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(Musical) creativity, technology and social interaction

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Preamble: The ideas presented below are rooted in music research but, in principle, they could be expanded to the whole creative and cultural sector. This text is meant as a background for discussion.

Abstract:

Music is part of a vibrant cultural and creative economy. Of all "content industries" (film, TV, art, heritage,…), music is the one which has been most affected by the digital revolution. In addition, music has an important psychosocial function and strongly contributes to well-being and social integration. In this paper, I argue that music, technology and social integration can reinforce each other. More advanced mediation technologies should extend the human body (the natural mediator between mind and physical environment) so that the mind can focus on domains where it has otherwise no access (such as social musical interaction). New methodologies should be developed that go beyond the limitations of the current bottom-up engineering research paradigms. The new approach can be called “transdisciplinary”, as it aims at transcending object-centred and subject-centred methodologies.

Music: a vibrant economical sector

Music is part of a vibrant cultural and creative sector. According to KEA (2006), the European music industry represents about 40% of the world-wide activity in this area. Europe employs about 650,000 workers in this sector, with an annual return of more than € 40 Billion.[1]

The study also claims that the whole cultural/creative industry to which music belongs is in total “twice as large as auto-mobile, and as large as ICT”, with remarkable growth figures of about 20% over the past 5 years. The sector represents 2,6 % of the GNP (compared with chemistry and rubber/plastics industry: 2,3%). Total annual return is € 654 Billion.[2]

Music and advanced technologies

[1] My own rough estimates: recorded music sales € 12.5 Billion; music publishing € 3.4 Billion; life concerts > € 12.5 Billion; collecting societies € 4.5 Billion.
[2] Compare with car industry = € 271 Billion in 2003, ICT factories = € 541 Billion in 2003.

Of all "content industries" (film, TV, art, heritage,…), music is the one which has been most affected by the digital revolution. Since the year 2000, the creation/production/distribution/consumption chain for music is almost entirely digital. Music is pushing broadband development (e.g. Napster and P2P) and mobile networks (GSM/GPRS, UMTS). Given this context, music has stimulated the uptake of broadband subscription and ICT by mass consumers (e.g. PCs, mobiles). Music stimulates e-business (e.g. iTunes), new management tools (e.g. Digital Rights Management, Audio-fingerprinting, Watermarking) and retrieval methods (Music information retrieval).

Music industry is currently transforming itself into an experience-based economy where musical audio will be distributed via large networks of ICT channels (broadband, mobile) and where services will provide an added economical and experiential value. The impact of music on media consumption has been huge in recent years and music has been a key driver for ICT uptake. Also in education, music has been a driver for young people to develop interest in science and ICT.

Music's key role in society

Apart from the economical importance, there is a strong and important social component in music. Indeed, music is rooted in the local cultures of people where it forms an important aspect of their active live. Music has appeal to active music makers, or it is used for dancing or in other social activities. Being involved with music therefore strongly contributes to personal development and social cohesion/inclusion, self-respect and pride. Music communicates cultural values and stimulates self reflection. Music is an excellent tool to promote:

- respect for the diversity of social/cultural identity
- the care of cultural heritage (preservation and archiving)
- openness to cultural change and new forms of expression
- democratic access to culture and knowledge
- a culture of participation and participation in culture.

While it is often difficult to educate these values in an explicit way, they can be implicitly educated when people learn about music.

Music at the core of innovation

There are at least two reasons why music, and art in general, will continue to throw up innovating challenges to technology:

- First of all, there is the desire for expression. If tools are used to be expressive, then one is always inclined to go beyond that what is actually possible. Examples can be given from the development of electronic music in the 1950ies-1960ies, where analogue audio-equipment was used to create new musical sounds and where the first steps were taken to develop a content-based approach to musical information processing. More recent, there are signs that real-time interactive music systems push the frontiers of sensing, multi-modal multimedia processing and gesture-based control of technologies.

- Secondly, there is the desire for social communication, as art is always intended to be communicated and to involve social interaction. Recent developments in music research have pushed back the frontiers of networking into technologies that deal with semantics as well as new forms of human-human and human-machine interaction. Music is an excellent domain to develop mediation technologies that focus on non-verbal communication patterns (related to gesture, corporeal articulation, kinetics and bioparametric sensing and related information processing).

