Overviewing a Field of Self-Organising Music Interfaces: Autonomous, Distributed, Environmentally Aware, Feedback Systems

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ABSTRACT
This paper aims to identify and discuss the music field of *self-organising music*: an emerging field based on different forms of self-organising music interfaces, that is to say 'intelligent' sound/music systems characterised among others by autonomy, distributed/decentralised feedback processes and of environmental awareness. A music field based on systems-oriented concepts (cybernetics, general systems theory, complexity) and which is formed spontaneously by individual cases of composers-researchers with unique yet converging approaches. We are describing the general context of self-organising music and presenting different cases of composers-researchers that deal with the subject both from a technical and a theoretical perspective. We conclude the paper suggesting the search for a system-oriented shared musical language in order to broaden and evolve the field's musical though.

KEYWORDS
self-organising music; systems-oriented music; feedback instruments; audio feedback systems; generative audio systems; autonomous music agents; artificial music intelligence; autonomous instruments; feature-feedback systems; adaptive synthesis; audible eco-systemic interface; eco-composition; performance ecosystems.

INTRODUCTION
We can observe and identify a new and active field emerging from individual cases (or small teams) of composers-researchers interested in what we can call *self-organising music*: a music field based on different forms of self-organising music interfaces, that is to say 'intelligent' sound/music systems characterised among other features by autonomy, distributed/decentralised feedback processes and of environmental awareness. A music field based on systems-oriented concepts (cybernetics, general systems theory, complexity) and which is formed spontaneously by individual cases of composers-researchers with unique yet converging approaches. A music field where common concepts such as self-organisation, emergence, environment and feedback are applied in different levels, technically or metaphorically. We are aiming in connecting the dots among individual cases which are fed conceptually and technically by the same systems-oriented context, and which result to very similar technological means.

By investigating different cases based on similar approaches of intelligent music interfaces, our aim is to outline the existence of a common ground; a common ground mainly shaped by common technological characteristics which consequently may have aesthetic consequences and implications.

Our investigation concerns cases that contribute to the emerging field of self-organising music with some form of originality – through an active model or some suggested advancement. Furthermore, we are interested in approaches where the technological domain is tightly interconnected with the compositional material and the conceptual/aesthetic principles in use. Our investigation is not interested in cases that are producing music through self-organising algorithms acquired by other researchers; where the algorithms are used as 'found objects' without the knowledge of their conceptual origins.[1] We are focusing on outlining some representative cases in order to establish a common ground of self-organising music. The collection of the approaches we expose, even if it is far from exhaustive, intends to be representative.

But, can we really talk about a consistent music field of 'self-organising music'? In other words, do the similarities and convergences among composers allow us to speak of a musical movement? This being the case, what are the common characteristics among composers-researchers that form a music movement of this kind? Then again, can we

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[1] We have to clarify that, we are not considering music created by algorithms/instruments designed by others than the composer himself/herself less important; nor do we believe that music by composers without explicit knowledge of the used algorithms/instruments creates less significant music. On the contrary, we can imagine several works of great originality and artistic value expressed by algorithms/instruments designed by others or without detailed knowledge on the principles of the algorithms'/instruments' design – for instance, new works for orchestra performed by traditional instruments.

talk about an aesthetic movement or are they just conceptual and technical coincidences that cannot legitimise a general classification into a movement? Or is it maybe our natural tendency to look for patterns everywhere, driving us to project meaning into something amorphous and arbitrary – as if we were looking for recognizable patterns in the night sky by making links between stars? And if we can talk about a self-organising music, what are these similarities and convergences between the different composers? What are the means of expression and the language of this musical stream? What are its aesthetic characteristics and what are the limits?

SELF-ORGANISING MUSIC INTERFACES

We can describe self-organising music interfaces, in general terms, as those interfaces composed by generative music processes directly influenced by their sonic environment; where the sonic behaviour emerges as a 'complex adaptive system' [8], resulting from numerous interaction at a basic organisational level.

Dynamically controlled audio feedback is an elementary yet crucial form of self-organisations as it is found at the basic organisational level: sound organises sound itself, i.e. sound self-organises. For that, controlled audio feedback is the most common feature of self-organising approaches.

