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Aspects of Musical Research at IRCAM

Andrew Gerzso

Musical research is an expression used in a variety of contexts leading to multiple meanings (and confusions) regarding this activity. In this article, three types of musical research attached to specific contexts are described; in particular, the context in which composers and scientists collaborate motivated by common concerns as is the case at IRCAM (Institut de Recherche et Coordination Acoustique / Musique). The methods—gleaned from more than two decades of activity—whereby musical research projects are defined, managed and evaluated are described while attempting to make explicit the conditions for successful research. Particular emphasis is placed on the role of mediators and technology viewed as a medium for communicating concepts. Some major challenges facing musical research in the future are also briefly sketched.

Keywords: Musical Research; Mediators; Mediation; Formalization; Interaction Notation

Overview

Three Contexts of Artistic Research

In order to avoid confusion concerning the scope and focus of musical research at IRCAM (Institut de Recherche et Coordination Acoustique / Musique), it is important to distinguish at least three contexts in which artistic research usually takes place.

Individual or private research
This is the level at which the vast majority of artistic research takes place. It is characterized by the artist who over time creates a 'private cosmology' (cf. Stravinsky, 1972) gleaned from a wide variety of sources coming from many directions (influences of artists past and present in the same field or other fields; philosophical, political, social influences; scientific concepts, etc.). Here, one can say that the results of this type of research are personal.

Collective research among artists
Here, we find typically a group of artists (from the same or different disciplines) who are motivated by common concerns. In painting, typical examples are the Surrealist

and Futurist movements. In the literature, a good example is the Ouilpo group concerned with the questions of 'potential literature' that brought together in the past writers such as Raymond Queneau or Georges Perec. In music of the twentieth century, the classic examples are the Vienna School (Schoenberg, Berg, Webern), the group of 'Les Six' (Auric, Durey, Honegger, Milhaud, Poulenc, Tailleferre), Darmstadt in the 1950s (Berio, Boulez, Stockhausen). Classic examples of inter-disciplinary research include the Bauhaus (Walter Gropius, Paul Klee, Vassily Kandisky) and the Black Mountain College project that brought together artists and intellectuals such as Robert Creely (poetry), Josef Albers (painting), Lou Harrison (music) and Albert William Levi (philosophy). In this group, we also find the mythical collaboration between John Cage (music) and Merce Cunningham (dance).

Collective research between artists and scientists

Here, artists and scientists (or developers of technology) are working together motivated by perhaps differing professional objectives but where there is nonetheless an identified common ground. The musician, for example, seeks to enlarge the musical vocabulary at his disposal via a new technology, and on the other hand, a scientist may find that the problem posed by the musician is a challenging one from the scientific point of view. Or, *a contrario*, the scientist may invent something which stimulates the imagination of the musician. The social difficulty here is that both the scientist and the musician are ultimately judged according to the specific criteria of their professional milieus. The collaboration between scientists and musicians is clearly a phenomenon that began in the mid-1950s and has expanded exponentially since. In France alone besides IRCAM, institutions such GRAME in Lyon, the ACROE in Grenoble and the GRM in Paris are very active in this domain. Elsewhere in the world, one finds institutions such as Ars Electronica and IEM in Austria, the ZKM in Germany, CNMAT and CCRMA in California and the Media Lab in Boston.

Clearly, IRCAM's focus is organized principally around this third and last context. However, while working on a composition, a composer at IRCAM will invariably navigate between the three contexts. Over the years, the need for collaboration among composers on purely musical questions has increased, and as a result workgroups, seminars and colloquiums have been organized to meet this increasing need.

Domains of Research

The evolution of new technologies (principally computer based) for music at IRCAM may be viewed as extensions of traditional practices (composition, interpretation, instrument building and sound projection) by revisiting or re-inventing compositional issues. This is illustrated in Figure 1. Sound projection, an awkward term, refers to the way music is organized and presented to the public in a given space for performance, be it in a concert hall or in a virtual listening space.

Computer-aided composition extends the possibilities and modalities of musical writing: the production of instrumental scores, virtual scores (whose finalization

depends on factors determined during performance), the generation of scores for electronics and the generative and interactive processes involved in computer-aided improvization. The principal technologies developed in this area are: OpenMusic (Assayag, Rueda, Laurson, Agon, & Delerue, 1999) and OMax (Lévy, Bloch, & Assayag, 2012).