In short, the context of music creation is constantly pushing for expressive, human-friendly and social technologies and therefore, it forms an active driver of innovation in the domain (Leman, 2005). The mutual enhancement of music, technology and social interaction can create a huge market for creative involvement.

Research situation

Despite the economical and social-cultural value of music, music research is still rather small-scale and its research context is organized in a bottom-up way, that is, without being possible to predict future developments at long term ($S2S^2$, 2007). Apart from a few exceptions (e.g. UPF-MTG in Barcelona, IRCAM in Paris), institutes working on music (in musicology, engineering, psychology, brain research) tend to be very small (mean: about 2 professors, 10 PhD students), although the number of doctoral dissertations and internationally peer reviewed papers has been growing over the past decennium. The scientific organisation at EU level is based on changing coalition networks of partners specialized in niche areas related to sound and music computing.

Both the KEA (2006) study and the $S2S^2$ (2007) survey show that Europe's potential power in music research, compared to US and Japan, is large. The is due to Europe's diversity. Groups from both natural sciences and humanities are active. There is a trend to specialize in niche areas while at the same time collaborating in larger European networks. However, the US is more versatile in terms of bringing a good idea into the market. The lack of continuity in research funding is one of the major difficulties of small scale institutes, especially when those institutes are operating in humanistic disciplines rather than science or engineering.

To sum up, Europe has a flourishing music research space which may play an important role in the development of a new music industry. This research space is mainly organized as a network of small institutes, and consortia are formed by changing coalitions among the members of the pool that defines music research. This research is rooted in Europe's very rich musical tradition and associated human sciences tradition. However, this research space is also vulnerable, mainly due to discontinuous funding (which for small institutes is more dramatic than large institutes due the fact that core know-how is in the hands of a smaller number of people). Transdisciplinarity in this context implies that small institutes have to cross the boarders of their own

institute and establish collaborations with other institutes. This can be done at home (own university) or abroad, possibly at an international level. Often the dynamics also implies that young researchers have to be flexible and change institutes throughout Europe according to the available opportunities.

Transdisciplinary research for music and the creative sector

A transdisciplinary approach to music suggests that music cannot be fully studied and understood if it is approached by only one single discipline, or perhaps by even by different disciplines which are just put next to each other without much interaction. Transdisciplinarity suggests that music can or should be approached by transcending scientific disciplines.[3] This implies a dynamics that goes beyond the boundaries of what separate disciplines can offer to music.

A key aspect of this methodology is that it relies on scientific measurement for gathering empirical data, and on data-analysis and computer modelling for hypothesis testing. Since music is both a subjective experience (related to thinking, emotions, feelings) and an objective matter (related to the physical world), a combined naturalistic and culturalistic approach is needed. This double root is at the core of the whole discussion of musical transdisciplinarity. It fully subscribes to the idea that to understand the true nature of music and what it does to people, it is necessary to combine methods from human sciences and from natural sciences. Transdisciplinarity, from the very beginning of systematic musicology, was not a idle concept, nor a luxury, but a core necessity.

The reason why a single discipline, be it music theory, psychology, sociology, acoustics, computer science, or even brain science is too narrow a basis to grasp the different ways in which people deal with music is that music is a highly multimodal phenomenon involving all human faculties and very different social and cultural contexts. Single disciplines often focus on particular aspects and fail to address aspects that go beyond the confines of the discipline. Indeed, music perception has a strong action-related component on which users rely when they address the semantics of music. A transdisciplinary approach could address the subjective and context-dependent way in which humans deal with music, without neglecting the physical environment in which music is perceived either. Indeed, focussing solely on subjective matters only is equally problematic.