This is why denominations based on the concept of feedback are relevant enough to describe our field and give to the concept of feedback the central importance it deserves. For that, the use of the term feedback is common: *audio feedback systems* [11, 17], *feature-feedback systems* [8] or *feedback instruments* [15]. We are dealing with music interfaces including at least one feedback function as a vital structural part. It's important to clarify that the feedback function should be playing a vital role for the entire use of the system, and without which, the whole system would not be functional.[2]

The feedback function is not only important for the audio domain, but also, it is used as a control signal, giving the possibility to observe and to guide other processes that are mapped with. Consequently, in this approach the composer/sound artist, instead of working only in the audio domain with DSP, he/she is also working in 'composing the interactions' with 'control signal processing' (CSP) [5].

Although we recognise the central importance of feedback's role, we have a preference for the term 'self-organising'. That is because, the term 'feedback' has been broadly overused, to the extent that it does not suggests any particular epistemology anymore. Instead, 'self-organising' is more specific and it is a clearly linked term to the systemic epistemology.

We are interested in the self-organising work from a compositional perspective. However, if a work is primarily created in order to be listened to,[3] the listener's perspective is of equal importance: the self-organising work as a process of the listeners cognition; in other terms, the perceptual manifestation of the work as a self-organising process between the listener's active listening and sound [14].

Here, we aim to outline the field around the concept of a self-organising music, by seeking technological as well as conceptual similarities and convergences among approaches of certain composers-researchers that we believe to be representative. We present some surveys dealing with the subject in similar ways yet under different denominators.

We have previously suggested an elementary schematic model of self-organising music [12], [14] (Figure 1). Based on second-order cybernetics [7], the model describes a system as a feedback loop with two inputs: the *goal*-input and the *perturbations*-input. Considering the system as an organised whole, the model describes the entire system as an emergent function of a feedback loop; an emerging system by individual interacting feedback functions. The model describes the whole system's emerging function; but also, it can describe any organisational level at which self-organising processes take place, regardless of their temporal scale.

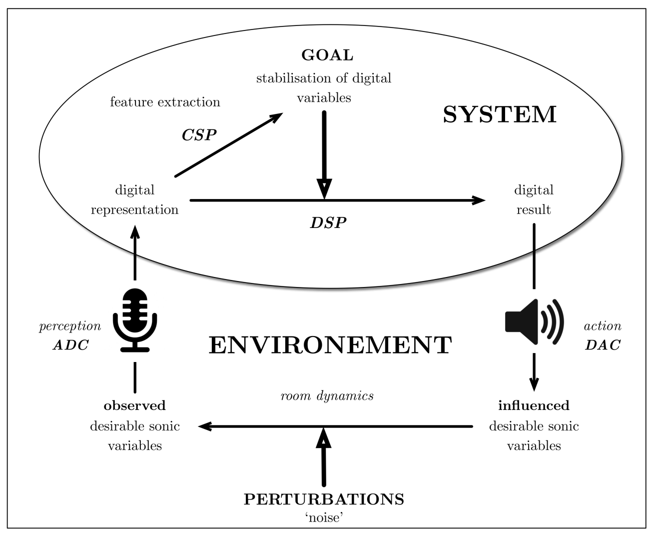

Figure 1. A schematic model of a self-organising music interfaces [12]

Each system's *goal* can be determined and be altered (statically or dynamically) by an external user. Alternatively,

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2 A counterexample would be a feedback function observing the sonic environment in order to preserve energy by switching off the whole system – something important in terms of energy efficiency, but which does not actively influence the sonic result.

3 Considering the case of music composed purely for the pleasure of the composing process *per se*. Even in this case, music is transmitted and it is perceived through sound medium. Therefore, even if the music will never be heard by an auditor, its creator will be its unique auditor.

in more advanced systems, the goal can be self-determined and self-regulated by the system. In the case of a self-determined goal, we are talking about a *second-order system* – in other terms, a *learning system* [6] – capable of changing the way in which it reacts with the environment.

We have previously described the self-organising work manifesting as an emergent complex; resulting from the interactions between some given structures and a certain performance/installation context; interactions which are defined by a model [12]. In self-organising music, the element of autonomy offers certain vitality to the work, an expressive spontaneity and a direct communication among the real-time sound production of the work, the acoustic space and the participant-listeners. The work's autonomy may cause the composer to relinquish a great degree of direct control over the end result. Nevertheless, we have suggested that it is possible to create a type of intelligent music interface where a desirable series of behavioural states can be provoked each time; a series of states which will be similar even when the circumstances change [12]. In this approach, a user/performer listens and changes behavioural states accordingly; in the meanwhile, the self-organising music system responds by continuously adapting to the new conditions. The sounds result is a direct sonification of each state's adaptation. This way, there is an intentional control of the overall sonic properties' self-organisation. The user/performer is in direct interaction with the self-organising music interface while the user-interface is sound *per se*.

