is what we mean, in what follows, by situated (musical) composition and (music) compositional situation, while understanding that this particularity is shared by other activities and situations.

3.2 One episode of a long story

The composition of the third movement of *Voi(rex)*, in the summer of 2002, involved several periods of elaboration: the accumulation of ideas in view of the composition of a vocal piece, with instruments and electronics, for which the title had not yet been fixed (second half of 2001, beginning of 2002); work in an IRCAM studio, which was undertaken while the first movement had already begun to be written (spring 2002); the gathering up of all of the sketches necessary to the composition of the third movement, that immediately preceded the composition of this movement (mid-July 2002); the first days of the realization of this movement, during a residence at Heiligenstein in Alsace for concerts and master classes (second half of July).

Before beginning to write the score, Philippe Leroux had determined certain characteristics of this movement (see the sheet of ideas for this movement, a document which is halfway between a list of ideas and an actual plan; cf. Fig. 1): to work on the absence of the voice (the general plan of the work indicates ''voice absent except at the end'' [''voix absente sauf à la fin'', top right]); to establish various relationships between the third movement and the first (notably from a scenic point of view)[6]; instrumental writing procedures inspired by a particular type of signal process-

[6] Middle of left hand column: ''At the end, the voice comes back and does the opposite of the beginning: spatial trajectory–>singer–>the sound disappears backstage (by making the gesture of catching the elect[ronic] sound and throwing it backstage?)'' [''pour la fin la voix revient et fait l'inverse du début: trajectoire spatiale–>chanteuse–>le son disparaît en coulisse (en faisant le geste d'attraper le son elec[tronique] et de le lancer dans les coulisses ?)''].

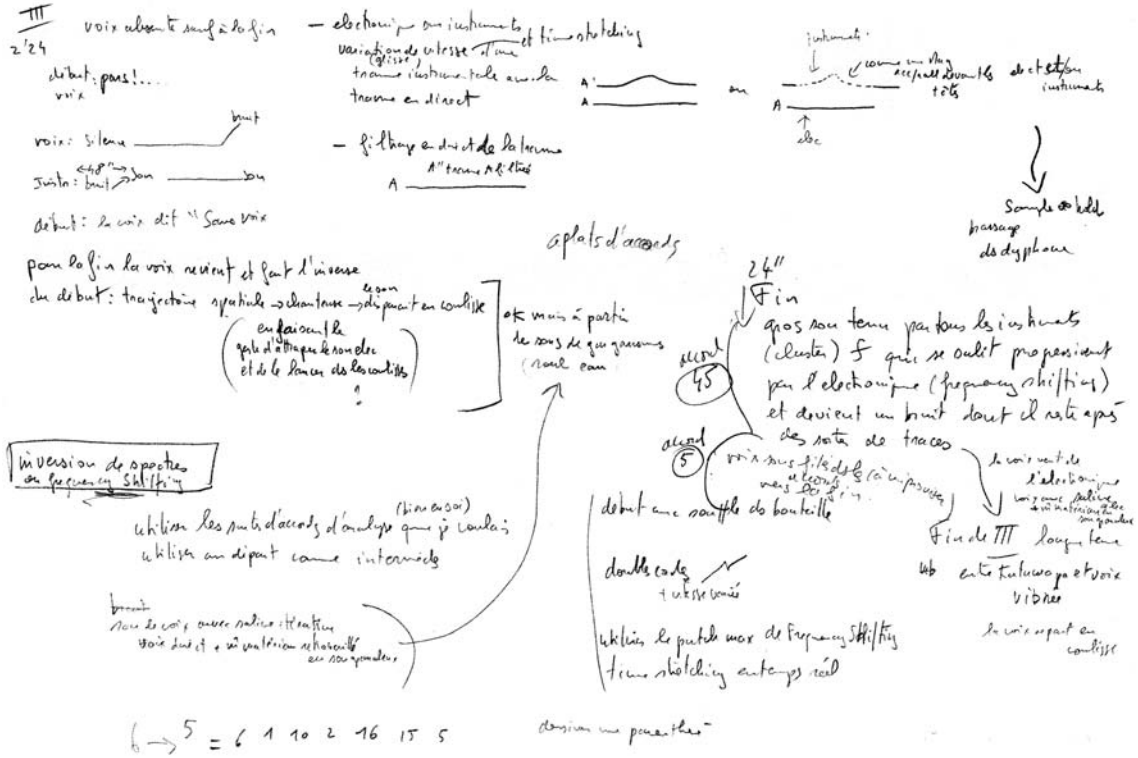


Fig. 1 A sketch from *Voi(rex)*: final state of the ideas sheet for the third movement. [© Philippe Leroux] Relevant parts of this document are translated and commented in the body of the paper

ing, namely ''spectral inversion'' [''inversion de spectres'', in the box at the bottom of the left hand column][7]; to take two initially identical chords which progressively diverge, one given to the instrumental ensemble, the other to the electronic part (the sheet of ideas for this movement contains two schemas representing this alteration[8] [see top right], and a third one just below them which specifies that this alteration is to proceed mainly through filtering [''filtrage en direct de la trame'']). Moreover, a poem was chosen from among those which Leroux had photocopied from the collection by Lin Delpierre.

3.3 Elements of the compositional situation at the time of re-reading

Collecting material for the writing of the third movement, at the end of June 2002 and copying indications which came from various preparatory documents (this is the case, for example, for the schema of chords) onto his sheet of ideas for this movement, helps Philippe Leroux to recall the major guiding ideas which are valid for the work as a whole (notably the ordered list of 26 chords), and he carefully re-reads the poem selected for this movement, from which he extracts the idea of being ''dazzled by white noise'' (''ébloui par le bruit blanc'') according to his note in the margins of the photocopied text) which evokes for him a process of successive filtering applied to an initial chord, which thus goes from being a rich traditional harmony to an inharmonic sound with a significant noise component.

This re-reading stage seems to be essential. All of these materials, initially dispersed (then later gathered together in a folder labelled ''III[rd movement]'') and dating from very different periods, are re-read and linked together to form a new compositional situation, while the two first movements are already written, and have created important divergences from the initial plan of the work (to such an extent that an large part of the first elements inscribed on the ''ideas sheet'' for the third movement were not used). To encapsulate it into a formula we could say that through their fabrication, these materials *prepared* the compositional situation of the third movement, but did not *predefine* this situation.

[7] As can be seen in the annotation added to the box, another type of signal processing, ''frequency shifting'', had been planned, but in the end had been reserved for the writing of a fourth movement, which, precisely at the moment of completion of the third movement, was decided to be abandoned.

[8] These two schemas already figure in an older sketch which listed ideas for the use of electronics throughout the piece, and in which we read: ''instrumental held notes and the same pattern put out of phase by the elec[tronics]''.

3.4 From re-reading to the beginning of score writing

Over the course of this re-reading, which involved various notes jotted down as well as preparatory work on computer patches or on the electronic component of the piece (*ProTools* sessions), Philippe Leroux decided to listen to the recording session he had made with the musicians, at IRCAM on April 18, 2002. This recording session took place at the same time as the composition of the beginning of the work (which began at the end of February) but was planned independently of it, and brought together at the request of the composer all of the performers who would be involved in the work's premiere, in order to have them play each of the 26 principle chords of *Voi(rex)*, each one appearing in a dozen-odd forms. This work session allowed the composer to experiment and to test the harmony, which he had already written out, and to constitute sound material which he could appeal to at many stages of the composition. Many sound files prepared long in advance had been used in the writing of the first movement, as well as, to a lesser extent, in the second movement. Thus the composer approached the material which came out of the recording session on April 18, 2002 with the knowledge that he might be inclined to use different fragments in some of the remaining six movements planned. In fact, it is in the program *ProTools*, which like any sequencer is a tool for positioning, cropping, and playing different sounds simultaneously—and not simply a tool for listening to them in a given order with a visualisation of their length and their waveform—that he places end to end all of these many sound files which constitute more than an hour of music.

