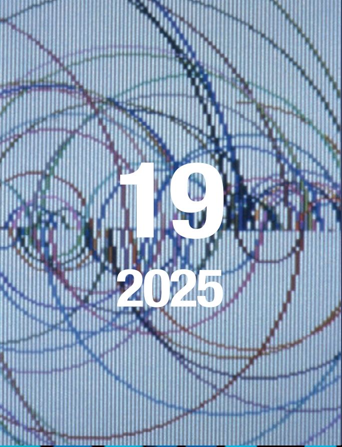
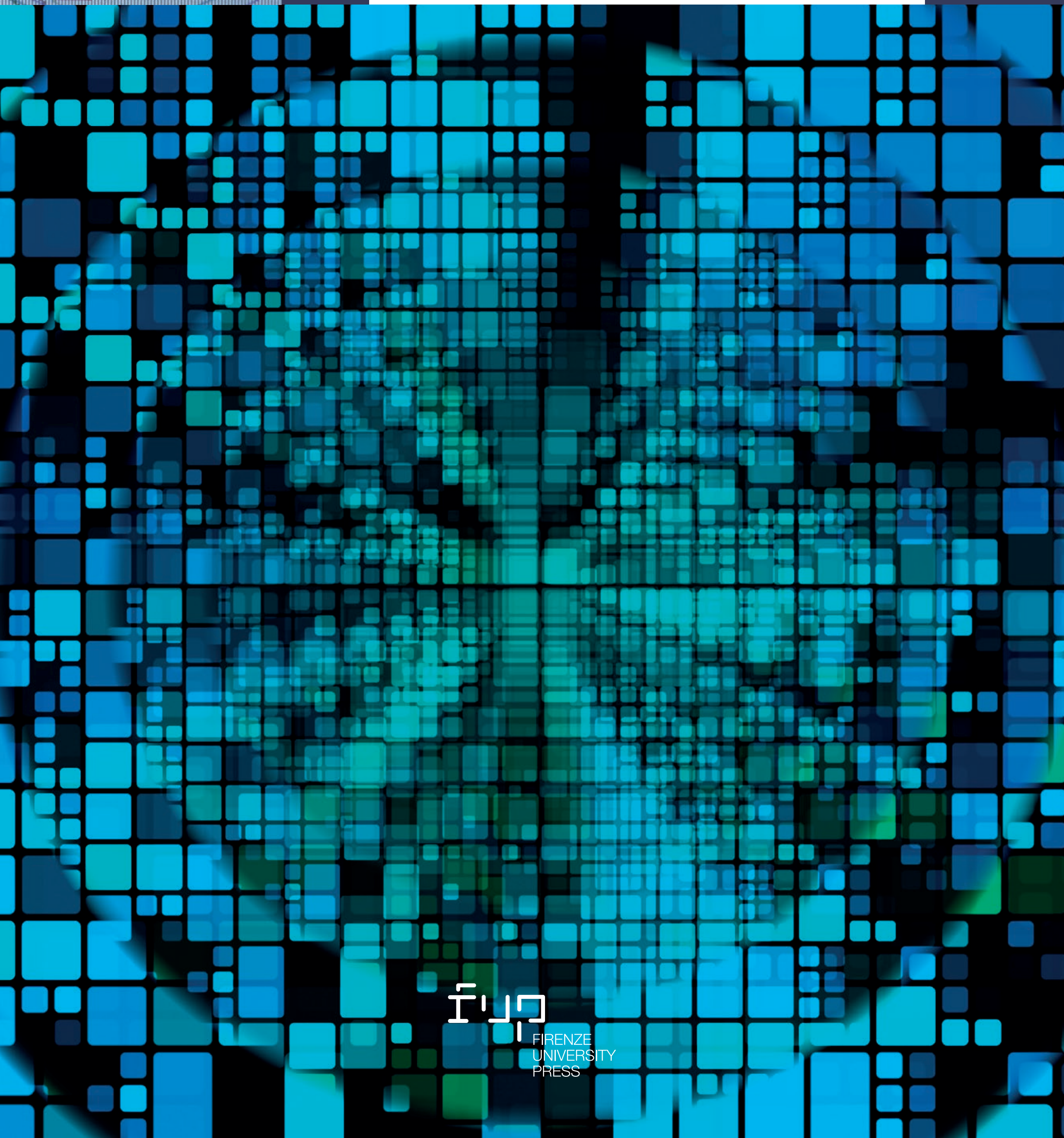
ISSN 1974-0042



Musica / Tecnologia

Music / Technology



FIRENZE
UNIVERSITY
PRESS

Musica/Tecnologia
Music/Technology

RIVISTA DELLA FONDAZIONE EZIO FRANCESCHINI

19 • 2025

Firenze University Press

Musica/Tecnologia
Music/Technology
19 (2025)
Registrato al n. 5489 del 31/3/2006 presso il Tribunale di Firenze.
ISSN 1974-0042 (print)
ISSN 1974-0050 (online)
Versione on-line: http://www.fupress.com/mt

Con il contributo dell'Ente Cassa di Risparmo di Firenze

ENTE CASSA DI RISPARMIO DI FIRENZE

Con il patrocinio di:

Conservatorio di Musica "Luigi Cherubini" di Firenze

CONSERVATORIO DI MUSICA LUIGI CHERUBINI FIRENZE

Istituto di Scienza e Tecnologie dell'Informazione CNR

Università degli Studi di Firenze – Firenze University Press – via Cittadella 7 – 50144 Firenze, Italy
web: www.fupress.com – mail: journals@fupress.com

Indice

New technological advances in electroacoustic feedback for music and composition

Il feedback elettroacustico è al tempo stesso gioia e tormento nella musica elettronica. Per la maggior parte di coloro che si occupano di progettazione di dispositivi e di spettacoli dal vivo, rappresenta un problema da risolvere, un'insorgenza indesiderata da impedire o eliminare. Per chi, invece, il suono lo pensa e lo manipola, può trasformarsi in una risorsa musicale di straordinario interesse. È proprio a questo pubblico che è dedicato questo numero della rivista, con l'intento di esplorare il feedback elettroacustico non come ostacolo tecnico, ma come fenomeno creativo ricco di possibilità espressive.

L'inclusione del feedback elettroacustico nei processi artistici risale agli anni '50, epoca che segna di fatto la nascita del repertorio acusmatico. Fin dai primi esperimenti con il nastro magnetico, i compositori hanno scoperto come il ritorno del suono attraverso circuiti di amplificazione potesse generare esiti sonori imprevedibili e affascinanti. Da allora, il feedback è sempre stato presente nella gamma delle risorse disponibili, e la sua tecnica di gestione si è evoluta di pari passo con il progresso tecnologico. Ogni epoca ha fornito strumenti nuovi per controllarlo, modellarlo e indirizzarlo: dai primi esperimenti con i microfoni e i nastri, passando per i sintetizzatori modulari e i processori digitali, fino ad arrivare ai sistemi di intelligenza artificiale e di live coding che oggi consentono un'interazione sempre più raffinata e dinamica con il fenomeno stesso.