As a case study, we have previously discussed our work *Ephemeron* (2008-2018) [12] [13] [14]; a self-organising work with a constantly developing algorithm[4], emerging each time through systemic interactions among 8-21 speakers, 2-4 microphones and the specific sonic environment of the performance/installation.

Sanfilippo and Valle' investigation uses the term *feedback systems* [17], comparing and presenting eighteen different approaches – including our *Ephemeron* interface – with the use of feedback as common denominator. Their investigation attempts to expose an analytical framework comprised of six categories:

1) information encoding: analogue or digital
2) information rate: audio signal or control signal
3) environmental openness: open or closed
4) trigger mode: internal or external
5) adaptability: absent or present
6) human-machine interaction: absent or present

Similarly to our schematic model described above (Figure 1), Sanfilippo and Valle present a schematic diagram in order to visualize their typology (Figure 2). Their diagram's goal seems to be a schematic explanation of the different categories rather than a definition; that is why it may include features that do not affect the essence of self-organising music understanding (such as internal or external triggering), but it may be important for understanding the general classifications.

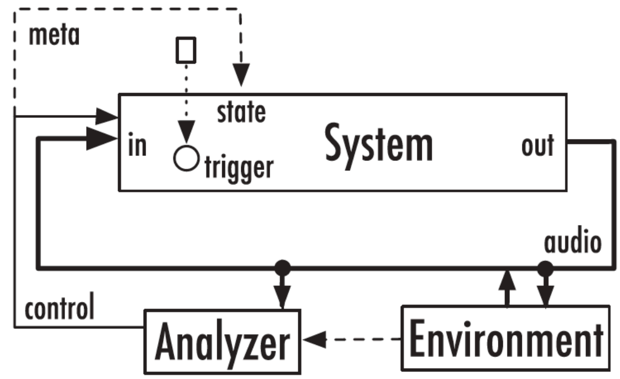

Figure 2. A general scheme of feedback systems according to Sanfilippo and Valle [17].

Morris uses the term *feedback instruments* [15]. Although his model is the result of his personal observations, we find it relevant in describing the essential characteristics of feedback instruments. Morris' classification includes four categories [15]:

1) the *loop* can be:
   a) electric
   b) electroacoustic
   c) digital
2) the *intervention*, the modifications on the feedback sound, for example may be:
   a) delay *period* change, which creates a pitch-shift effect
   b) *phase shift*, which changes certain resonant modes, as in the case of a violin touching a string results in a natural harmonic.
   c) *filtering* change, which alters the active frequency range of a feedback or causes a range of resonant frequencies.
3) the *interruption*, the action of stopping the feedback:
   a) *manual* interruption, for example switching off a microphone
   b) a *shutter*, like an envelope that dynamically forms the feedback's amplitude
   c) a *pitch shifter*, changing the self-amplification of a frequency range
4) the *excitation*, which triggers the feedback resonance:
   a) *unintentional* sounds – 'noise'
   b) *intentional* sounds – 'played' sounds

[4] Before each presentation, the algorithm is updated with technical improvements in terms of stability and performance, but also with additional functionalities which expand its capabilities.

c) *iterative feedback* sounds – the use of another feedback as a sound source for the feedback system

Surges, Smyth and Puckette talk about *generative audio systems*, i.e. feedback network systems focused on dynamic filtering [18]. In this type of system, the output signal is used to dynamically control the coefficients of all-pass filters that are redefined to be flexible yet stable. They refer to them as 'audio systems' in order to distinguish them from 'music systems': as they explain, in audio systems, there is a strong coupling between lower-level organisation sound production and higher-level sound organisation [18].

Kim, Wakefield and Nam also talk about *audio feedback systems* [11]. It is interesting to note their interaction with our music research and in particular the concept of intentional control of sound properties we have previous described [12]. Similarly to what we suggest, Kim et al. suggest a goal-oriented feedback system in which, the intended sound characteristics are specified as goal-conditions [11]. However, in their approach, they replace the level of self-organisation in the system performed by a human-agent by adding an additional organisational level including machine learning techniques; a process that observes and guides the parameters to the desirable goal-state each time.