[3] The idea of transdisciplinarity is not entirely new. Since the late 19th Century, systematic musicology has been promoted as an integrated multidisciplinary approach to music research (see e.g. Adler, 1885; Elschek, 1992). Based on a tight collaboration between scientific disciplines, systematic musicology offers a way to understand how people engage with music, and how music functions in perception, performance, and as an aesthetic and social phenomenon. In its scientific approach, systematic musicology was first influenced by the Gestalt theory and, later, by information psychology and cybernetics. In the 1970ies, with the advent of computers, systematic musicology culminated in the so-called cognitive musicology approach which, up until today, still offers a main scientific research paradigm to systematic musicology (Leman and Schneider, 1997).

It should be added that the recent interest in transdisciplinarity is not just a postmodern trend based the use of some new words. To the contrary, the use of this term in musicology is well-conceived and believed to be a core aspect of the actual scientific music research methodology. Indeed, since a few years, the terms “transdisciplinarity” and “multidisciplinary” [4] have been used in European initiatives that aimed at identifying the role of music research in relation to the upcoming creative and cultural industries. It is commonly believed that the transdisciplinary nature of music research may be a strong asset to the development of a new type of creative music industry.

Identification of the major challenge for music research

Modern digital media handle music as encoded physical energy, while the human way of dealing with music is based on beliefs, intentions, interpretations, experiences, evaluations, and significations. The use of technology thus creates a gap between music as experienced and music as encoded physical energy (Leman, 2007):

- Current access to music is a problem because the retrieval technologies are insufficiently taking into account the user’s search intentions, personal attitudes and social/cultural contexts.
- Current interactive music making is a problem because electronics eliminates the direct causal transfer of bio-mechanical energy of the player into sound energy (as in acoustical instruments). As a result, the action-intended music control is rapidly lost.

The engineering approach to the semantic gap problem

The classical approach to the semantic gap is object-oriented (in the sense of a material object), using feature extraction and classification as a means to transform physical energy into concepts which humans can mentally access. However, the engineering results are far from being sufficiently robust for use in practical applications. The use of powerful stochastic and probabilistic modelling techniques (Hidden Markov Chains, Bayesian modelling, Support Vector Machines, Neural Networks) (see also http://www.ismir.net/ for publications) do not close this gap much further. That means that the semantic gap problem is a hard problem which the current paradigm cannot solve.

Among experts (see e.g. S2S^2, 2007), there is a growing understanding that the techniques are excellent, but that the approach may be too narrow. Briefly listed, I tend to characterize the current approach as follows:

- Unimodality: the focus has been on musical audio exclusively, whereas humans process music in a multi-modal way, involving multiple senses (modalities) such as visual information and movement.

[4] In particular, the UK-roadmap for music research uses the term “transdisciplinary” extensively, whereas the (Continental) S2S2-roadmap uses the term “multidisciplinary”. The difference between multidisciplinary and transdiscplinary is subtle and I would propose to use the terms here as synonym. The rationale behind this is that true multidisciplinary work is also based on work that goes beyond the boundaries of the disciplines involved, and from that moment on, this work can be said to transcend the disciplines on which it is based.

- Structuralism: the focus has been on the extraction of structure from musical audio files (such as pitch, melody, harmony, tonality, rhythm) whereas humans tend to access music using subjective experiences (movement, imitation, expression, mood, affect, emotion).
- Bottom-up: the focus has been on bottom-up (deterministic and learning) techniques whereas humans use a lot of top-down knowledge in signification practices.
- Perception oriented: the focus has been on the modelling of perception and cognition whereas human perception is based on action-relevant values.
- Object/Product-centred: research has focused on the features of the musical object (waveform), whereas the subjective factors and the social/cultural functional context in musical activities (e.g. gender, age, education, preferences, professional, amateur) have been largely ignored.

In short, the approach starts from the object, and does not really take into account the proper context, nor the subjective factors that define how users would like to access music.