Real-time technologies have introduced a new dimension to interpretation and musical performance through technologies capable of analyses, recognition and synchronization with musical performance. The principal technologies developed in this area are: Antescofo (Cont, 2011) and GF (gesture follower) (Bevilacqua, Baschet, & Lemouton, 2012).

Sound analysis and synthesis technologies have extended the notions of instrument building. Broadly speaking, the results of these developments have impacted the sound engine more than the gestural aspect so important in instrumental performance (especially the strings, and percussion). The principal technologies developed in this area are: SuperVP (Bogaards, Roebel, & Rodet, 2004), AudioSculpt (Bogaards et al., 2004), CataRT (Schwarz, Cahen, & Britton, 2008) and Modalys (Iovino, Caussé, & Dudas, 1997).

Sound spatialization has led to a redefinition of the relation between a musical work and the space in which it is performed leading to a new relation between the work, the performer, the listener and a virtuosity in the manipulation of sources and the spaces

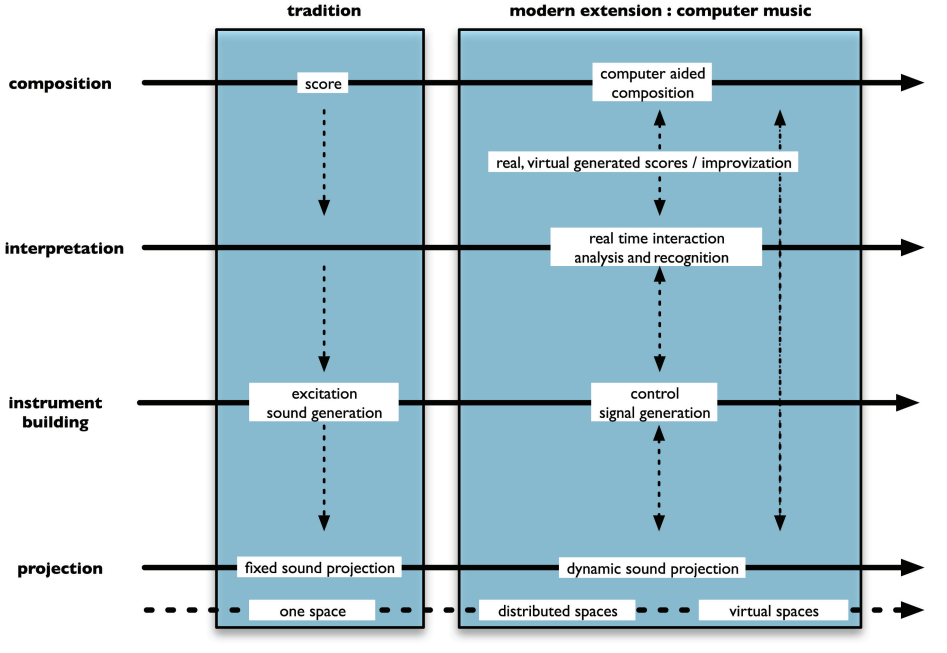

Figure 1 Traditional Musical Practices (on the left) and their Extensions (on the right) via Modern Computer Technologies.

in which they evolve. The principal technologies developed in this area are: the Spatialisateur (Jot, 1999) and the Ambisonics (Malham & Myatt, 1995) and WFS (Baalman, 2008) approaches to listening spaces.

Underlying a majority of the technologies mentioned above, is the IRCAM invented Max (from Cycling74: http://cycling74.com/) visual programming environment for creating real-time musical applications.

A final point concerning musical practice concerns the directionality and the evolutionary pace of these practices. Traditionally, the directionality was: composition, score production, interpretation and performance—with instrument building evolving in parallel as the musical languages changed in conjunction with the slow evolution of technologies (mastery of the craftsmanship of wood, the technologies of steel …). Today, composition, score generation, interpretation and presentation may interact highly even within a single performance. So, the clean distinctions of the past have become blurred. The slow evolution of instruments tied to physical materials has accelerated as the new instruments have become dematerialized and linked with the evolution of computers. In addition, a major challenge is combining the newer 'instruments' with the traditional ones in order not to renounce the rich heritage of 'classical' performance practice.