Dal punto di vista esecutivo, l'aspetto ludico dell'uso dei trasduttori in conflitto tra loro è, a mio avviso, una delle ragioni principali per cui questa pratica ha attraversato decadi, estetiche e tecnologie senza mai perdere il suo fascino. Il feedback non è solo un effetto acustico, ma un vero e proprio strumento espressivo che richiede abilità, sensibilità e una profonda comprensione della relazione tra gli elementi coinvolti.

Nel mio brano *Anche questo è silenzio* (2020)[1], scritto per l'Experimental Ensemble del SWR di Friburgo, gli strumentisti generano feedback elettroacustico facendo entrare in ricorsione microfoni e altoparlanti a contatto. A seconda di come i microfoni sono maneggiati e delle zone degli strumenti che vengono esplorate, il feedback varia in altezza e timbro. Dietro il semplice gesto dell'esecutore che indaga il proprio

[1] Edizioni Suvini Zerboni, Milano, S. 16244 Z.

Musica/Tecnologia, 19 (2025), ISSN online 1974-0050, ISSN print 1974-0042, pp. 5-8
DOI: 10.36253/music_tec-16208 – http://www.fupress.com/mt

strumento con un microfono, si cela un lungo lavoro di selezione dei trasduttori e di programmazione informatica, necessario affinché questa pratica possa essere gestibile, riproducibile e integrata in un contesto compositivo preciso. L'equilibrio tra casualità e controllo è uno degli aspetti più affascinanti di questo approccio: da un lato, il feedback possiede una componente intrinsecamente imprevedibile; dall'altro, l'uso di strumenti tecnologici e di algoritmi avanzati permette di guidare e plasmare il fenomeno in modi sempre più sofisticati.

Nella pratica di tutti i tempi, troviamo esempi di come il feedback elettroacustico sia stato usato come materiale da registrare e quindi fissare su supporto oppure come risorsa codificata per mezzo della scrittura in partitura. Con altrettanta importanza, le pratiche audiotattili sono parte integrante di questo mondo sonoro.

Il feedback elettroacustico, dunque, non è solo un fenomeno fisico da gestire, ma una vera e propria risorsa musicale dalle molteplici implicazioni. La sua presenza nella storia della musica elettronica è tanto vasta quanto sfaccettata: lo troviamo nelle sperimentazioni pionieristiche degli anni '50, nelle improvvisazioni radicali della musica live electronics, nell'universo noise e industrial, fino ad arrivare alle più recenti ricerche sulla spazializzazione del suono, sulla costruzione di nuovi strumenti e sulle interazioni tra strumenti acustici e dispositivi digitali.

Per questo motivo, ho ritenuto interessante approfondire il tema coinvolgendo musicisti, musicologi e programmatori, con l'obiettivo di indagare non solo le prassi artistiche legate all'uso del feedback, ma anche le questioni tecniche, estetiche e teoriche che esso solleva. Questo numero della rivista vuole essere un'occasione per riflettere su un fenomeno sonoro tanto affascinante quanto complesso, capace di mettere in discussione le convenzioni dell'ascolto e dell'esecuzione musicale.

Gli articoli di Rosani, Verga e Pozzi offrono uno sguardo approfondito sulla pratica artistica in cui il feedback elettroacustico è generato, controllato e spazializzato secondo modalità proprie. Trovo particolarmente interessante come, nel processo compositivo contemporaneo, l'integrazione del feedback sia spesso accompagnata da una riflessione sulla spazialità. Questo può manifestarsi sia nella scelta dei luoghi per l'esecuzione delle opere, sia nell'impiego dello spazio come elemento attivo nella generazione di fenomeni acustici. Sin dalle scorse decadi, spazio e feedback sono stati strettamente connessi nei lavori di molti autori, segnando la continuità di una tradizione viva, in costante evoluzione attraverso la creatività dei compositori.

Maestri, nel suo articolo, propone una disamina della pratica del feedback elettroacustico oggi, inquadrandolo nel contesto storico della musica elettronica e analizzandone il ruolo nella definizione di un linguaggio autonomo.

Maurilio Cacciatore

Electroacoustic feedback is both a source of joy and torment in electronic music. For most professionals involved in device design and live performances, it represents a problem to be solved, an unwanted occurrence that must be prevented or eliminated. However, for those who conceive and manipulate sound, it can transform into an extraordinarily compelling musical resource. This issue of the review is dedicated precisely to this audience, with the intent of exploring electroacoustic feedback not as a technical obstacle but as a creative phenomenon rich in expressive possibilities.

The inclusion of electroacoustic feedback in artistic processes dates back to the 1950s, an era that effectively marks the birth of the acousmatic repertoire. From the earliest experiments with magnetic tape, composers discovered how the return of sound through amplification circuits could generate unpredictable and fascinating sonic outcomes. Since then, feedback has always been present in the spectrum of available resources, and the techniques for managing it have evolved in parallel with technological advancements. Each era has provided new tools to control, shape, and direct it: from the first experiments with microphones and tape to modular synthesizers and digital processors, up to today's artificial intelligence systems and live coding environments, which enable increasingly refined and dynamic interactions with the phenomenon itself.

From a performance perspective, the playful aspect of using transducers in mutual conflict is, in my opinion, one of the main reasons why this practice has spanned decades, aesthetics, and technologies without ever losing its appeal. Feedback is not merely an acoustic effect but a true expressive instrument, requiring skill, sensitivity, and a profound understanding of the relationships between the elements involved.

In my piece *Anche questo è silenzio* (2020)[2], written for the SWR Experimental Ensemble in Freiburg, performers generate electroacoustic feedback by creating recursive interactions between microphones and contact loudspeakers. Depending on how the microphones are handled and which areas of the instruments are explored, the feedback changes in pitch and timbre. Behind the seemingly simple act of a performer

[2] Edizioni Suvini Zerboni, Milano, S. 16244 Z.

Musica/Tecnologia, 19 (2025), ISSN online 1974-0050, ISSN print 1974-0042, pp. 7-8

exploring their instrument with a microphone lies an extensive process of transducer selection and software programming, necessary to ensure that this practice is manageable, reproducible, and seamlessly integrated into a precise compositional framework. The balance between randomness and control is one of the most fascinating aspects of this approach: on one hand, feedback possesses an inherently unpredictable component; on the other, the use of advanced technological tools allows the phenomenon to be guided and shaped in increasingly sophisticated ways.