Why human sciences are needed to solve the semantic gap problem

There is a growing awareness that more input should come from a better analysis of the subjective human being and its social/cultural context. Such a subject-centred approach would involve:

- Multi-modality: the power of integrating and combining several senses that play a role in music such as auditory, visual, haptic, kinaesthetic sensing. Integration offers more than the sum of the contributing parts as it offers a reduction in variance of the final perceptual estimate.
- Context-based: the study of the broader social, cultural and professional context and its effect on information processing. Indeed, the context is of great value for the disambiguation of our perception. Similarly, the context largely determines the goals and intended musical actions.
- Top-down: knowledge of the music idiom to better extract higher-level descriptors from music so that users can have easier access to these descriptors. Traditionally, top-down knowledge has been conceived as a language model. However, language models may be extended with gesture models as a way to handle stimulus disambiguation.
- Action: the action-oriented bias of humans, rather than the perception of structural form (or Gestalt). In other words, one could say that people do not move just in response to the music they perceive, rather they move to disambiguate their perception of music, and by doing this, they signify music (see below).
- User-oriented: research should involve the user in every phase of the research. It is very important to better understand the subjective factors that determine the behaviour of the user.

It is my understanding that the subject-based approach should be based on an empirical and evidence-based methodology, so that it connects with object-centred approach.

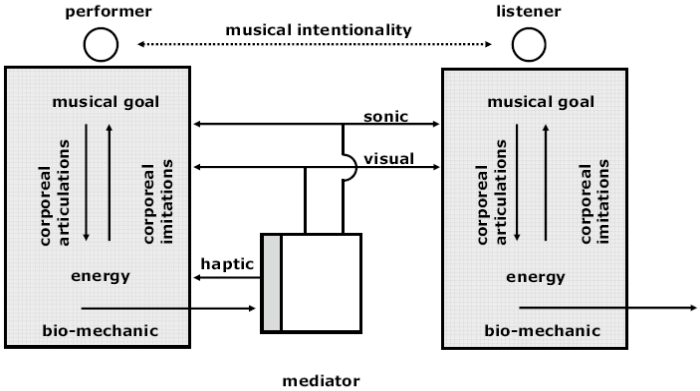
Transdisciplinarity "transcends" natural and human sciences

The combination of subject-centred and object-centred approaches is indeed what is needed for tackling the semantic gap problem. The results are likely to have a high impact on the fast developing cultural/creative and ICT industries. Music technology may boom in this area, but it is likely that this will only happen when technology is developed in collaboration with users. This is another aspect of transdisciplinarity in music research, namely, that it starts from the user and aims at improving the conditions in which the user may interact with other users and machines so that new ways of music interaction can be explored.

Our solution: closing the semantic gap with embodiment

In my book (Leman, 2007), I propose a solution to the semantic gap problem in terms of embodiment. In particular, I consider the human body as the core starting point for technology research. The core idea is that music semantics has a strong corporeal aspect and that this corporeal aspect is largely unexplored until today. As shown in Figure 1, the human body supports action causation and perception from musical goal to bio-mechanical, haptic, sonic, and visual energy (back and forth via corporeal articulations and corporeal imitations) so that an interaction at the intentional level can emerge. The approach is related with the modern perception theoretical notions of emulation and simulated perception.

Figure1. Music communication: the body a slink between mental and physical environment



In this approach, it is not the intention to reduce music to physics, nor to reduce gesture and embodied meaning to the biomechanics of the human body. Instead, the human body is considered to be a core component of the mediation between the mental and the physical world. In this context, transdisciplinarity means that disciplines which address the mental world, the physical environment and the human body should be involved.

Embodiment and social interaction

Embodiment has a strong social component because the articulations of the human body in response to music are mainly meant for social interaction. Movement, behavioural resonance, corporeal interaction, and entrainment are currently the key concepts in our understanding what music is about (Leman, 2007). It radically differs from the disembodied approach which was still dominant at the turn of the 21st Century and where the focus was on musical structures and cerebral interpretations.

As the communication model of Figure 1 suggests, non-verbal communication patterns, for example, the responsive and expressive movements of body parts, are key indicators of the musical communication. It can be assumed that they are also key indicators of the social musical communication. However, up to now, the understanding of these corporeal types of non-verbal communication related to a social interactive context is very poorly understood. I do believe, however, that certain states of social entrainment (based on the mutual adaptation of non-verbal corporeal communication patterns) can be somehow perceived by the human mind as a state of optimal experience or flow, and consequently, that there is a semantic aspect of social entrainment that can be accessed as well, and possibly also related to the (objective) measurements of the human body. We may assume that this mechanism is a central factor in the state of mind that relates to social well-being.