Objectives

Arguably, IRCAM's main goal from the beginning has been the expansion of the musical vocabulary—understood in the widest sense of the term—available to the composer via the new possibilities offered by new technologies, with the inevitable impact on the various musical languages and styles of today. Of course, the musical vocabulary is explored and put to use in musical compositions that in time entail other obligations and goals as we shall see below. The term vocabulary may apply to low level elements (such as spectra, envelope and descriptors) as well as high level ones (such as musical form). The vocabulary is 'expressed' via its embodiment in an extension of an existing technology or through a wholly new technology. New elements of vocabulary may extend an existing domain (as in the case of musical composition or sound spatialization discussed above) or inaugurate a new domain or musical form. A good example of the latter has been the emergence of 'mixed works', that is, works mixing traditional instruments and electronics. Another important goal that has emerged over the years is that of making sure that the innovative vocabulary thus produced should be generic (i.e. of use by others) and put into practice collectively (and thereby submitted—de facto—to evaluation by others). This is where the collective element enters into the dynamics of the process.

A word about what musical research is not at IRCAM. Musicology, musical theory (based on the analysis of past works, the creative process, the heuristics of invention, etc.), are not the explicit domains of musical research at the institute. In other words, musical research is oriented more towards an operational, prospective outlook rather than a retrospective one.

Conditions

It is not enough to speak of the goals and domains of musical research. What is crucial is the organization of the conditions in which it should take place in order for it to be successful. These are some of the conditions that have emerged over the years as IRCAM's model for musical research has evolved.

(1) *Mediators*—One of the essential conditions is the presence of mediators (called at IRCAM 'réalisateurs en informatique musicale'—dubbed 'RIM' in French corresponding to the expression 'computer musician' in English) who act as 'go betweens' among scientists, composers and instrumentalists. These mediators play an important role in the definition of objectives of both musical research projects and relevant hardware and software development. They serve as 'translators' between the scientific and artistic domains. The wide vision they possess helps to identify generic features and new paradigms as they emerge within a project and across a multitude of projects. At IRCAM, the mediators are active both in the production domains (i.e. working with composers whose compositions will be performed during the musical season) and the research domains (i.e. working in teams made up of scientists and composers).

(2) *An experimental environment*—This should be both physical (composers and scientists in direct contact) and virtual (interaction of researchers and work groups within organized networks). The environment should provide a context in which expertise is readily available and the venues for interaction and exchange should be actively organized. An important element here is the use of open technologies, that is, software environments that make for easy prototyping and experimentation. It is no accident that IRCAM has developed two such environments: Max and OpenMusic. The venues for exchange and interaction include: weekly seminars (also accessible as online videos (IRCAM seminars URL) where musical projects and related technological issues are presented; work groups made up of a composers and scientists working on a specific musical topic (rhythm, orchestration, spatialization …); prospective seminars organized with the R&D department where scientists outline some of the upcoming challenges and projects needing musical input.

(3) *Focused and coherent research themes*—The broad domains of research have been outlined above in the form of extensions of musical practices. However, from one year to the next, a more precise definition of the research themes is necessary. This is another condition for successful musical research. The themes are chosen as a result of the identification of emergent common preoccupations of the artists and the connected research domains. In addition, it is necessary to not only have a critical mass of composers working on the same theme at the same time, but also that there be at least one composer who acts as leader of the group. So, for example, during a period of one or two years, there might be a particular emphasis given to computer-aided orchestration or the musical writing of sound synthesis while research in other domains continues.

(4) *Formalization*—As the artist slowly clarifies the elements of the new vocabulary, he is creating or contributing to, it is essential to be able to formalize it. This is what will enable the new elements to be integrated, represented and manipulated in the available technological environments. This process is an absolute necessity especially when interacting with the scientific and technological domains. Here also, the mediators play an important role because of their 'double vision'.

(5) *Interaction*—The interactive process is in fact a very important condition for successful musical research. The exchange of ideas, their embodiment in technologies, the critique of the concepts and their technical embodiments are all phases in this process where questions are revisited in a spiral like process leading to a clearer and clearer grasp of the essential components of the emergent element of vocabulary. The action of the mediators in this interactive process is essential.

(6) *Technology viewed as a medium for communicating*—For a long time, technology was viewed at IRCAM as a goal in itself. But the increasingly organized musical research has revealed the importance of technology viewed as a medium for mediation and dialogue in the interactive process. Technologies (software in particular because of its flexibility, especially open-ended development environments such as Max/MSP, for example) embody explicitly or implicitly the concepts, vocabulary, practices, aesthetics (to varying extents) as they have emerged over time during the process of musical research. The shortcomings of a technology may be viewed as the identification of the missing elements of a desired vocabulary. Technologies play the role of a 'lingua franca' in the dialogue between members of a community sharing common concerns. In this context, technologies cut across aesthetic boundaries, thereby encouraging aesthetic cross-fertilization. Widening the community of users of the technologies increases the potential for innovation in the widest sense.