Throughout history, we find numerous examples of how electroacoustic feedback has been used both as a recorded material, fixed onto a medium, and as a codified resource through score notation. Equally significant are the audiotactile practices that have become an integral part of this sonic world.

Electroacoustic feedback, therefore, is not merely a physical phenomenon to be managed but a true musical resource with multiple implications. Its presence in the history of electronic music is as vast as it is multifaceted: it appears in the pioneering experiments of the 1950s, in the radical improvisations of live electronics, in the realms of noise and industrial music, and in the most recent research on sound spatialization and interactions between acoustic instruments and digital devices.

For this reason, I found it interesting to delve deeper into the topic by involving musicians, musicologists, and programmers, with the aim of investigating not only the artistic practices related to the use of feedback but also the technical, aesthetic, and theoretical issues it raises. This issue of the journal aims to provide an opportunity to reflect on a sonic phenomenon that is as fascinating as it is complex, capable of challenging the conventions of listening and musical performance.

The articles by Rosani, Verga, and Pozzi provide an in-depth look at artistic practice in which electroacoustic feedback is generated, controlled, and spatialized according to its own modalities. I find it particularly interesting how, in contemporary compositional processes, the integration of feedback is often accompanied by a reflection on spatiality. This can manifest both in the choice of venues for the performance of works and in the use of space as an active element in the generation of acoustic phenomena. For decades, space and feedback have been closely connected in the works of many authors, marking the continuity of a living tradition that continues to evolve through the creativity of composers.

Maestri, in his paper, offers an examination on the practice of electroacoustic feedback today, framing it within the historical context of electronic music and analyzing its role in defining an autonomous language.

Maurilio Cacciatore

Audio feedback on metal panels and emotion detection for sound classification in low-hierarchy performance spaces

Silvia Rosani
Conservatorio Benedetto Marcello, Venezia, Italia
silviarosani@yahoo.it; Orcid: 0000-0002-7559-6844

Abstract. Social inequality in both the classical music production and consumption practices is undoubtedly at the base of the lack of involvement of the so-called new audiences in the contemporary music scene and it has been observed that timbre-based approaches to synthesis tends to favour listening and interaction when people have no music background. The present paper investigates the use of audio and electromagnetic feedback for the stimulation of vibration in metal panels and metallic musical instruments within the frame of interactive sound installations and compositions to pursue the exploration of less hierarchical structures within the performance space. A variety of feedback algorithms implemented for those works will be described along with the machine learning techniques used to expand the human-machine relationship via web-applications, which allow for remote interaction of the audience. Classification of sound according to its emotional content was used because non-musicians tend to relate to music mainly through their emotional response to it. Sound analysis and re-synthesis enabled the production of control data to steer AC devices as well as regulate the activation of the audio feedback algorithms. Given its non-linearity and its reluctance to control, feedback turned out to be particularly successful in the generation of a vast variety of timbre-based audio material and agency, thus laying the ground for free improvisation and interaction within the performance space.

Keywords: audio feedback, electromagnetic feedback, Convolutional Neural Networks, emotion detection, audience participation, intermedia, hierarchy, agency.

Introduction

The present paper mainly investigates the use of audio feedback for the stimulation of vibration in metal panels and metallic musical instruments within the frame of sound installations and compositions. Some of the specific feedback algorithms used in these works will be described as well as how common metallic objects can be regarded as hybrid electroacoustic instruments for the benefits of non-musicians, who develop short improvisations with them without feeling intimidated as it is the case when they happen to interact with musical instruments with a long history, specific repertoire and playing techniques.

Undoubtedly, the fascination for audio feedback is partially due to its unpredictability, its tendency to resist repetition and its intrinsic bidirectional ability to foster interactivity. Those features alone provide valid agency for free improvisation. That embodies what Di Scipio calls 'agentive potential of complex feedback systems'[1] and

[1] Di Scipio, 2022.

Musica/Tecnologia, 19 (2025), ISSN online 1974-0050, ISSN print 1974-0042, pp. 9-25
DOI: 10.36253/music_tec-15472 – http://www.fupress.com/mt

what Nakamura's words refers to when he states that 'it seems like there is quite an equal relationship between this machine and me'[2]. Especially when employed to activate vibration in metallic objects, audio feedback tends to resist the dominance of the performer/composer and, hence, displays a natural reluctance to hierarchy. This resistance fits particularly well with an interactive sonic environment which aims to reduce hierarchy in the performance space[3]. According to Nakamura 'you can't be a feedback improviser when you have your brains filled with your big beautiful pictures prior to your performance'[4]. Although not necessarily aimed at non-musicians, Nakamura's statement points out how easy it becomes to find a way to interact with a hybrid instrument which embed such a system if one has no specific sonic plans for it, as it is mainly the case for non-musicians. Moreover, Landy's work (2011) seems to have proven that, when non-musicians experience sound, complex frequency content, thus rich timbral situations, favours listening, and the sparse distribution of sources in the performance space can offer multiple listening perspectives to the audience as an alternative to a sweet spot structural strategy[5]. The idea of populating the space with objects which emit different sounds along with the use of audio feedback clearly relates to some of David Tudor's works. In the *Rainforest* series[6] and *Microphone*[7], the material mediator is absolutely necessary for the production of sound. The agency of the audience shifts remotely in *AmotIon*, an installation with which people can interact through the use of a web-application. In this case, the feedback loops are framed within a larger human-machine loop which integrates machine learning algorithms for determining choices with regard to sound synthesis, instrumentation and agency.

In the following sections of the paper I will be describing how *Intermezzo 4* is an installation which creates a frame for musicians and non-musicians to realize free improvisations through the use of audio feedback on metal panels and small DC motors to change the position of some of the driving elements. Another section will focus on how a system for audio feedback on metal panels was embedded within a larger human-machine loop through a web-application for Emotion Detection implemented via Convolutional Neural Networks (CNNs). The section which precedes the conclusions concentrates on audio feedback systems directly applied to musical instruments and on my plans for future research. A classification of the feedback systems described according to the schema suggested by Sanfilippo e Valle (2013) will be attempted and discussed in the conclusions.