A nice surprise awaited him when he listened to these recordings: the instrumentations, which he had hastily jotted down a few days before the recording session, produced interesting sounds, in particular because several of the takes by the ensemble sounded like synthesized sound or else like acoustic sounds modified electronically in real time. Moreover, some of the sounds which were held for a long time by the instruments, which fit in well with his desire to work on ''swathes of chords''[9], an idea which he noted well before the composition of *Voi(rex)* on a scrap of paper which he had stored in one of his folders but which he had not yet copied onto the ideas sheet for the third movement. By manipulating these files laid out in the session, Philippe Leroux finds a way to use these long files of approximately 15 s duration each, and which convince the composer to composer the entire movement on the basis of this *ProTools* session.

[9] [Translator's note] In speaking of ''aplats d'accords'', Leroux is using a visual arts metaphor. An ''aplat'' is a flat patch of uniform colour in a painting. Throughout, this word has been rendered, however imperfectly, by the word ''swathe''.

3.5 A new meaning attributed to a particularity of the sound files

In fact, this surprise during the re-reading, which then became the triggering element for the beginning of the score writing, is linked to a particularity of these manipulated sound files which were made for other reasons: because they were meant to be a material that would later be used in various electronic transformations, each notation which was played at the recording session was played for a fairly long duration (10 to 20 s) in order to be able to extract the best excerpts of a few seconds in length, without being constrained by any incidental noise or passing defect in the sound. ''[To be on the safe side, I] needed to use quite long held notes in order to be able to work on them later, and on the other hand, very detached notes, [without dreaming that I would] use the maximal durations of these notes, for example 15 seconds.'' The length of these sounds would then allow the composer, during the score writing, to flesh out the idea of ''swathes of chords''. In other words, this property of the sound files, linked to the horizon of the segmentation of recordings, is deprogrammed and reprogrammed differently in a single step—a step which turned after the fact out to be essential, since it marked the beginning of the composition of the movement.

We will return in Sect. 5 to the idea of ''swathes of chords'' and how it is put into practice, in order to show the role and the evolution, during the activity of composition, of musical ''ideas'' which it allows to emerge. Before we get to this analysis which deals with the long term cognition in all its extension, we must discuss another case, not only as a way to show another aspect of the notion of compositional situation, but also as a way to add a degree of complexity which reflects the way in which this notion of ''long term cognition'' manifests itself.

4 The situated composition of the last movement: the dynamic of accumulated constraints

The reconstitution of the activity of composition of the third movement which was just presented shows that the initial plans—even when they are no longer valid, the little notes containing jotted down sound ideas—even when they were recopied elsewhere, the computer generated material—even when it was already used in a past context, are all resources for the action situated at the moment of composition itself.

This remark applies just as much to the fragmentary preparation of any given situation (fragmentation in time and also by the multiplicity of retentional media), as to the global conception of a movement at the beginning of its

composition—even if, contrary to the third movement, it had already been defined with precision in previous stages.

4.1 Making one out of three

So it is with the fifth movement, which the composer now characterizes as the concatenation of three different movements of the initial plan: movements VI, VII and VIII. This fifth movement was constructed in several stages beginning from these three, in particular during two distinct stages of the composition of *Voi*(*rex*).

Right from the moment that the third movement was finished, the composer decided to modify the general plan of the work: to discard movement IV, to preserve V (which would become the fourth) and to concatenate the last three movements conceived as a single movement (the fifth). This concatenation was conceived as a unified integration of the guiding ideas of each of these movements (on the general plan ''scat[10]'', ''propagation of figures'' and ''multiprocesses'' are the words which figure just below each movement number). As the composer himself states after the fact, this logic of concatenation endangered the unity of the last movement:

> ''As a movement, this fifth movement is not very coherent in the way that it is constructed. But taken as a part of the piece as a whole, it is absolutely coherent. But I think that I would have liked it to be more coherent in and of itself. At times it almost approaches mere juxtaposition of certain things at the end. But since everything comes from far back and was very much prepared, it works.''

In the second step of concatenation, before writing the fifth movement, the composer goes back to the sketches for movements VI, VII and VIII as they were initially planned, and he recopies the significant elements onto a unified sketch of the movement that he is about to work on; in so doing, he updates his vision for their fusion at the time of the revision of the general plan. By recopying onto his new ''plan for V'' the selected guiding ideas, he makes clear what he intends to preserve and reorders the elements into an order different from the one in which they would have occurred had he decided to preserve the three movements.

In so doing, he moves from a ''logic of movements'', to a synthesis of heterogeneous elements:

> ''In order to continue, that [points to plan for V with a list of elements taken from the last three movements] is the most important, because I see there that I am saying: 'from VI I'm going to keep the scatting', I'm going to keep the melody which follows the shape of the letters and uses rhythmic elements from III, I'm going to keep moments of rest with the swathes of chords (but in fact, that's not what I did), and also some Doppler effects and some breaks in the scatting, things which hover a little (marked 'floating'). Next, from VII, I keep the propagation of figures, delay patterns/''.

The question of unity does not only come into play in the issue of the order of succession, but also in the proportions of the movement. While the proportions between movements had been carefully defined before the writing of the work, and then progressively taken less into account as the writings of the movements progressed, the fifth movement was different. Although Leroux had a rough idea of its global duration, the durations of its sections had not been defined, neither with respect to the proportions defined for the former movements VI, VII and VII, nor by any other means:

> ''I knew that I could not keep the initial proportions, and since I abandoned the idea of using multi-processes, it wouldn't have made sense to keep them.''

The writing of the fifth movement proceeds in the same way as the third: the situated writing of a movement depends on the writing of preceding movements. But here this idea is all the more evident because it is the last movement to be composed and Philippe Leroux begins writing this movement with a determinate knowledge of the work, which he puts in relation to what he prepared to this end and with what he had decided at the start of the composition:

> ''On the other hand, I now have a vision of the piece as a whole, so I have a good idea of the global duration. I can't be mistaken about the duration of the fifth movement, give or take a minute. […]''.

4.2 Summing up material, making connections in order to conclude the piece

As the writing of the fifth movement progresses, it confronts the difficulty of making concrete the relationship between this movement and the ones which preceded it. From the moment of the re-reading which preceded the writing, it is said that operations and local elements should refer back to passages from previous movements:

> ''[In this sketch] I am simply imagining the beginning of the fifth movement: exactly what is going to happen. As I spoke of swathes of chords (see Sect. 3), I do want swathes of chords, but I want them to be triggered by a figure (because I want the figure to

[10] [Translator's note] ''Scat'' or ''scatting'' is a term used in jazz, which refers to a singer's use of meaningless syllables to intone a melody in imitation of a solo instrument.

propagate later), which I take from the Doppler effects which I made right at the beginning, in the first Doppler effect patch which was made long before the writing of the first movement and all that. Except that I apply it to a precise chord and to a precise letter [a reference to the second movement in which the composition is marked by the use of the calligraphy of the letters of the poem as a graphic model for the melodic writing of the score, using *OpenMusic*], the letter which will determine the speed of the Doppler effect.''

From the preceding paragraphs, we see that the problem of unity is posed on two levels simultaneously throughout the writing of this movement: on the level of the movement (for which the unity must overcome the heterogeneity of the previously planned, but later abandoned, movements from which it emerges) and on the level of the work as a whole (for which the concluding movement must give closure and/or complete, in a balanced manner, the network of relationships springing from the similarities and contrasts between the preceding movements).