Two projects—both initiated by the author—have emerged as a means of promoting this mediation process. The first is the IRCAM Forum that began as a means of making available to a wider community—than just IRCAM itself—the technologies invented at IRCAM. Today, the Forum actively supports musical research by providing a wide range of tools geared for the experimental process and which provide a richer vocabulary of possibilities. The second is the 'Pôle Spectacle', a project aimed at targeting some of the technologies (spatialization, voice synthesis, gesture processing) created at IRCAM towards other artistic disciplines such as the theater and dance. Here also, users have found the open-ended technologies as a way—in the form of a sort of conceptual currency—of exchanging and expressing their ideas.

Evaluating the Results

The question of evaluation in the artistic domains has always been a delicate one and most of the time people think of evaluation as simply a question of taste, i.e. that it is a subjective question. The model for musical research developed over the years proceeds

differently by asking a number of specific questions concerning the results both over the short term and the long term.

On a short-term basis:

(1) What is the desired form of the result? (The general approach is to produce a result which is best adapted to the expression of the results.) Is it conceptual? Is it the embodiment of new elements of a vocabulary in software? Is it expressed in the form of a musical 'etude' that best illustrates the ideas? Is it a short memoir or part of a thesis?
(2) Were the goals met? If not what was the reason? Poor formalization? Real difficulty encountered in the realization of the research?
(3) In what way has the vocabulary been enlarged? Is the increase significant or marginal?
(4) What is the generic impact of the results? Can other composers integrate the new vocabulary in their work even in different aesthetic contexts?
(5) Do the results taken individually or in conjunction with other results in a similar domain suggest a new emerging paradigm?
(6) What is the role the results will play in a future artistic project?

On a long-term basis:

(1) Since the notion of proof (in the sense of proof in the scientific domain) does not exist properly speaking in the domain of artistic research, have the results in musical research in a particular domain, say spatialization, been confirmed through widespread use by composers? Is there a sort of 'resonance' in the musical community?
(2) Is the widespread use or 'resonance', in turn, suggesting an emerging paradigm?

Some Challenges for the Future

A Notation for Musical Interaction

Much of the musical research at IRCAM has crystallized in the form of work contributing to mixed works, a particular musical genre popularized by IRCAM. The mixed works combine acoustic instruments and electronics in a tightly synchronized form through the use of real-time technologies. The real challenges arise when it comes to preserving the works in order that they may progressively form part of a growing repertoire that can be mastered by a generation of musicians. As long as the principles of operation of sound transformation are understood from a technical point of view, one can be fairly confident that they will remain available in the future, albeit implemented in new ways. Mixed works are typically interactive and what is completely missing for the moment is a precise, explicit formalization of the interactive process. In the same way that musical notation expresses what is to be done by the

performer, a notation (with a sound mathematical basis) for expressing what should happen in an interactive context is becoming an absolute necessity. This is true for at least two reasons:

(1) Currently, it is very hard to deduce when looking at an electronic score (when one even exists) what the interactive processes are doing and what can be expected.
(2) It is a cliché (but a true one) that the real-time technologies in which compositions are implemented in are in a state of constant flux even within the lifetime of one software program. From one release, generation or version to the next, subtle differences arise and so forth. Over time, the differences may even increase. What is necessary, again, is a notation of musical interaction that could be implemented automatically in a 'normal' computer language, say C++ or the successors to C++, or musical computer languages, say Max or PD. This also implies that normal computer languages will have acquired the capacity to express time and interactive processes explicitly (as in the case of real-time critical systems that must behave in the same way in different technological and performance contexts).

Re-Visiting Some Basic Musical Categories

The efforts made over the years to develop successfully the concepts and technologies currently used have masked to some extent efforts that need to be made on a deeper level concerning musical thinking. Two examples come to mind:

The first concerns musical form. A recurring reaction upon listening to recent compositions by young composers is that the musical material locally may be attractive even interesting but somehow there is a lack of overall directionality; we are frequently in the presence of a series of 'events' without real cohesion; there seems to be an excessive preoccupation with local musical material at the expense of overall form.