2 Nakamura, 2002: 5.

3 Rosani, 2020.

4 Nakamura, 2002: 5.

5 Rosani, 2017.

6 Rogalsky, 2002.

7 Space Echo, n.d.

Audio feedback and DC motors: Intermezzo 4

While I was studying for my Phd at Goldsmiths, University of London, I had the chance to take part in the New Music/ Québec – UK Exchange and spent a month in Montreal working with Ensemble In Extensio. In that occasion, I met Canadian percussionist Tom Jacques, who asked me to collaborate to a Canada Art Council supported project on a augmented vibraphone. During a Subnet residency at the Human-Computer Interaction Center of the University of Salzburg (SubnetAIR n.d.) we started experimenting on how to stimulate the vibration of the vibraphone tone bars via feedback. The idea of using feedback to augment the vibraphone came to me while reading about the EMvibe project being developed at the Augmented Instruments Laboratory at Queen Mary University of London[8]. The EMvibe system required a complex tuning procedure to stimulate the correct harmonics of the vibration tone bars, while I thought that a feedback-based system similar to how previous augmented instruments had been developed in the same lab might spare the need for that procedure. Since the residency at HCI turned out to be too brief to allow for the development of a feedback system that could also be easily transportable back to Canada, I continued the exploration of audio feedback within another project of mine. In particular, I implemented audio feedback on metal panels as thin as 0.5mm which displayed a way stronger proclivity than the thick tone bars of the vibraphone to react to feedback. The project ended up becoming *Intermezzo 4* (2019), an installation for audio feedback and DC motors on metal panels. The installation consists of 5 metal panels, on which one or two contact microphones are hung. On each of the 4 panels hung on metal stands there can be either Dayton sonic exciters or speaker drivers. While the former are fixed in their position, the latter can be moved by hand or via the use of DC motors controlled with a MIDI controller. The fifth metal panel, which does not hang but can be moved around the performance space is made to vibrate via a feedback loop between a contact microphone and a lifting magnet, which creates a different timbre in comparison to the other drivers and is smaller. That makes actions like twisting and torquing of the panel easier, since the lifting magnet is quite small and, hence, does not interfere with the handling of the panel or risk dropping from it. The frequency content of the feedback loops change as the speaker drivers move along the surface of a metal panel either manually or via the DC motor connected to it (see Fig. 1). It is also possible to easily move the position of the contact microphones – clip Korg CM-300 contact microphones -- on the edges of the metal panels. As one removes the microphone from the panel, the sound stops. Therefore, that is an action I often pursue during performances, since it makes it clear to the audience that I am not necessarily projecting sound through the sonic exciters or speaker drivers.

Since the position of the sonic exciters is fixed, the sonic loops which make use of these drivers varies algorithmically. The strategies implemented for the exciters aim to generate interferences by activating two exciters on the same panel, feeding the input

[8] Britt et al., 2012.

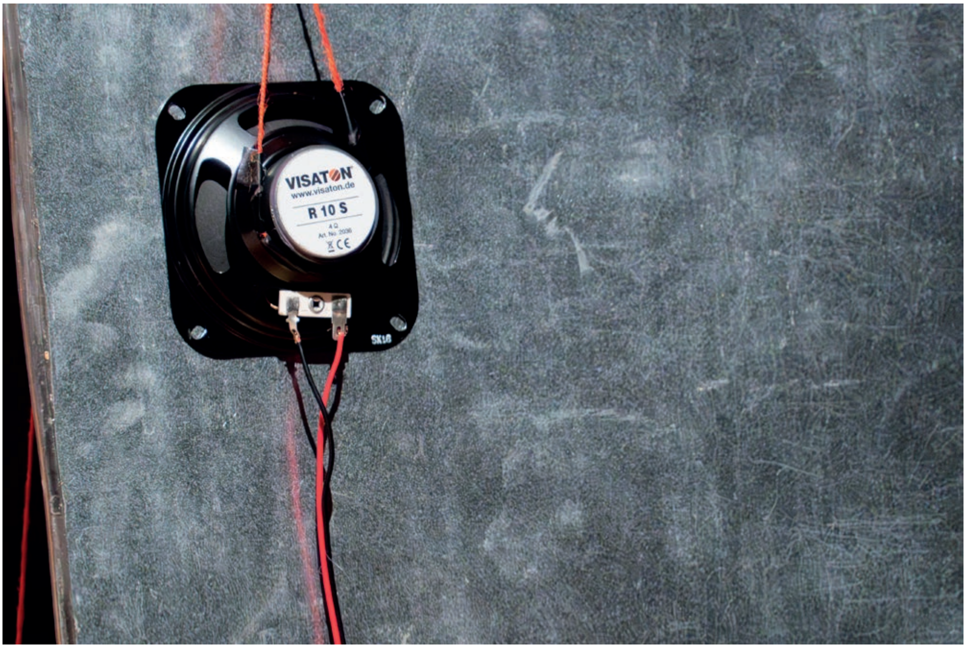


Figure 1. Speaker driver sliding along the surface of the metal panel. Photo credit: Laura Stefanie Kleindopp.

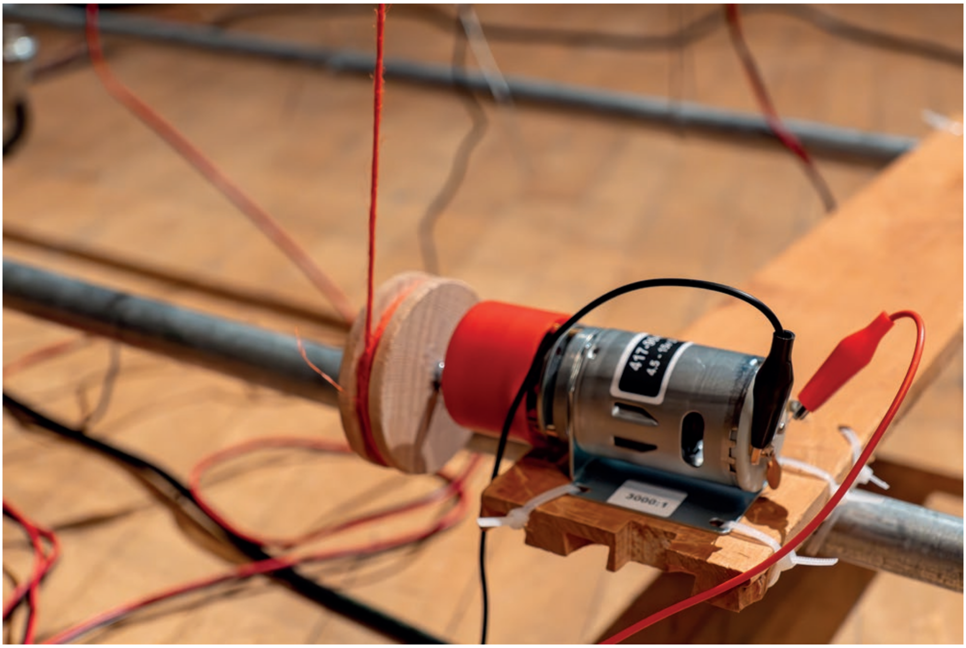


Figure 2. DC motor supporting movement of the speaker driver. Laura Stefanie Kleindopp.

from two different microphones to the same exciter, or a combination of the two techniques. Alternatively, the feedback loops are varied digitally as it is described below. In all figures, I indicated the contact microphones as CM followed by 1 or 2, since on each metal panel there were between one and two microphones. Similarly, I used SE to indicate a sonic exciter followed by the correspondent number.