The writing of this movement accumulates relationships with older periods of activity, during which plans as well as material were elaborated, at the same time as ideas and projects which did not yield any inscription or leave any traces. These ties range from realising a passage which had been planned long before, to seizing a good opportunity to create a relationship *a posteriori* with an element from a preceding movement. What are these types of relationships and how are they constituted and how do they evolve over the course of the composition? Different types of relationships can be distinguished:

- Clarifying and acting on anticipations
- Exhausting/recycling materials
- Transferring structures
- Passing from an idea to its determination, that is, from the vague anticipations linked to an idea, to actual realisations of it

4.3 Clarifying and acting on anticipations

An anticipation can be fairly determinate in terms of its content, while at the same time being more indeterminate in terms of the suitable moment for its future use. This is the case with occasional links made with preceding movements: every opportunity is used to make reference in a detail of the writing to characteristics and/or ideas from one of the preceding movements: a drone which makes reference to the first movement, a melodic profile of a letter which refers back to the second and fourth movements, etc. These anticipations are generally only formulated at the instant of their being used in the situation. But the writing of the fifth movement also leads the composer to complete, modify, or to eliminate lists of things to do. He does so by basing himself on elements carried over, from the writing of a preceding movement, from a sketch concerning this movement to elements reserved for what was to come next (''There are several things that I wrote when I was working on the third: 'for the voice, folding over of the high notes (for conjoint motion)', 'reuse elements from the rhythmic writing of III', 'make moments of calm with swathes of chords; cf. III'''). He also does so by verifying retrospectively an aspect of the composition by making a list (''by going back to see which of the real-time signal processing techniques I had used in the preceding movements—as a way to see what I was going to reuse at the end'').

4.4 Exhausting/recycling materials

Without using notations produced over the course of the writing of a preceding movement, the composer can also make use of elements already used during the writing of a preceding movement but which were in the end not included in it, having been replaced by variants which were deemed to be more appropriate to the context. This reuse of elements strongly linked to the context of another movement allows him, when he uses them for other purposes in the fifth movement, to exhaust material which he judged to be particularly interesting and which constituted for him a reservoir of potentially applicable elements. This is especially true of elements produced via computer, because the computer allows for the identical reproduction of objects which can each be altered in a different way while still conserving some of its previous aspects.

''[This] sound file [F104] comes out of the third movement. It is one of the strongest filterings of chord 6, which is the basic chord of the third movement, and which was supposed to be used for the end of the third movement.

Where did you get it from? How is it classified?

It is a very noisy sound. […] I kept it on reserve. I was left with two or three files like that, with a strong noise component. […] I had to go into a *ProTools* session for the third movement and take whichever one was of interest to me. I might have reworked it, it probably wasn't exactly like that, I surely must have changed its shape, its duration/''

Therefore, this reuse of elements, often undertaken directly on the technological medium which allowed them to be generated, explores possibilities which were not relevant beforehand, but which were already available and at-hand. The *OpenMusic* patch in which the composer can produce melodic profiles by crossing a set of notes with the contours of a drawing (in this case the letters of the alphabet),

constitutes at once a tool and the memory of these operations:

> ''Where are they [the melodies imitating the letters of the alphabet used in this passage of the fifth movement]? [searches in the computer, opens the *OpenMusic* application] Oh wait! No, I didn't rewrite them because I already had them. For example, 'i' of chord 1. I must have changed the chord, I removed this one and imported chord 1, and then I took the [profile of the] letter.''

It is the use of the operation ''Save as…'' (equivalent to the duplication of a patch) which allowed the composer to select the most successful letter-drawings when he was working on the second movement, which made use of this procedure; and it is this very same operation which allows him to adapt the results which were obtained at that time for a new harmonic context (the harmonic context is another parameter of the patch) which is what he does in the fifth movement.

The intersection between the logic of reusing elements and referring to preceding movements on the one hand, and on the other the practice of replication-variation of computer-based elements, rapidly engages the composer (over the course of the writing of the first section of the movement) in a particular style of activity:

> ''So there [returns to the line ''calm voice chords (III)...''] I start to say to myself: I'm going to take the chords from the third, make them proliferate in such a way as to create a material with the possibility of figures which propagate from inside of it, and which will evolve towards the rhythms of the freeze/[reads examples from his sketches] ''recopy with the instruments the rhythms of 2'38 to 3'38 from III with another chord.'' I think I really did that, I did another dictation of elements from the third that I had used in the form of sound files, but not as instrumental writing/''

4.5 Transferring structures from the third movement

At this point the composer finds himself engaged in creating numerous connections with preceding movements on the one hand, while at the same time still being in need of material specially prepared for the compositional situation at hand, an engagement which becomes increasingly urgent as the date of the first performance of the work approaches. The composer then goes about reusing an element from the third movement which is neither a sound file, a patch, nor a motive, but rather a structure—a structure resulting from the third becoming the infrastructure of the fifth. The fact that it was saved into a different file of the session(s) of the third allows for a recycling of the structure of the third as a formal guide for the writing of the fifth

> ''*In point of fact, you're following, section by section, the structure of the third movement. Do you then have [the corresponding passage in the score] in front of you? How do you do it?*
>
> No, what I have in front of my eyes is the [*ProTools*] session of the third. I don't reuse elements from the writing of the third.
>
> *You rework that session a lot, you remould it as you like. So you have the intact session of the third in front of you?*
>
> Yes, and from time to time I take something from the third, I look at it in detail, and I put it into the fifth. In the work session on the fifth, I have the session of the third (at the beginning) in its entirety [verifies as he goes, listens to a passage]; and then what I did was either to enlarge some things, or/
>
> *In fact you don't exactly start with the session of the third but with a re-arranged copy.*
>
> Yes, I recopied many things in order to do my dictations in a practical way/ this session is 30 minutes long [as compared to the movement which lasts only 5 minutes].''

The strategies of exhausting/recycling materials as well as that of transferring structures apply to elements which are fairly determined, and the decision to use them is made at the moment of their use, in the same way as the anticipations presented above. The fourth type of relationship which will be considered in greater detail is the movement from an ''idea''—as is the case for the different types of the composer's sound and musical ideas—to its determination.

5 ''Ideas'' as efficient: 'Scat' and 'Swathes of chords'

We have already encountered the term ''idea'' as an element of the vocabulary of the composer. Philippe Leroux speaks about ideas in numerous ways: ideas for ''sound actions'' (often jotted down on bits of paper); ideas for pieces which are hardly developed, or not at all (key word and/or key-phrase and/or sound action to make use of in the writing of a piece, defined by the instruments used or according to some other significant criterion); global idea for a movement or a part of a movement which takes shape during the preparation for the composition of a work (spectral inversion, scat, etc.).