Collins talks about *autonomous agents,* where their design responds to questions of musical artificial intelligence [4]. His discussion concerns systems with features of machine learning techniques emulating perceptual abilities. The machine learning techniques use a simulation of human perception pertaining to the peripheral and central auditory system. However, the algorithms perceptual abilities can change or exceed the original human abilities from which they were modelled. We stretch Collins' remark, that the artificial intelligences of these systems do not have a physical presence, as is the case with any manifestation of artificial intelligence techniques [4]. We add that, autonomous agents, similarly to any self-organising music systems, have no embodied intelligence. They are only a piece of software coded in a piece of hardware [19].

Blackwell & Young use the term *self-organised music*[5] [3]. Their approach is based on *swarm intelligence* [2], a case of distributed self-organisation: the system's global behaviours emerge as a complex whole comprised of local agents with simple behaviours. Blackwell & Young's approach is based on the original work of Reynolds, who created visual simulations of bird swarms [16]. In Reynold's approach, each unit has a rather simple movement behaviour: Each bird has its own autonomous behaviour, while at the same time, each bird is a particle of the swarm, interacting with all other particle-birds. The complexity of bird cloud behaviour emerges through the local interactions between individual birds [16]. Similarly, Blackwell & Young apply the same principle in the micro-temporal domain by using the paradigm of granular synthesis: sonic grains take the role of self-organising particles which form self-organising swarms of sound, what they call the *swarm granulator* [3]. In this practice, we find a bottom-up approach in which time scales emerge – from the micro-structural level to the meso-structural level – from which consequently larger formal structures emerge.

Holopainen also uses the terms *autonomous* (like Collins) and *self-organisation* (like Kollias or Blackwell & Young) to synthesise the term *self-organised sound with autonomous instruments* [9]. He also uses the terms *feature-feedback systems* or *adaptive synthesis*. Although referring to the same field his interest in the subject is non-real-time, unlike the approaches we have discussed above. Consequently, self-organisation takes place as a set of non-linear algorithmic interactions, without a physical environment (acoustic or social); they are abstract interactions that occur in a virtual space and time. For that, we may consider 'autonomous instruments' (at least according to Holopainen's use) rather as adaptive effects, including simulated perceptual characteristics, using feature extraction techniques. As he says, it is a special case of algorithmic composition, which resides at the sub-symbolic level [9]. Way may consider his approach as a case of non-environmentally aware self-organising music – since there is no physical environment.

Di Scipio's approach has an important leading role in the field of self-organising music as one of the first to contribute theoretically and musically. Di Scipio proposes his *audible eco-systemic interface*, in which music emerges as an ecosystem of interactions between the algorithm, the sound environment and the resulting sound [5]. He talks about an *audible* interface, because all interactions take place at an auditory level, avoiding any visual representation. Although he refers to the term *ecosystem*, his references are closer to system theories (interactions between systems and parts of systems) than those of ecology (interactions between organisms in an environment).

Keller seeks to find a common field between different composers for what he calls *eco-composition*: as the common denominator, he defines the integration of natural phenomena in the compositional process, integrated with the formal, perceptual and/or social factors in the work's material [10]. As he says, many composers use environmental concepts, but with different terminologies depending on the focus of their interests – just as is the case of the perspective we suggest through self-organising music. It is interesting that in Keller' suggestion, all factors – the

[5] We note here that our use of the term of *self-organisation* into music is a direct reference to systems theories (see Kollias 2008 & 2011), independently from Blackwell & Young. For our part, we use the term *self-organising music* to describe *all cases* of music where the work is self-organising. Whereas, the case of Blackwell & Young is a rather special case of music self-organisation.

formal, the perceptual, the social – are interconnected, having an equal importance, without any of them being considered as an extra-musical factor. In addition, we should mention his suggestion of the correlation between different time scales and emerging perceptual scales that pass from the personal perspective to the social perspective (Figure 3). Even if we find several system-oriented concepts in his perspective, Keller tries to establish a field based on ecological studies.