Fig. 3 – Algorithm 1

The simplest algorithm (Larsen) includes a limiter with a threshold that is regulated via the MIDI controller or automation. The signal from each of the two contact microphones is routed to the correspondent sonic exciter with the exception of the first, which can also optionally leak into the second output. This option is valid also with any of the other algorithms and, hence, the first contact microphone has been added with dash lines in all of the following schemes too.

Fig. 4 – Algorithm 2

A second algorithm implements a variable delay line with a feedback line – comb FIR filter. The length of the delay line and feedback factor can be adjusted via a MIDI controller or automation.

Fig. 4 – Algorithm 3

Within the third algorithm a concatenation of all-pass filters as in the [rev1~] object created by Miller Puckette (2007) is embedded within the second algorithm. The

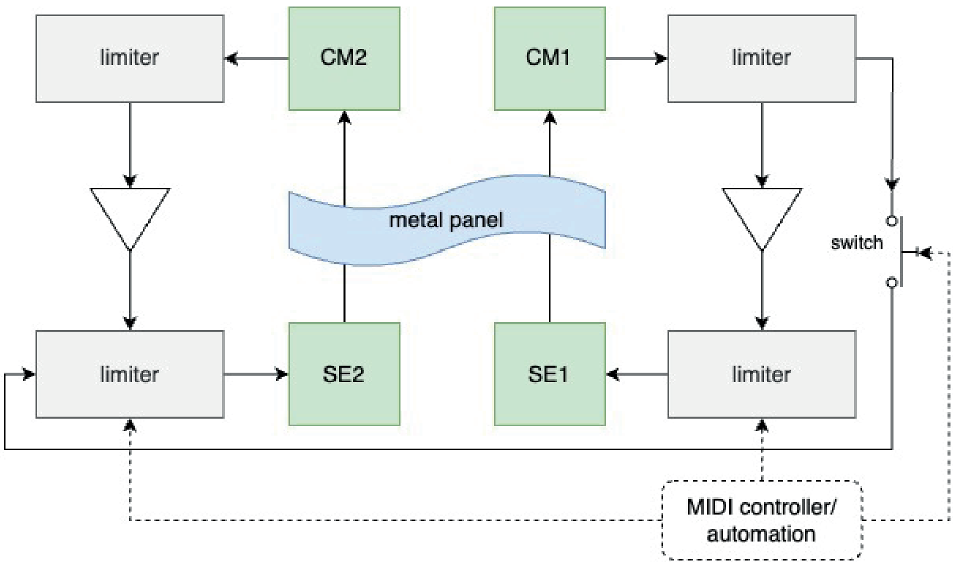


Figure 3. Algorithm 1: Larsen and second contact microphone (optional).

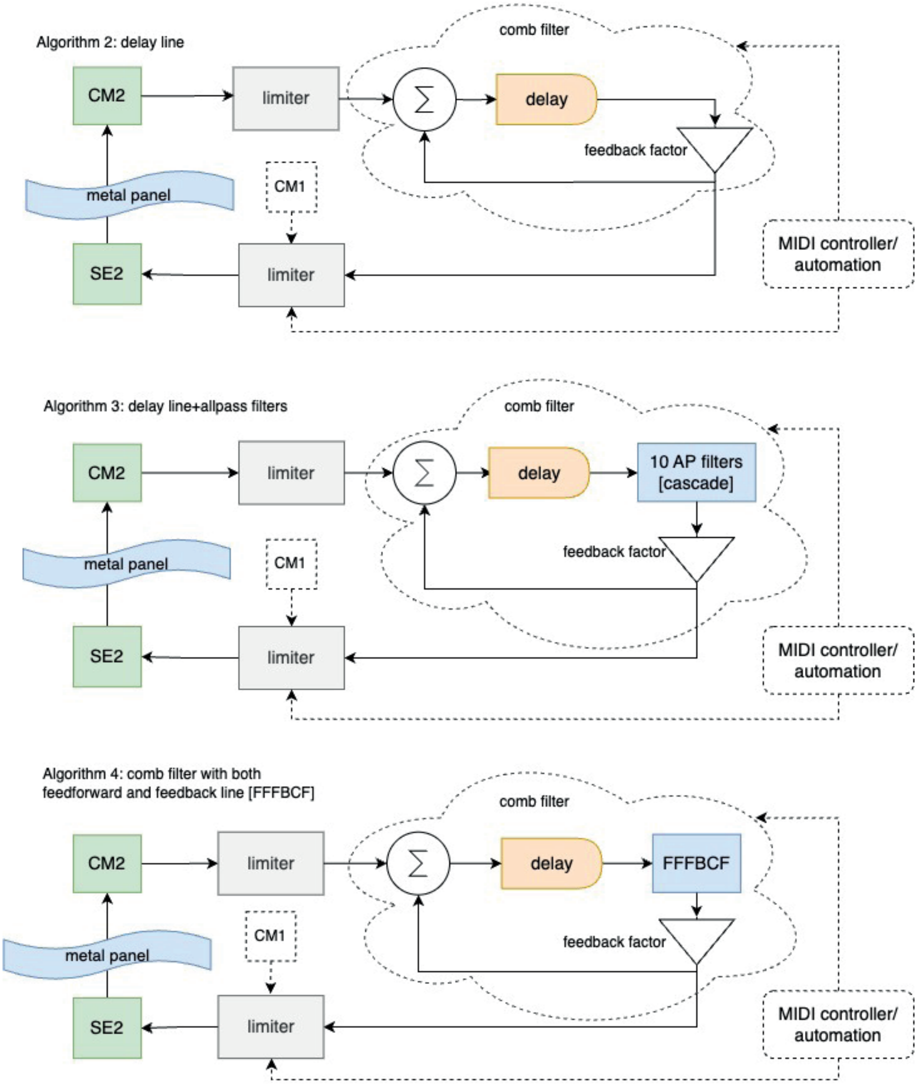


Figure 4. Algorithms 2-4: delay line, delay line+allpass filters, delay line with feedforward and feedback line.

reverb time can be controlled via MIDI controller while before every activation the filters are cleared.

Fig. 4 – Algorithm 4

The fourth algorithm implements a comb filter with feedback as well as feedforward line embedded within the second algorithm. Both frequency and decay time can be controlled via MIDI.

The last 3 algorithms all include modulations.

Fig. 5 – Algorithm 5

The fifth algorithm implements ring modulation between the feedback sound and an sinusoidal LFO. The MIDI controller enable control over the frequency of the oscillator.

Fig. 5 – Algorithm 6

Here a delay line similar to the one in the second algorithm is followed by a ring modulator. All parameters can be controlled and, hence, varied.