Of course the term ''idea'' has a long and varied history in philosophy. Without attempting to summarize this history, we note simply that the essential characteristics of what Leroux calls ''ideas'' can be assimilated to ideas of

Kantian reason as analyzed and generalized by Gilles Deleuze, notably in *Différence et répétition* : ideas ''present three moments: undetermined with regard to their object, determinable with regard to objects of experience, and bearing the ideal of an infinite determination with regard to concepts of the understanding'' (Deleuze 1994, p. 169). Following this conception, ''The undetermined is not a simple imperfection in our knowledge or a lack in the object: it is a perfectly positive, objective structure which acts as a focus or horizon within perception'' (ibid.). By extending Deleuze's elaboration and by connecting it to other empirical research and theoretical elaborations (cf. Theureau 2003), it seems to us that the ''idea'' can be seen as an essential notion in the analysis of creative long-term cognition inasmuch as an idea constitutes a kind of unit of the cognitive activity at a given instant—therefore in the short-term—which is significant for the actor being considered and for which the nature and the function only become clear in the long term. More specifically, this notion of ''idea'' is relevant to phenomena of cognitive activity which bear the following traits:

- Monadic character: the idea is born in juxtaposition with other ideas—some of these remain implicit—and their relationship with the first idea are only defined over the course of future activity;
- Symbolic character in embryonic form: the idea leads to a private discourse and to the evocation of more or less constructed schema;
- Simplicity: the idea is short and synthetic, whereas the non-idea is composite, extensive and computable;
- Reference and area of application left undefined;
- More or less vague and indeterminate character but with the potential for being determined;
- Potential and indeterminate fruitfulness until exhausted;
- Ability to be inscribed: over and above the private discourses and the evocations of more or less constructed schemas, the idea can be inscribed; what is important to the actor is that the idea be potentially comprehensible by him or herself in the future, whence an intermediate language between public and private language.

Therefore, returning to the musical composition under examination, the vague anticipations which characterize ideas are different from those just presented: not only their eventual use, but also the very possibility of their realization at various degrees is left open. Moreover, we saw (Sect. 3) that many important elements of the compositional situation at a given instant were constructed by the composer himself in the past. Consequently, as far as these vague anticipations which characterize ''ideas'' go, an important place must be given to the construction by the actor of stimulating problematic situations for creation, in relation to certain ideas.

An idea requires time in order to emerge, to be (re)formulated and to become determinate. This opens up, as far as musical composition is concerned, a long term which exceeds the conscious preparation of a given work, but nevertheless does not span the entire career of the composer. It is precisely the birth, inscription, recopying and, most of all, the determination of the ideas of ''scatting'' and of ''swathes of chords'' which we encountered in the second the third sections respectively, which have a well-documented history through our system of data collection. In this way, this study of the activity of music composition allows for the clarification of the nature and function of an idea in general, through the specification of given ideas.

In this section, we will examine these ideas and their place in the creative process, by developing the descriptions we presented in Sects. 3 and 4, respectively, concerning ''swathes of chords'' and ''scatting''. We will begin with the idea of the scat. As an idea, its content is progressively determined, but it is nevertheless more determined from the beginning than the idea of ''swathes of chords''. Moreover, once the idea of scat is inscribed into the general plan and the ideas sheet of the planned movements VI, VII and VIII which were replaced by movement V, it has non-negligible effects on the musical writing of movements which precede this movement V.

5.1 The role of the scat idea before its determination

The scat is the principle element of the fifth and final movement (see Sect. 4), after being at the heart of the initially planned movement VI, and the composer had planned from the beginning of the composition to use this element. He abandoned a ''logic of movements in which the scat would have been a piece in itself'' in favour of a synthesis of heterogeneous elements into a unique movement: ''Now that [the scat] is no longer a movement, it has to be part of a gesture, a musical content'', which leads him to make it the central section of the new movement, which contains successively elements from VII, VI and VIII.

Before constituting an important point in the writing of the fifth movement, the scat was anticipated only vaguely.

So it is that on one of the various notes collected into the folder marked ''ideas of all kinds for vocal pieces'', we read: ''jazz style / [underneath the white space between the two words:] onomatopoeia / at high speed pa pa da tou Kou'', which characterizes the scat, while giving special emphasis to its speed. As it is implicitly understood by the composer that he will not undertake a realistic transcription of scat (for various reasons, notably for reasons of aesthetic

compatibility), it could be said that this note expresses the idea of scat in terms of an indeterminate distance from a prototype (cf. Rosch and Lloyd 1978)—that of scatting as it is used in jazz.

In the general plan of the work, the idea of scatting implies a sinuous and rapid melody with a homophonic relationship between voice and instruments, inspired by jazz:

> [Reads on the general plan: ''scat / with *OpenMusic* / melody follows the shape of the text''.] ''So, from the sixth movement, I am going to keep the idea of scatting, and of homophony between the voice and the instrument, a little in the spirit of jazz—well, not really jazzy, but it comes from jazz.''

The idea of the scat emerges more clearly in certain circumstances, for example during the writing of the second movement, when he had to carefully dose the difficulty and the tension of certain vocal passages:

> ''*The repetitions [of certain motifs] are there to help the singer?*
>
> Possibly, yes. What's more, I know what the fifth movement would be like!…[…]
>
> *What was your idea at that time for what the fifth movement would be like?*
>
> I don't have a complete idea, but I know that there will be a long section of scat, very quick, and it is going to take a lot of work. I have to divide up the effort. That's what I often tell my students. It's OK for performers to encounter great difficulties in a piece from time to time, but if the whole piece is like walking on a tight-rope, it's depressing for everybody.'' [Excerpt from the first interview on the second movement (February 5, 2004)]

At the beginning of the fifth movement, the scat is hardly more defined than it was beforehand, but it remains an expected moment, which focuses attention:

> [Beginning the writing of the movement:] ''Well. What do I know about this end? Super important. Well. I know that the scat will come in [leafs through the score for the scat passage]/''

It is only when he began to write the fifth movement that the composer anticipated the beginning and the content of the scat passage in a more precise manner, with reference to the structure of the preceding movement [see the making of the structure of the third movement and its transfer into the fifth movement in Sects. 3 and 4 above]:

> ''*You don't know when the scat will begin?*
>
> Yes I do. The scat will begin at the point at which the voice enters in the third movement, where the voice comes back in the third movement.''

Finally, soon after this point, which is at that point precisely determined, in which the scat begins, Philippe Leroux draws up a plan of the scat onto an idea sheet entirely devoted to this particular section. Following a process comparable to that of re-reading which was mentioned above with regards to the approach to the third movement, he associates several elements which will become constituent parts of the section: the poetic text, the chords invoked for each measure, the letters which supply the melodic line, etc.:

> ''Here I'm trying to structure the scat a little, I lay out all the letters that are going to be accentuated, so I have an idea of the placement of the accents, I have an idea about the caesurae with the sloping [letters], the letters that are going to generate tremors [tremblements]—the m's and the n's, etc.''

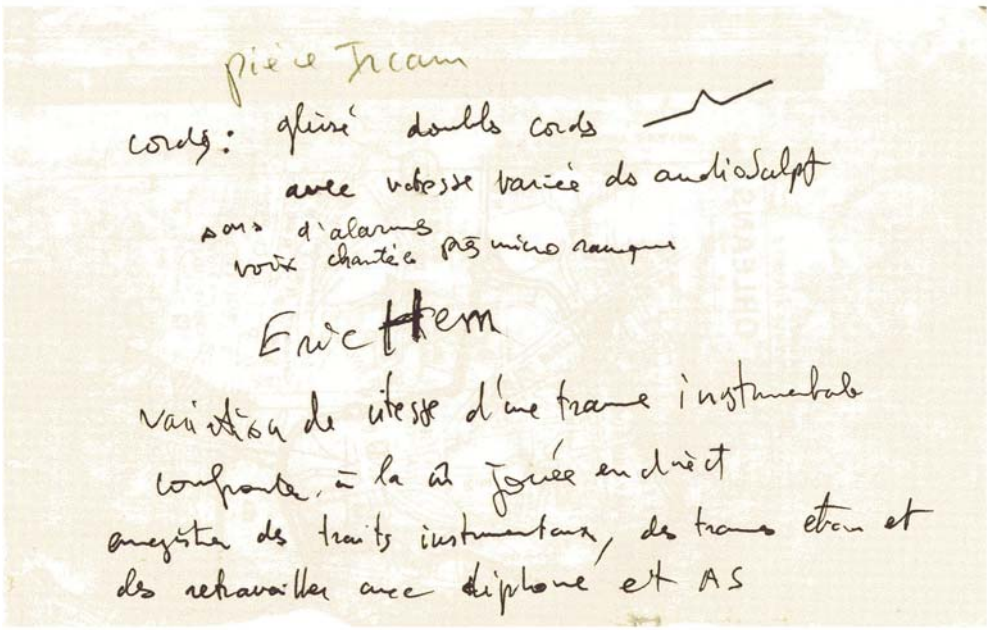
In fact, the way to write the scat would only be fixed after a dialogue with the singer [referred to here as Donatienne] concerning one of the first versions of the score manuscript:

> Here we have the scat [m. 432]. I told you that at first I thought that I would only put the first and last note, and didn't think I would fill them in [with the intermediary pitches]. Because I said to myself, this poor singer! […] In fact Donatienne said to me ''I want you to note every single note''. [So] I wrote out all the notes.