The S2S2-project: a roadmap for transdisciplinary music research

On 16 April 2007, the consortium of the S2S^2-project launched its roadmap on Sound and Music Computing in Brussels at the headquarters of the European Research Council. This roadmap is an ambitious document which aims at defining the major challenges for future music research. As a guide, it will have impact on the strategic planning for sound and music research within the European Union. In what follows, I will briefly introduce the rationale behind this roadmap and I will argue that transdisciplinary is a core aspect of the European music research as it is envisioned for the future.

The S2S^2-project was based on an interdisciplinary consortium of music research laboratories in Europe, with the major task of writing a roadmap for sound and music computing[5].

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[5] The consortium included:

1. Media Innovation Unit, Firenze Tecnologia, Firenze, Italy (N. Bernardini)
2. Music Acoustics Group of the Kungliga Tekniska Högskolan in Stockholm, Sweden (R. Bresin)
3. Music Technology Group of the Universitat Pompeu Fabra in Barcelona, Spain (X. Serra)
4. CSC - Dept. of Information Engineering, University of Padova, Italy (G. De Poli)
5. Austrian Research Institute for Arti_cial Intelligence of the Austrian Society for Cybernetic Studies in Vienna, Austria (G. Widmer)
6. Département d'Etudes Cognitives of the Ecole Normale Supérieure in Paris, France (A. de Cheveigné)
7. Laboratoire d'Etude de l'Apprentissage et du Développement of the Université de Bourgogne in Dijon, France (E. Bigand)

Content of the S2S^2-project

The S2S^2-project has produced three major outcomes, namely a book containing the state-of-the-art in sound and music computing (currently edited by D. Rocchesso, to be published by LOGOS-verlag), a series of summer schools (Barcelona 2004, Genova 2005, Barcelona 2006, Stockholm 2007), and of course, the roadmap itself, which is a text of about 100 pages (edited by X. Serra, M. Leman and G. Widmer). The latter material will be polished and published in the special issue of the Journal of New Music Research (edited by N. Bernardini and G. De Poli).

The roadmap contains three parts, namely, (i) a description of the context and main trends in which music research operates, (ii) a state-of-the-art and identification of the research points and open issues, and (iii) a description of the research challenges.

(i) Context: This consists of the research context, the educational context, the industrial context, and the social/cultural context. These contexts tell us about the societal framework in which music research is currently operative. It reveals that transdisciplinarity is necessary in research, for industrial development and cultural applications, but rather difficult to implement in education.
(ii) The state-of-the-art then focuses on the main open issues. A distinction is made between research that focuses on sound and research that focuses on music. In between, there is the interaction between the two. For each research field (sound, interaction, music), there is an analytic and a synthetic component. The analytic component goes from encoded physical (sound) energy to meaning (sense), whereas the synthetic component goes in the opposite direction, from meaning (sense) to encoded physical (sound) energy. Accordingly, analytic approaches to sound and music pertain to analysis and understanding, whereas synthetic approaches pertain to generation and processing. In between sound and music, there are multi-faceted research fields that focus on interactional aspects. These are performance modelling and control, music interfaces, and sound interaction design. The nature of these distinctions reveals the inherent transdisciplinary character of the research field, as both the analytical (from sound to sense) and the synthetic (from sense to sound) approaches.
(iii) The challenges part looks ahead and identifies the key challenges for music research together with the strategies with which to face them. These challenges fit with the open problems that were identified in part ii, and they are constrained by the contexts which were identified in part i.