Fig. 5 – Algorithm 7

The last algorithm implements phase modulation between what would otherwise be a simple feedback signal (Larsen) and an oscillator. The resulting signal is then fed to a ring modulator. The MIDI controller enables variations of the modulation index, the frequency of the carrier and the oscillation frequency of the LFO in the ring modulator.

The first 4 algorithms can be freely selected for panel 2 via the MIDI controller, while the last 3 algorithm can be selected on panel 3. Panel 1 is set up with 2 speaker drivers which can both be moved via DC motors up and down the surface of the metal panels and, hence, already varies the frequency content of the feedback loops through the different positioning of the transducers involved. Panel 4 is equipped with a speaker driver which can be moved by hand and panel 5 is also usually handled by hand, as the lifting magnet mentioned above is attached to it. Sound examples of the outputs produced by the algorithms and by different routings of the microphone inputs to the driver outputs are provided in the reference section (Rosani, 2025).

Intermezzo 4 has 3 different settings. The first one turns the installation in a fully automated installation and is activated when no human interaction is required, although that is still possible. Audience members interacting with the installation at the Huddersfield Contemporary Music Festival (hcmf) are depicted in Fig. 6.

The second setting entails partial automation and that is the setting I use when I develop an improvisation with no other collaborators. The third setting is totally manual and that is the one I activate when I work with either musicians or non-musicians. The first 2 settings were mainly used in the first years of the installation[9], while the last setting was used more recently when I improvised with the students of the Leeds College of Music (Rosani, 2025) and in Salzburg with Ensemble NAMES (Sounding Sculptures, 2021). Nevertheless, not all the algorithms had been implemented by 2021. They are now fully functional and will be used for the performance at Festival Mixtur in October 2024. There I will be improvising with the installation myself, at

[9] Huddersfield Contemporary Music Festival, 2019; Susch Muzeum, 2021.

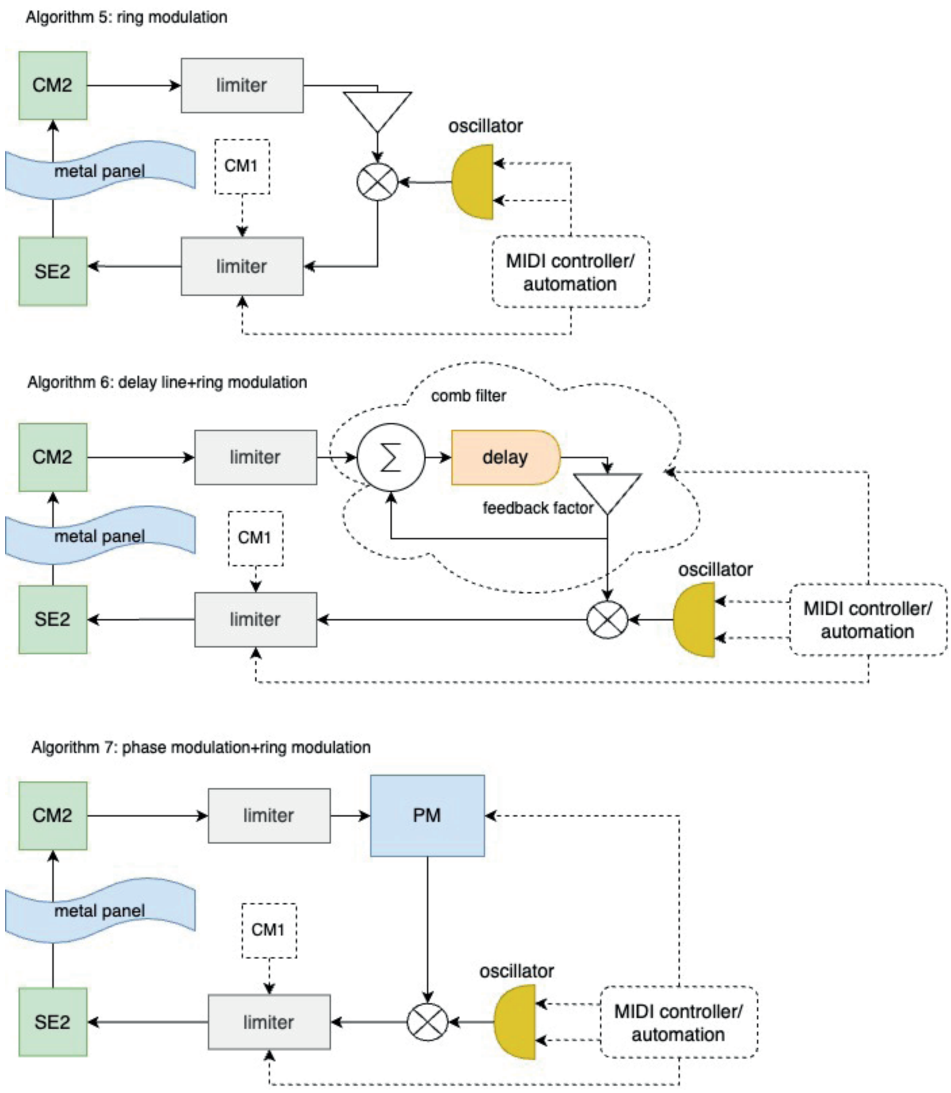


Figure 5. Algorithms 5-7: ring modulation, delay line+ring modulation, phase modulation+ring modulation.

times leave the first setting active and finally develop improvisations with the audience members and the students from ESMUC. A link to the video of the performance with Ensemble NAMES is available in the reference section (NAMES, 2021). While I was in residence at Muzeum Susch, visual artist Agnieszka Mastalerz (Susch, 2021) shot brief videos of audience members interacting with *Intermezzo 4* (Susch, 2021). A few seconds of the improvisation developed by the students of the Leeds Music College with my installation were recorded and are available in the reference section (Sounds Like THIS, 2020).

Figure 6. Audience members interact with *Intermezzo 4* at hcmf 2019. Photo credit: Brian Slater.