5.2 The important and unexpected consequences of the idea of ''Swathes of chords''

We have seen in Sect. 3 that one of the ideas for the third mouvement which appeals to the composer is that of ''swathes of chords'' [aplats d'accords]. ''Aplats d'accords'' is inscribed in the very middle of the sheet of ideas for the third movement (cf. Fig. 1), but reformulated through a pictorial metaphor (see Lakoff and Johnson 1980)—which, like the indeterminate distance to a prototype in the case of the idea of scatting, attests to its indetermination—a description contained in a fragment [bearing the title ''Ircam piece''—cf. Fig. 2]:

> ''Swathes of chords, I must have written that in later (than the rest of the sheet of ideas), but I know that there will be swathes of chords, very simple things…which come from one of the little notes I had jotted down and I risked my life for that because I was listening [to the radio] while driving on the expressway surrounding Paris, I can still remember a certain bend in the road, and I was busy noting it down at the same time, it was a little complicated. I was listening



Ircam piece	pièce Ircam
strings : glissando double stops [schema]	cordes : glissé doubles cordes [schéma]
with speed varied in Audiosculpt	avec vitesse variée dans audiosculpt
alarm sounds	sons d'alarmes
singing voice, near microphone, hoarse	voix chantée près micro rauque
Eric Hem	Eric Hem
speed variation of an instrumental track	variation de vitesse d'une trame instrumentale
to be confronted with itself played live	confronter à la même jouée en direct
record instrumental lines, tracks etc. and	enregistrer des traits instrumentaux, des trames etc. et
work on them with diphone and AS [Audiosculpt]	les retravailler avec diphone et AS [audioscuplt]

Fig. 2 The first formulation of the idea of « swathes of chords »: an older fragmentary note (dating from several months before writing the ideas sheet for the third movement), consigning this sound idea to the ''IRCAM piece'' (line 1) [© Philippe Leroux]

to France Culture on the radio while driving, and I was listening to a piece by a guy named eRikm [notated ''Eric Hem'' on the fragment ''Ircam piece''] […] In any case the idea came to me of swathes of chords, and to have the same chord which transforms very slightly with respect to the first, from a harmonic point of view, from the point of view of pitch, just as well as from the point of view of its texture, of its internal rhythms, etc. / I knew that I wanted to play on that idea a lot in that movement. That's why I put that, on that sketch, here it is [partially parallel lines in the upper left hand corner]: a chord A and a chord A' which will diverge slightly, then return; that [the second schema] is the same thing but there is also going to be a phenomenon of slowed down acceleration like a tape recorder in front of the heads''.

Like the little note on the scatting described above, this little note about the idea of swathes of chords belongs in fact to one of the folders which the composer uses throughout the writing of *Voi(rex)*; it had the title ''Ideas of all kinds for vocal pieces''.

We have also seen that a pleasant surprise awaited him when he listened to the recordings of the chords of *Voi(rex)* which came out of his recording session with the musicians, at IRCAM (see note 1) on April 18, 2002: not only were the obtained sounds interesting, they were also consistent with the idea of ''swathes of chords''. Listening to the resulting sound files in his usual work environment for sound processing, the software *ProTools*, Philippe Leroux is on the point of reworking them.

By manipulating the sound files arranged in the *ProTools* work session, Philippe Leroux discovers the value of conserving the original durations of certain sounds. We have seen in Sect. 3 that during the recording he felt ''the need to have notes held quite long in order to be able to work with them later, and also, conversely, to have very detached notes''; but in no way did he think at that time that he would ''use the maximal time of the held note, for example 15 seconds'', in the process of concretizing the idea of ''swathes''—it is only ''to be safe'' that he asked the musicians to hold their notes for a considerable length of time. It is only at the moment that he is in the compositional situation that he exploits this particularity in order to play with auditory ''signposts''. He separates the sound files onto different tracks of a *ProTools* work session in order to try various combinations. For example, as he says, ''The first thing I do is to introduce the first chord and to have it followed by the same chord but played backwards'', the result being that the pivot between the two is imperceptible at first hearing. He imagines having the first sound played by the instruments (by recopying into the score the sketches for the instrumentations which the musicians sight-read during the recording session), while the second sound would be a file played through loudspeakers. In so doing, he creates a play of imitations between the instrumental ensemble (which, in concert, plays the fragment of the score used in the April 18 recording session) and electroacoustic sounds (which, in concert, will prolong the sonorities produced by the ensemble in such a way as to make it impossible for the audience to situate clearly the transition between the two). As the first trials of this type were convincing, the composer decided to make the recordings with the musicians from April 18 the principle material of this movement, and it is at this point that he adds the mention ''swathes of chords'' in the middle of his sheet of ideas: what was supposed to constitute a single element, a section, or a category, becomes the all-encompassing logic of the movement.

Over the course of these first days of work, more and more sound files from the original recording session are used: either conserved and placed with more or less precision (depending on whether they are located closer or farther from the beginning), or else cast out (deleted or relegated to the end of the *ProTools* session). In this way, the entire movement starts to take shape:

> ''At the beginning, I finish one chord, then would go on right away to the next […] [but] later I project things through time, I go on to realize—but not to finalize—a little passage, at [for example] the 2 minute point.''

At the same time, the relationship between the *ProTools* work session and the score becomes more complex: certain reworked sounds (notably through the *freezing* effect which allows for micro-fragment of a given sound to be played in a loop) are themselves used as models to be ''copied'' by the instrumental ensemble—in other words, in the writing of the score, Philippe Leroux makes dictations into musical notation of sound files which have been modified through various electroacoustic manipulations which have rendered them considerably distant from any instrumental idiom. The play of imitations and simulations is progressively integrated into the score, leading the composer to experiment with types of writing with which he feels unaccustomed—with the result that the next phase of writing, during the month of August, takes place for the most part on the score itself.

This progression would have been for the most part circumscribed by the compositional situation of the first days, whose situation was itself prepared extensively beforehand. The relevance of the recorded chords which Philippe Leroux listens to at the moment in which he begins the writing of the movement only obtains because the context of this writing is suitable for them, i.e. because having gathered a priori the constituent elements of the movement to be written, the composer searched for a means of crystallizing them—to put a great number of them into a network, or to fuse some of them together. In this case, it is the application of the idea of ''swathes of chords'' (exploiting the rich material obtained from the recording sessions with the musicians from April 18) to the entire movement and not only to a single determined passage, which allows for the elements to be instantaneously put into relation with one another.