The second concerns 'vertical thinking'. Clearly, the one of the failures of serialism was its inability to foster a new way of thinking about harmony. It is no accident that even in his last years Schoenberg implicitly admitted as much by his continued thinking about harmony, typified by his book *Structural Functions of Harmony* (Schoenberg, 1983) written at the end of his life. Since then each composer creates his or her solutions to this problem via ad hoc or more systematic approaches (see Eliot Carter's book on harmony Hopkins & Link, 2002, for example). But this issue applies not only to traditional 'note oriented' harmonic thinking. It applies especially to the elements of vocabulary made possible by the new relationships existing in harmonic and inharmonic synthesis, as well as by computer-aided orchestration that seeks to create orchestrations of given instrumental or synthesized targets.

Whither in the Shifting Sands?

Traditional instrument making and score production rely on relatively simple technologies that have been stable over long periods of time measured in decades and have been mastered in the context of small, highly centralized populations of 'experts'. Musical research using computer technologies, on the other hand, relies on a multitude of both well-established and emerging technologies. The Fourier Transform is the backbone of sound analysis and synthesis. But methods of time frequency representation are now showing their limits in the face of challenges coming from the need for understanding nonlinear phenomena. Some aspects of computer-aided composition rely on a variety of programming paradigms (such as constraint or genetic programming). Real-time score following (such as Antescofo) relies partly on probabilistic models. Real-time improvization software (such as OMax) relies partly on automata and graph theory. The recently developed orchestration project (Carpentier & Bresson, 2010) became possible only when databases, combinatorial optimization and audio descriptors became mature and manageable technologies. All of the technologies just mentioned—and this is just a tiny handful of examples—were created elsewhere for purposes other than music (even less for musical research!). Furthermore, their development is in the hands of networks of collaborations that are highly decentralized. As a result, the following dilemma arises: in this shifting and diffuse context, what form should the results of musical research take in order to become part of an identifiable musical language and/or corpus of musical concepts?

The resolution of this dilemma will have to take into account at least two important factors: the pluralism of aesthetic perspectives and our own attitude towards permanence. As we will see below, these two factors are separate but interrelated.

Concerning the first factor. The desire for a unifying 'mainstream corpus' made more sense perhaps in a time when populations were smaller and cultural activities more limited, but it does not make sense in the presence of the ever increasing multiplicity of populations and cultural outlooks. Throughout the nineteenth century, a common musical language existed that cut across aesthetic perspectives. This situation no longer exists in the twenty-first century music. Witness the variety of perspectives in contemporary music alone: serialism, spectralism, adepts of saturation, repetitive music, minimalism, complexity and so forth. So, when speaking of 'a' musical corpus, it is perhaps more realistic to speak in terms of a constellation of corpuses each connected to a particular aesthetic perspective. It is interesting to note here that technologies common to differing aesthetic perspectives might possibly play an important mediating role in the future.

Concerning the second factor. Our musical tradition is largely associated with the idea of permanence. (Our educational programs alone attest to this.) But with the breakup of a common 'mainstream' language, the desire for permanence receives a first blow and the 'shifting sands of technology' outlined above deal a second blow. (In the face of this, how will our educational programs evolve?) One consequence of this

situation is an emerging contrary attitude that considers the quest for permanence outdated and useless. So, clearly we are in the presence of two attitudes:

Desiring permanence. With this attitude, each aesthetic perspective must identify the invariant elements of its corpus of musical concepts. In a digital world, however, we are faced with the threat of the 'digital dark age' which refers to a situation where digital data will become lost as a result of outdated, unsupported or simply forgotten data formats and computer programs. A consequence of this is that, in order to survive, each aesthetic perspective will need to define the invariants both of its concepts and its form of conservation. (The need for the notation of interaction described earlier is just one example of this.) It is worthwhile to note in passing that the desire for permanence flies in the face of marketing strategies that implicitly plan technological obsolescence.

Accepting impermanence. Here, we are in the presence of an 'ad hoc' and 'whatever works at the moment' attitude. When technologies no longer work, they are simply abandoned and replaced by whatever emerges and is available. It is no accident that in this context 'free software' is a popular rallying point. Here, reflection on corpuses is replaced perhaps by a reflection on opportunistic strategies and, perhaps paradoxically, the identification of the invariant elements of these strategies. The dangers of the 'digital dark age' do not apply here. Finally, this attitude works best in the context of planned obsolescence.

So, as we can see, musical research navigates in challenging waters, but as Alfred North Whitehead once said: 'A clash of doctrines is not a disaster, it is an opportunity'.

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