Audio feedback and Emotion Detection

In 2021, a combination of residencies gave me the opportunity to move the necessary steps towards the creation of *AmotIon*, an interactive installation for emotion detection implemented via a web-application and audio feedback on metallic objects. During a EASTN-DC residency at ZKM in Karlsruhe I had the chance to start working on emotion classification in voices which then was embedded in an installation for the Internet of Things. These expertise came in handy when I was awarded a residency and project budget of the European platform EMAP/EMARE (AmotIon (2021), n.d.), for which I collaborated with the multimedia center RIXC in Riga (Latvia). In *AmotIon* a web-application uses Convolutional Neural Networks (CNNs) to classify recordings sent by the audience members, who can also access the app remotely. Once the recordings are classified, the information is sent to a local app, which dialogues with Pure Data and activates the feedback loops on metallic objects in the installation space. The reaction of the installation is then recorded and classified into 8 emotional categories. If the result of the classification does not match the emotional content of the recording collected through the global app, the system triggers a second activation of the installation, which again gets recorded and classified. The process

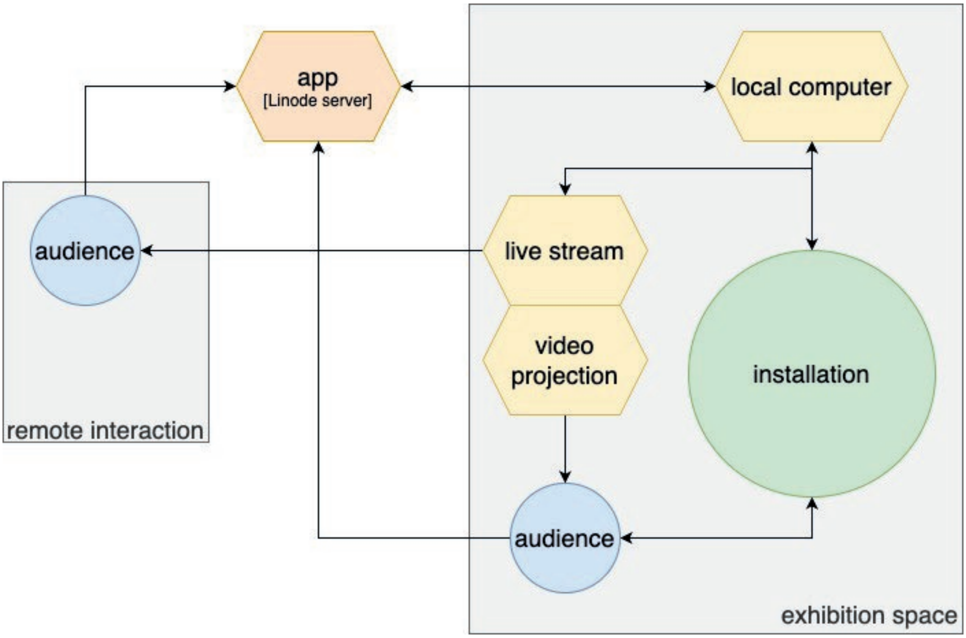


Figure 7. Scheme of the overall architecture and functioning of the installation as a loop.

stops if an emotional match is detected or after 4 repetitions of the comparison have been processed. This loop between the human agent and the machine response aims to implement an emotional attunement between the human sonic intervention and the audio feedback response of the installation. Even remotely the audience members can witness the response of the system via a live streaming from the installation space. The scheme of the whole loop involving audience members – remotely and not, the web-application and the audio feedback on the 3 objects in the installation space is illustrated in Fig. 7.

The web-application was programmed with Python and Flask as an improvisation partner, since once the audience submit their recording the algorithm can randomly choose among 4 actions. After the submitted recording has been classified, an audio file could be re-synthesized once exctracted from a folder where recordings with the same or similar emotion were classified. Alternatively, the audio file could be selected from a folder containing recordings corresponding to emotions contrasting to the one detected in the audience's recording. Otherwise, the algorithm can select an audio file with an emotional content which has no strong correlation to the one in the audience's recording or even not react to it at all. These 4 options somehow cover what a human improviser might choose to do during an improvisation, thus playing something similar, contrasting material, unrelated sounds or remaining quiet. Although the choice of the action is random, a database keeps track of the choices and makes sure that all 4 options are selected with the same frequency.

The re-synthesis of the classified audio files takes place in terms of either dynamic envelope or frequency content. Another random choice the algorithm carries out has to do with which type of feedback algorithm is used and on which of the metallic objects. The feedback loops can activate simple Larsen effect through the opening and closing of the gates between contact microphones and sonic exciters on one or more of the objects according to the dynamic envelope detected in one of the audio files classified by the CNNs model. The envelope can alternatively be stretched in time – 3 different time factors can be selected – to allow for variants in terms of the duration of the reaction the installation displays. A second type of algorithm takes into account the frequency content of the audio file which is being re-sinthesized. Mel-frequency Cepstral Coefficients provide this information in the form of a matrix. When this algorithm is selected, in case no emotional match is detected in the first comparison round, different rows of the matrix are used for the re-synthesis process. Hence, the audio file remains the same, while its frequency content is explored. A third and last type of synthesis algorithm is employed, which uses FM with the frequency information provided by the above mentioned matrix. The resulting sound is not played through sonic exciters but rather diffused via loudspeakers.

Besides 2 large metallic objects – Fig. 8 to 10, *AmotIon* includes a 50 cm diameter tambourine – Fig. 11. A flat contact microphone is attached at the bottom of it along with a sonic exciter. Since the audio feedback loop involves a membrane rather than a metallic surface, the sound resulting from the vibration of this instrument provides one further timbral variant. A brief video of the interaction between the web-application and the audio feedback system is available in the reference section (Nova Synagoga, 2021). Classification of sound according to its emotional content was used because non-musicians tend to relate to music mainly through their emotional response to it and I thought that that could further enhance the process of emotional attunement between human and machine.

A variant of the classification algorithm for emotion detection was used in *Ni anverso ni reverso*, a composition for violin and web-application which was a commission of Vertixe Sonora ensemble and was performed by violinist Roberto Alonso Trillo at the Museo Interactivo da Historia de Lugo during the IX Ciclo de Musica Contemporanea de Lugo (Spain, 2021). In that case the app is used by the violinist as an interface to activate the dynamic envelope re-synthesis through 4 ventilators – Fig. 12. A dpa microphone is used to pick up the instrumental sound and the vocal utterances of the violinist at instants which are either selected by the performer or regulated by the algorithm. The violinist follows the music score according to the result of the classification provided by the emotion detection algorithm. A link to the video of the performance is available in the reference section (Vertixe Sonora, n.d.).