The following will then be undertaken: the schema of the two chords becoming progressively out of phase with each other, the play of reciprocal imitations between the ensemble and the electronics, being ''dazzled by white noise'', and the development of unexpected writing situations which stimulate the invention of the composer (in particular the idea of ''instrumental simulation'' of sound files, starting from a re-worked musical dictation). At the same time, many of the initial ideas for this movement are abandoned:

> ''There are things which I didn't do. For example, I had intended to use certain chords to which I had given the name ''chords which are good in

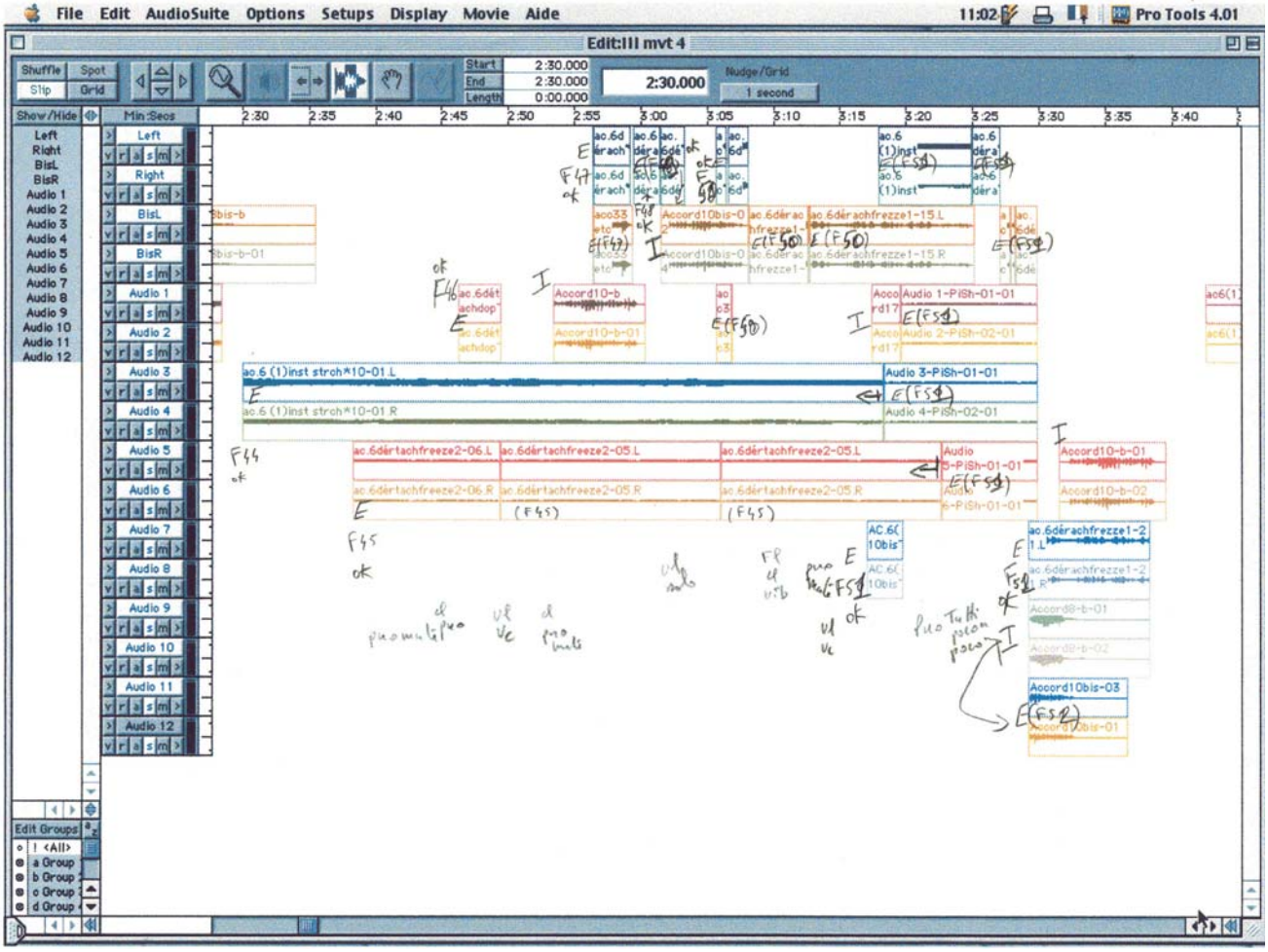


Fig. 3 Screenshot of a *ProTools* session (different from the one discussed below concerning the first seconds of the movement), annotated by Leroux in August 2002 (during the composition of the corresponding passage—here, from approximately $t = 25''$ to $t = 3'10''$ environ) [© Philippe Leroux]

> themselves'', but in fact I didn't use them/ there were a few instances in which I wanted to use these chords in the piece, either as interludes between the movements, or even in this movement itself; but in the end I didn't do it, I didn't use them at all.''

This extension of the place given to the idea of ''swathes of chords'' leads him also to give pride of place to one particular kind of signal processing, frequency shifting, which he had initially reserved for the writing of the fourth movement, with the corollary of minimizing spectral inversion, which had been initially assigned to this movement. Frequency shifting did not seem appropriate until after having begun work with *ProTools*. It is at this point that Philippe Leroux drew a line indicating that the indications ''frequency shifting'' and ''spectral inversion'' were to switch places relative to the third and fourth movements, and he added the mention ''or frequency shifting'' to the mention ''spectral inversion'' written in a box in the sheet of ideas for the third movement (cf. Fig. 1). A box of this sort, according to his personal convention, defines in his plans and idea sheets for each movement the principle modes of sound processing attributed to that movement.

Although this logic of imitations and reciprocal simulations is made possible by the particular quality of the collected sound files, it also depends on the Cartesian space of the *ProTools* interface[11] (cf. Fig. 3). Contrary to the usual practice of the composer, who places sounds into

[11] The interface of this type of sequencer consists of a number of horizontal audio tracks which can be listened to simultaneously or individually, and in which stereo sound files can be positioned in various ways according to a linear representation of time which is common to all of the tracks. A *session* is a collection of files (with their respective positions) brought together into a single workspace using this interface. In *ProTools*, a series of plug-ins also enable certain manipulations of the audio signal without having to export the files into a sound-editing program and then to re-import them back into the sequencer. Philippe Leroux uses plug-ins designed by the G.R.M. [Groupe de Recherches Musicales], a French institute of music research specialising in the composition and study of electro-acoustic works fixed onto a recording medium.

tracks according to a logic of simultaneity but without giving an identity to each horizontal line, here each track of the session tends to acquire a function: one sound to be played by the ensemble (track 1), one sound file to be broadcast in the hall (track 2), another accessory sound file which allows for the transition between the two others (track 3), ornamentation and enrichment of certain passages which are richer from an electroacoustic point of view (other tracks). It is only later, over the course of the writing of the first minute of music in *ProTools*, that Philippe Leroux begins writing onto the pages of the score. He does so not so much as a way to fix the scoring of the instrumental part (which is largely based on the orchestration of the sheet of initial chords), but rather as a way to place the voice. The voice had not been taken into consideration up to that point. Its absence, starting from the second page, which had been decided in advance and held to, had to be taken into account in the realisation of the play between instruments and electronics (since the electronics develop throughout the movement). One of several consequences of this procedure is that a larger part of the work of composition takes place in *ProTools*, the place of discovery and a convenient means to elaborate the simulation. The software interface becomes a constituent medium for the logic which governs this movement, whereas in the composition of previous movements the score was from the beginning more preponderant. The inhabitual nature of this approach is recognized by the composer:

> ''It is a movement which I composed principally on the computer, by simulating what was going to happen. […] For the electronics, there is going to be a constant interplay between the real chords [= those which will be played by the musicians during the performance of the piece in concert] and the false ones [= those which will be broadcast over loudspeakers]—which are in fact the same.''