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8. Institute for Psychoacoustics and Electronic Music of the Universiteit Gent in Ghent, Belgium (M. Leman)
9. Laboratory of Acoustics and Audio Signal Processing of the Helsinki University of Technology in Espoo, Finland (V. Välimäli)
10. Vision, Image Processing & Sound Laboratory of the University of Verona, Italy (D. Rocchesso)
11. Laboratorio di Informatica Musicale of the University of Genova, Italy (A. Camurri)

Challenge 1: to design better sound objects and environments

- Strategy 1: Seek directions in which to extend the notion of musical instrument
- Strategy 2: Improve technologies for pervasively producing, transforming and delivering sounds
- Strategy 3: Intensify research in sound modelling that goes beyond imitation towards capturing the communicative potential of sound
- Strategy 4: Promote research in fields involved in the shaping of natural, artificial and cultural acoustic ecosystems
- Strategy 5: Promote research on the effect of environmental constraints on artificially diffused sound and music
- Strategy 6: Promote studies aimed at reducing sound and music pollution in public and private ecosystems

Challenge 2: to understand, model, and improve human interaction with sound and music

- Strategy 1: Promote computational modelling approaches in human auditory perception and cognition research
- Strategy 2: Provide extensive augmented perception paradigms
- Strategy 3: Intensify research on expressivity and communication in sound and music
- Strategy 4: Develop an embodied, integrated approach to perception and action
- Strategy 5: Intensify multimodal and multidisciplinary research on computational methods for bridging the semantic gap in music
- Strategy 6: Intensify interaction with the arts

Challenge 3: to train multidisciplinary researchers in a multicultural society

- Strategy 1: Design appropriate multidisciplinary curricula for SMC
- Strategy 2: Promote broader integration of Arts and Sciences
- Strategy 3: Promote cross-cultural integration
- Strategy 4: Promote better coordination in Higher Education
- Strategy 5: Enhance education resources for Higher Education.
- Strategy 6: Promote the dissemination of available Higher Education in SMC.

Challenge 4: to improve knowledge transfer

- Strategy 1: Promote dissemination of SMC research and objectives among the general public
- Strategy 2: Promote projects containing artistic components
- Strategy 3: Promote the awareness of the various models of IP protection of research results
- Strategy 4: Promote venues for meeting industry experts
- Strategy 5: Promote direct industrial exploitation of research results
- Strategy 6: Promote academic quality standards.

Challenge 5: to address social concerns

- Strategy 1: Identify social needs relevant to SMC development; develop methods for the evaluation and assessment of SMC technologies in social contexts
- Strategy 2: Expand existing SMC methodologies (currently targeted at individuals) to understand music in its social dimension
- Strategy 3: Promote development of technologies and tools for broader collaboration, information and communication engagement; emphasise user-centred and group experience-centred research and development
- Strategy 4: Exploit cross-fertilisation between human sciences, natural sciences, technology, and the arts
- Strategy 5: Expand the horizon of SMC research through a multi-cultural approach.

Challenge 2, Strategies 4-6 mention integration, multimodality, multidisciplinarity and interaction with arts. The notion of multidisciplinarity is taken up explicitly in Challenge 3, where the need for multidisciplinary curricula is addressed. In Challenge 4, the mentioning of cross-fertilisation between human sciences, natural sciences, technology, and the arts contains an explicit reference to transdisciplinarity. Reference to augmented perception, expressivity, embodiment and multimodality support the core challenges for music research. In Challenge 5, there is an explicit call to develop music technology in its social dimension. The latter aspect is not unimportant. After all, music is a very important aspect of all human cultures. Music gives meaning to life. It is a basic ingredient of cultural, group and personal idenfication and social bonding. Music affects the mental and bodily health of people.

Conclusion

I argue in favour of the development of mediation technologies that extend the human body (the natural mediator) into domains where our mind has otherwise no access. These domains should include a strong social component such as the musical domain.

The development of these technologies requires knowledge of the subjects, their life style and way of non-verbal social interaction. Research in this domain can be stimulated by both bottom-up, grass-roots initiatives and also the top-down initiatives of administrations and institutes. These social and cultural strategies are beneficial to the economic environment because they:

- reinforce social integration and help build an inclusive Europe
- contribute to fostering territorial cohesion
- contribute to reinforcing the self-confidence of individuals and communities
- participate in the expression of cultural diversity.

The trend of allying content-based music technology to economic rationality has started already. But it is reasonable to assume that artistic creation

remains a major factor in maintaining the former's innovative character. This can be developed in approaches that stimulate the reinforcement of music, technology and social interaction.

Major concepts in this paper are:
- transdisciplinary
- embodiment
- mediation technology
- social interaction

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