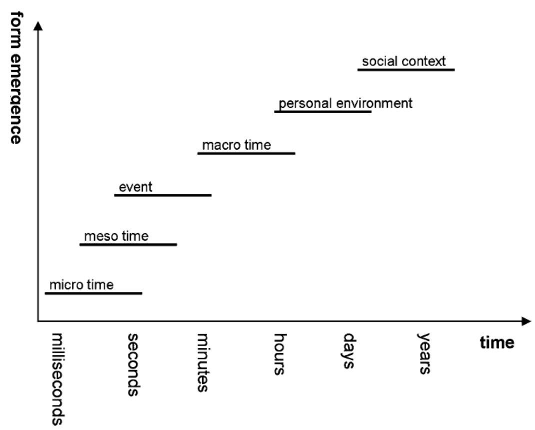

Figure 3. Time scales according to the ecological paradigm [10].

Waters refers to *performance ecosystems* [20]. He describes music as a complex system from the viewpoint of sonic and social perspective. He distinguishes three parts: the *performer* and his 'corporeality (bodilyness)', the *instrument* and the goal-oriented approach and finally the *environment* and its 'otherness' in regard to the system of performer-instrument. In his survey, he refers to various approaches that include ecosystem relationships through technology. According to Waters, the performance ecosystem is not merely a metaphor inspired by natural ecosystems. On the contrary, he suggests that the musical trend is interconnected with our corporality, our sensory agility and our interaction with the environment [21].

CONCLUSION

We have investigated and identified a new and active field of composers-researchers who deal with the subject of what we can call *self-organising music*. A music whose means of expression is the computer; the tools are microphones, controllers, sensors and so on; the expression material is the "live" electroacoustic sound that includes the source of its production but also the space in which it is expressed.

We can identify a shared tendency inspired by system-oriented theories towards a self-organising music practice. However, we can find as many different approaches as composers who practice them. Each composer tends to choose a perspective according to his/her own priorities and values to interpret the systems concepts in a different manner. In this sense, several authors use the same terms to explain different things; or conversely, others may use different terms to deal with similar themes. Consequently, the music discussion tends to be in rather vague terms, dealing with extra-musical subjects such as metaphors, modelling through visual representation, or imprecise abstractions.

However, apart from the more or less vague common concepts, a field of convergence between different authors arises from the fact that they publish and discuss their algorithms' blueprints (or their circuits) or even the algorithms' code. Consequently, this results in a more concrete source of discussion and an important tool for technical exchange. Compared with systems terminology which is a meta-language, and thus highly abstract by definition, an algorithmic blueprint is a clear and well-defined reference point: i.e. diagrams with well-defined symbols and connections representing interconnected DSP modules.

Nevertheless, it cannot change the fact that it is a point of convergence around purely technical characteristics. Thus, it does not suggest a specific set of aesthetics. We would like to emphasise that, until now, to the best of our knowledge, we cannot find a musical language based on systems epistemology which is really linked with musical material; either a systems' musical language that deals equally with the organisation, creation and processing of sound *per se*, and not merely with poetic references or connections with techniques in a vague manner.

We would like to ask some open questions: would it be possible to reach a point where we will have and use a system-oriented shared musical language? A language with which we could describe, discuss and imagine what we call self-organising music – as is the case of the conventional musical language for notated music, or for instance the spectromorphological terminology, for acousmatic music? This could be a powerful tool of broadening musical thought through systemic conceptual and methodological tools. Where music would really be genuinely *linked* with systems thinking and not just *inspired* by its concepts.

However, even if it was possible, who would take the responsibility to 'impose' a language with the possibility to be used by many? Would it be someone able to take the decisions for everyone, by preparing a language and exposing it in the form of an 'aesthetic manifesto' – as was the case rather often in past art history? Nonetheless, if a 'specialist' proved to be able to do this, from our systemic viewpoint, this would appear to us as an authoritarian tendency while imposing itself on the possibility of social self-organisation. Or otherwise, what if it was a team of peers – that is to say, respectable colleagues on the field with equal and similar skills – with its own criteria in determining a systemic language? As this was the case with Macy conferences, the very source of systems thinking, organised in order to construct a shared consensual metalanguage [1] [22]. Once again, from our viewpoint, we can see the danger of a certain kind of elitism, and again the problem of a dictating and opposing the tendency of a social self-organisation.