6 The appropriation of technical devices and the making of a unique individual cognition

In the preceding sections, we considered the different ways in which the characteristics of the musical work emerge. This description showed the role of various computer tools and functions available to the composer. Another kind of emergence must be considered in this section: the very-long-term emergence of new procedures of composition which the composer then considers as available for his future compositions. This too concerns the use of computer tools: the emergence of new compositional procedures involves new procedures for the use of computer tools, and the former integrates the latter.

6.1 Temporal horizons in the composition of a work to composition over the very long term

We saw that the composition of any part of *Voi(rex)* called into play several temporal horizons. The compositional activity of Philippe Leroux must also be considered over the very long term. Through this change of scale, not only the transfers and repercussions from one work to the next, but also the transformations of Philippe Leroux's manner of composing, can be apprehended, even in the study of the single work examined here. These transformations will be emphasized in this section.

Through this study of the composition process of *Voi(rex)*, but also through a new ongoing study about the composition of *Apocalypsis*, a new composition by Philippe Leroux which is related to *Voi(rex)* (see Sect. 2), we can state that the content and organization of the composer's studio (computer and software included) is a relative invariant built up over a number of years. Long time-span creative cognition, unique individual cognition and situated cognition appear as constituting three related characteristics. In this way, we may speak of a unique individual cognition of a technically situated actor.

It is worth recalling that Newell and Simon (1972) point out a difficulty in the now classical ''human information processing system'' approach when facing cognition in chess masters: ''We are, in fact, somewhat handicapped in studying the behaviour of masters and grandmasters in chess, since we cannot attain a better understanding of the task environment than such subjects'' (1972, p. 64). The same difficulty arises when studying the behaviour of composers of music. But it appears more as a difficulty related to the coupling between composer and his different tools and environments than as a difficulty related to the composer himself. Formulated this way, this difficulty may be solved—at least in part. In other words, not only must the training-development of the composer be considered, but also the way in which the composer appropriates existing tools and environments. By appropriation, we mean that an actor, in this case the composer, integrates some tool or element of his environment into his possibilities of action (that is, his ''*corps propre*'' [proper body], to use the formula of Merleau-Ponty 1945) in a way that can be specific to him; hence, appropriation is also individuation, which depends on his ongoing situation and past experience.

Over the course of our analysis of the exhaustion/recycling of material, in Sect. 4 of this paper, we showed how the *OpenMusic* software constitutes both a tool and the memory of the operations considered. We can now add that the appropriation/individuation of this program, through the development of personal patches and through the conception of a unique program library (with the help of an

Ircam assistant, who is at once a technician and a musician), was from the beginning one of the important aspects of the project of this work for the composer. He also took up, during the composition of *Voi(rex)*, technological ideas initiated in the past (in the context of an older version of this software) but never brought to fruition; and he hoped to capitalize, in view of future works, on the technological conception worked on for *Voi(rex)*. Musical ''ideas'' exist, therefore, which are destined to an operationalisation in the form of libraries of patches; from the beginning, they are planned to be concretized on the scale of several compositional projects, and their effects are felt on the scale of several works.

Over the course of this analysis of the progressive determination of essential characteristics of the third movement (Sect. 5), we showed the important role played by the program *ProTools* in the composition of the third movement with respect to the idea of swathes of chords. In this case, contrary to the previous example, the appropration/individuation of the program is not an explicit *a priori* of the artistic project, but rather, it appears exclusively while *in the situation*, through the emergence of a significant compositional operation. This operation might only have been significant at a precise moment, without later becoming a compositional procedure in and of itself; or else, it might have been subsumed under such a procedure, but only by means of a generalization which detached it from the specific technology which allowed it to emerge. In fact, the operation does in fact become a procedure, and does retain the use of *ProTools* to stabilize the modes of appropriation which we have partially described in the preceding section. In order to describe this phenomenon in the long-term scale which is of interest to us, we will use data collected from different periods of the composition of *Voi(rex)* (writing of the third movement, particularly the beginning, and the first third of the fifth movement).

6.2 Another step in the appropriation of *ProTools*

The unexpected writing situation of the third movement, stimulating the invention of the composer, which has just been analyzed, might only have been of interest for him relative to the writing of this particular movement in this particular piece. But in fact it marks in his mind the acquisition of a new ''tool'' of musical writing—a stylistic innovation in relation to a new procedure—whose value seems to him to be attested by the success obtained here and now:

> ''Freezing a chord, shifting the window inside an arpeggio, I don't see any operation of instrumental writing in the past that resembles this. It inaugurates then something that is very new on the level of writing, at least in part. However, my starting point is sound. It is not like with MIDI instruments, in which the notes are already there, and the rhythms, and all you need to do is to adjust things, or to rework the timbre. And neither is it purely electroacoustic sound in which you have to reinvent everything.''
>
> ''I wrote things that I would never have written on my own. For example, that little violin thing, there, all alone in the middle [mm. 243–244]. By myself, […] I would never have written that […].
>
> It starts to be really fantastic then, because [after] the very hard work of inner listening, to try to really hear what's going on, to adjust things, etc., after all that, I have really gained a new writing tool which I can use in fifty pieces to come, pieces which won't [necessarily] have anything to do with electronics.''

This writing procedure is however not absolutely new. It already existed in emergent form or, in the composer's words, ''globally'':

> ''In terms of a global approach, I've used it before. [...] For example, I used it once for a piece that I wrote for four wind instrument MIDI controllers. It was really unusual. Later I made an instrumental version of it which is called *AAA*. But in that case they were MIDI instruments, so there was already a part of it which was automatically written out. Here I start from the complete sound files which come from instrumental sounds processed through electroacoustic techniques. This is a different case altogether.''

Retrospectively, the composer relates moreover this compositional innovation to a large family of procedures already utilised, going all the way to ''pure'' musical dictation of a sound file, which is a procedure which is far from being specific to him:

> ''While the fifth movement is almost pure musical dictation, here [in the writing of the third movement], there is some dictation but at the same time, in the end, I frame many things rhythmically on *taleas*. In fact, what the electronic layer is doing here is something like [hums], a little haphazard. And then I rewrite everything in order to get the right notes, the right pitches, within the framework of the *talea*, my rhythmic theme.''

Even if, in the end, this is only relatively new in terms of its content, its novelty lies in its potential for synthesis and imagination in paving the way for promising future applications.

Moreover, the genesis of this innovation must be related to an aesthetic culture, and a particular practice, that of the electroacoustic work on sound developed by the Groupe de

Recherches Musicales (see note 11) in which the composer developed his first compositional arsenal. More specifically, Philippe Leroux studied composition with Ivo Malec at the end of the 1970s, a period in which this composer had thoroughly explored the domain of mixed music (which combines tradition instrumental writing and pre-recorded sounds, broadcast during the performance), in the framework of the G. R. M. Having intensively practiced electroacoustic composition at this time, Philippe Leroux has maintained since this time a great degree of familiarity with the tools which allow one to work on recorded sound (samplers, sound processors), and has often had occasion to work on these configurations in which there is a reciprocal influence between the world of instrumental writing which leads to performance, and the world of sounds which are fixed on a medium and transformed. It is on this basis that he approached the composition of works using real-time electronics, notably at IRCAM for the composition of *M* (1997). The emergence of the innovation which we have described can then be understood as a displacement, qualitatively important, but quantitatively negligible, in favour of a given compositional situation, with respect to a body of very stable practices which constitute the individual/collective musical culture of Philippe Leroux.

6.3 A confirmation resulting from the writing of the fifth movement

The exploitation of the procedure of recycling of the structure of the third movement on the scale of a large part of the fifth movement (see Sect. 4) is linked to elements from the compositional situation of this movement such as the need to save the voice before the scat section and the desire to establish solid ties with the third movement. But it must also be understood as a confident exploitation of the compositional innovation of the third movement, but on a larger scale than the first time around (see Sect. 3). In this sense, this innovation is confirmed to be fruitful in this test situation defined by the urgency to finish the manuscript in order to submit it to the publisher, without spoiling the efforts of preparation of the three movements initially planned, nor to reduce the relationships between the fifth and the preceding movements. Our characterization of this ''new writing tool'' in the analysis of the third movement would not have been complete if we had not taken into account this ''second time around'' which confirms a process of emergence-creation-recognition of innovation.

Such empirical results may be generalised: appropriation is a phenomenon of long time span cognition which appears at a certain period of time, during a process which may be long or short, in relation to past experience, while being confirmed by future experience.

7 The method and time of the inquiry

Phenomena of large temporal span of creative cognition just presented seem to us to point towards a methodology of analysis of verbal protocols collected within a situation simulation through the material traces of the activity that we presented here above. The kinds of analytical elements which we have presented are not presently available to music listeners. They were not immediately available to the composer himself either, at least not in detail or in their construction. They show how fruitful the investigation situation that was practiced in this study turned out to be. The validity of the data collected is essentially assured, during the interviews and after them, through, on the one hand, the confrontation of different affirmations of the composer, and on the other hand with the material traces available. This fruitfulness and this validity, we anticipated them from past theoretical and methodological experiences concerning the analysis of activities in work situations, in sports and in education (Theureau 2003).

This method is closely linked to theoretical hypotheses about both long time span cognition and situated cognition (and is not limited to creative cognition). The classical work on verbal protocols, Ericsson and Simon (1984), presents ''retrospective reports'' in relation with an internal storage view of memorizing, memory and retrieval. With such a theory, there is no need for any material (external) reconstruction of the situation where the activity under study took place. On the contrary, we make the hypothesis that both this activity was situated in a strong sense—see above in Sects. 3 and 4—(in situation 1) and that a new situation of simulation (situation 2) of this situation 1 will be necessary for the composer to replay the details of his activity and verbalize them.

Every data collecting method or situation has its limits. The limit of this situation simulation interview method which we did not at first anticipate concerns the verbal and gestural expression of activities concerning a future movement while writing a given movement. We can find in some of our data this kind of verbal and gestural expression. For example, at the end of the situation simulation interview concerning the writing of the third movement, we collected the following dialogue:

> ''*When you get to the end [of the writing of the first movement], you have almost used everything that you had in those sketches over there [detailed sketches], perhaps not everything that was in your plans, or in your older sketches. I'm wondering if there are things which you really intended to use, but which you didn't end up using?*
>
> There are. For example, the idea that I would start from a noise and end up with a single strand of sound,

and then to have it vibrate more and more. I made notes about certain playing styles, for the strings, vibratos of rhythmic intensities [imitates: wawawa], and I didn't use any of that in that movement, I used them in the second one.

In the progression from noise to sound, I thought that there would be a part, a moment with sounds of voices and air. Because I had quite a few of those in stock in my binder, and I hadn't used any of them there, but only in the second movement.

About those things, did you say to yourself: ''I absolutely must use them?''

No, because I don't want to absolutely/i take things as a reservoir. […]

At what moment did you realise that you hadn't used them?

As soon as I had passed the period in which they were supposed to be.

So, you recopied them onto another sketch?

Yes. In that period, around page 7 [of the score manuscript], between pages 6 and 7. Did I recopy it directly, or did?/i'd have to go see the sketches for movement two.'' [He does so]

But it was only during the reconstitution of their use in the composition of the fifth movement that we were informed that during the writing of the third movement, but in preparation for the fifth, the composer noted (in sketches for the movements VI, VII and VIII which were replaced by the fifth), certain elements intended for the third which he removed from that movement, as well as developments envisioned for other elements of the third. Despite our asking the composer to document all of his activity, these elements produced in relation to activity themes appealed to punctually, whereas the dominant activity theme was the writing of the third, were only mentioned when reconstructing the moment of their final utilization:

''I wrote that at a point in which I was writing the third movement; I said to myself: what I am doing at this moment, such and such an operation, for example, possesses such and such a development which will fit in perfectly at the end'' [Interview about the writing of the fifth movement].

The fact that they were forgotten during the situation simulation interview for the composition of the third movement shows the limits of the simulation situation: the de facto monopoly accorded to the activity theme that was dominant. What is remarkable is that the access by the same methods to their effects during the writing of the fifth allowed them to be recovered.

Similarly, as was noted above, it is only during the compositional situation simulation for the fifth movement that the process of compositional innovation of the third movement turns out to be made explicit and thus recognised (as an operation common to the two stages of writing with a wide interval of time between them).

One thing that we could anticipate in principle but not in terms of its realization is that the compositional situation simulation of certain movements allows us to discern certain globally shared characteristics of the activity of composition. This is particularly true of the fifth movement. For example, it sheds light on the ''intimate knowledge'' for a movement that the composer gained after the writing of the preceding ones:

''There is a very important thing there, and there's no trace of it anywhere; that's the fact that I just composed the four first movements, so I have intimate knowledge of the time of my piece: I re-read it often, and what's more, for the third, a simulation in time is available, so I feel / I see very well the balance / if such and such a section might tend to unbalance the piece as a whole, I would feel it right away. It is at the beginning, perhaps, that that type of thing is the most critical. After, I could almost continue with my eyes shut. […]''

Also by way of example, the logic of collecting, transferring and transforming which is put to use by the composer is particularly evident in the writing of the fifth movement because it gives closure to *Voi(rex)*. In point of fact, its characteristic of being a concluding movement sheds light on the properties of the activity of composition over the course of the writing of all of the preceding movements.

These interviews within situation simulations through material traces could obviously be held throughout the writing of a work (or any other long term cognitive process). This is as a matter of fact the method we are adopting today as part of a new research project on the activity of musical composition, with respect to *Apocalypsis* by the same composer, the artistic project of which motivated, among other reasons, the composer to accept to participate in our research project (see Sect. 2). The grain of the analysis is made finer in this ongoing study taking place not afterwards but during the composition process. The same situation simulation interviews are conducted every month over the course of the compositional process (preparation and writing). The changes in sketches and manuscript score used as traces of the composition activity in order to make the composer replay this activity and verbalize it are finer, and the composer's memory is fresher.

8 Conclusion

Through this empirical study of Philippe Leroux's activity of musical composition of *Voi(rex)*, large temporal span of

human creative cognition appears as a challenge in terms of data collecting methods and cognitive theory, at least if its study aims at connecting different time spans and not at reducing complexity at all costs. The method of interview within situation simulation through material traces allows one to document empirically this connection, at least to a certain extent.

We have characterised the situated (musical) composition as a special case of the notion of situated cognition in situations essentially built previously by the actor. We have noted that the essential role played by memorization, inscription, and by rereading and its techniques is connected to this specificity. The study of this type of cognition situated in other situations should allow us to pass from a descriptive statement to theoretical elaborations as well as to generalisations which have a higher degree of precision and reliability.

However, the theoretical elaborations of the notion of idea as well as the role of ideas in the development of the creative process, and of the notion of appropriation/individuation of tools, as well as the role of appropriation/individuation of tools in the making of situated individual cognition, already allowed us to make interesting generalisations concerning the long time span of cognition.

Many research projects studying different situations, like those which we have cited in the introduction, face the same challenges. The methods and notions presented here should contribute to the development of their ''heuristic power'' and ''growing capacity'' (Lakatos 1970), while at the same time questioning in a new light the assumptions and the methods of disciplines which study works of art (in this case, music analysis, genetic criticism and musical aesthetics).

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