Since the demand for a common language that can be shared and used by the community cannot be imposed, the only legitimate way would be again a collaborative project. And if we are talking about true self-organisation, this project itself should be equally self-organising. A kind of project that would determine the conditions under which a common language could be built or chosen, tested and shared. We could imagine a form of *wiki* capable of responding to this demand, where any choice would be genuinely open, and the language self-organising. We leave the proposal open.

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REFERENCES

1. Ludwig von Bertalanffy. 1968. *General System Theory: Foundation, Development, Applications*. Reference to the revised edition, 1969. George Braziller, New York.
2. Eric Bonabeau, Marco Dorigo, and Guy Theraulaz. 1999. *Swarm Intelligence: From Natural to Artificial Systems*. Oxford University Press, New York, NY/Oxford, UK.
3. Tim Blackwell, and Michael Young. 2004. Self-organised music. *Organised Sound* 9, 2: 123-136.
4. Nicholas M. Collins, 2006. *Towards autonomous agents for live computer music: Realtime machine listening and interactive music systems*. PhD Dissertation. University of Cambridge, Cambridge, UK.
5. Agostino Di Scipio. 2003. ‘Sound is the interface’: From interactive to ecosystemic signal processing. *Organised sound: An international journal of music technology* 8, 3: 269-277.
6. Hugh Dubberly, Paul Pangaro, and Usman Haque. 2009. ON MODELING: What is interaction? Are there different types?. *Interactions* 16, 1: 69-75.
7. Francis Heylighen, and Cliff Joslyn. 2001. Cybernetics and Second-Order Cybernetics. *Encyclopedia of Physical Science & Technology*. Academic Press, New York, 155-170.
8. John H. Holland. 2006. Studying Complex Adaptive Systems. *Journal of Systems Science and Complexity* 19, 1: 1-8.
9. Risto Holopainen. 2012. *Self-organised sound with autonomous instruments: Aesthetics and experiments*. PhD Dissertation. University of Oslo, Oslo, Norway.
10. Damián Keller, and Ariadna Capasso. 2006. New concepts and techniques in eco-composition. *Organised Sound* 11, 1: 55-62.
11. Seunghun Kim, Graham Wakefield, and Juhan Nam. 2016. Augmenting environmental interaction in audio feedback systems. *Applied Sciences* 6, 5: 125.
12. Phivos-Angelos Kollias. 2008. Ephemeron: Control over Self-Organized Music. In *Proceedings of the 5th International Conference of Sound and Music Computing* (SMC '08), 138-146. Revised version of 2009 published in: *Hz Music Journal*, 14. Retrieved December 12, 2017 from http://www.fylkingen.se/hz/n14/kollias.html
13. Phivos-Angelos Kollias. 2011. The Self-Organising Work of Music. *Organised Sound*, 16, 2: 192-199
14. Phivos-Angelos Kollias. 2017. *Vers une pensée musicale orientée-système : l’œuvre musicale auto-organisante*. PhD dissertation. University of Paris VIII, Paris, France.
15. Jeffrey Morris. 2007. Feedback instruments: Generating musical sounds, gestures, and textures in real time with complex feedback systems. In *Proceedings of International Computer Music Conference* (ICMC '07), 469-476.
16. Craig W. Reynolds. 1987. Flocks, herds and schools: A distributed behavioral model. *ACM SIGGRAPH computer graphics* 21, 4: 25-34
17. Dario Sanfilippo and Andrea Valle. 2013. Feedback systems: An analytical framework. *Computer Music Journal* 37, 2: 12–27.
18. Greg Surges, Tamara Smyth, and Miller Puckette. 2016. Generative audio systems using power-preserving all-pass filters. *Computer Music Journal* 40, 1: 54–69.
19. Francisco J. Varela. 1988. *Cognitive Science. A cartography of Current Ideas*. Reference to the enlarged French version: *Invitation aux sciences cognitive*. 1996. Editions du Seuil, Paris.
20. Simon Waters. 2007. Performance ecosystems: Ecological approaches to musical interaction. In *Proceedings of Electroacoustic Music Studies Network* (EMS '07)
21. Simon Waters. 2011. Performance ecosystems: Editorial. *Organised Sound* 16, 2: 95-96
22. Norbert Wiener. 1948. *Cybernetics, or control and communication in the animal and the machine*. Reference to the 2nd paperback edition, 1965. The MIT Press, Cambridge, MA.