Audio feedback on instruments, electromagnetic feedback and future research

In a couple of cases, I investigated audio feedback applied directly to the body of an instrument. In 2021, I worked with TRIO vis-á-vis and requested of the flutist to attach a lifting magnet on the main body of a bass flute, while a contact microphone

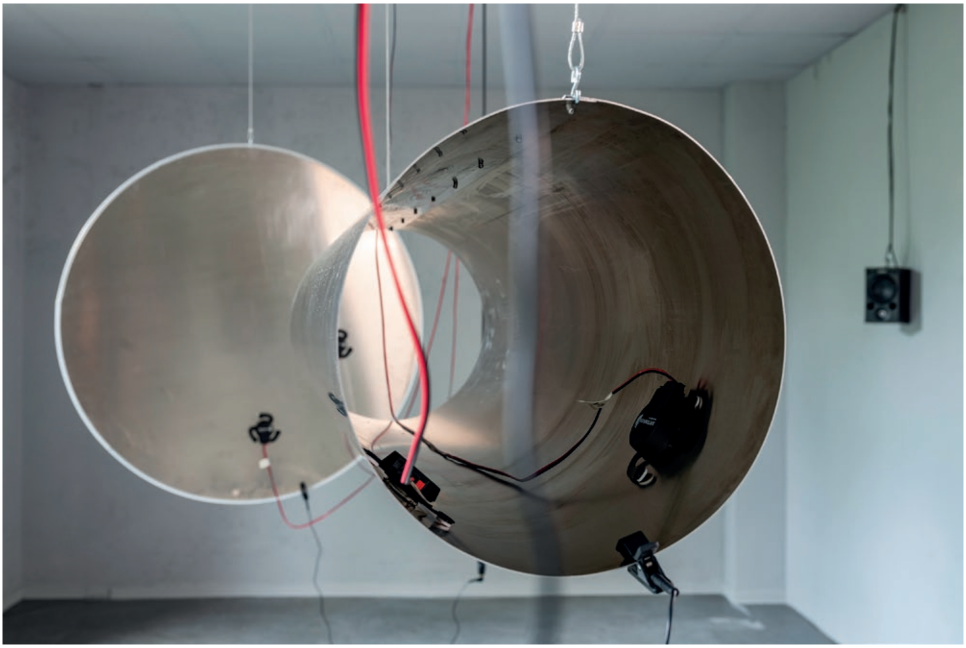


Figure 8. *Amotion* at the Werkleitz Festival (Halle, Germany). Photo credit: Werkleitz Festival 2021 move to … © Werkleitz, Foto Falk Wenzel.

Figure 9. *Amotion* at the Nova Synagoga (Žilina, Slovakia). Dancer interacting with one of the two metal objects during a free improvisation. Photo credit: Luna Mafo.

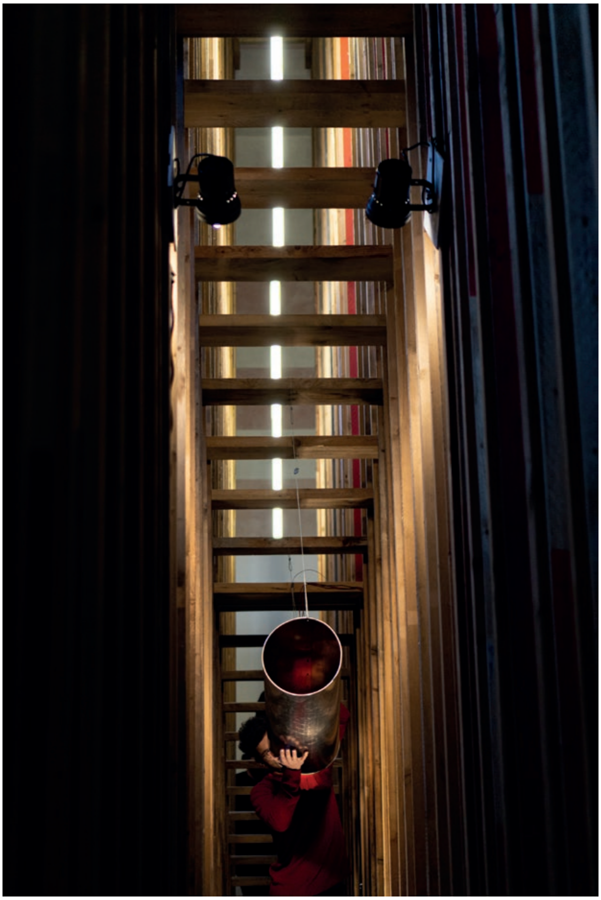


Figure 10. *Amotion* at the Nova Synagoga (Žilina, Slovakia). Visual artist interacting with one of the two metal objects during a free improvisation. Photo credit: Luna Mafo.

was clipped at the exit of the tube[10]. As one could expect, that setting did not provide a variety in the feedback reaction like it might be possible if microphone and driver were arranged respectively at the bore and exit of the tube, as it was the case in some of Collins's works with woodwind and brass instruments or as experienced by Graham with pipes[11], since in my case the feedback environment is the metallic body rather than the air in the tube. Nevertheless, my setting was effective in combination with the energetic percussive sounds in the flute part. The composition integrated also metal panels with an algorithm of filtering for audio feedback. That enabled me to select specific pitches for the audio feedback and to contribute at the re-synthesis of a piece by Claudio Monteverdi along with acoustic instruments.

[10] TRIO vis-á-vis, 2022

[11] Collins, 2002; Di Scipio, 2022.

Figure 11. *Amotion* at the Nova Synagoga (Žilina, Slovakia). Children interacting with the tambourine. Photo credit: Luna Mafo.

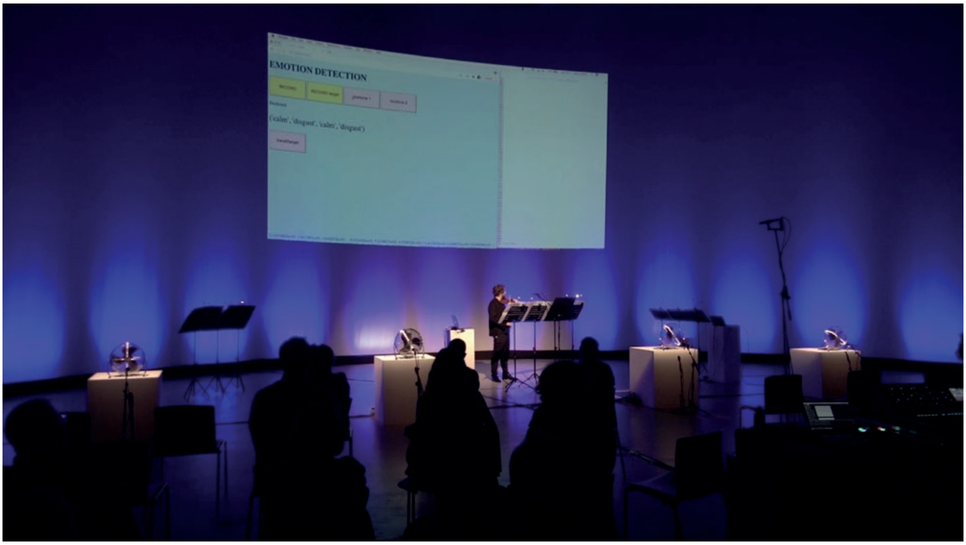


Figure 12. Violinist Roberto Alonso Trillo performs *Ni anverso ni reverso* in Lugo. Photo credit: Vertixe Sonora.

A similar hardware setting was used for *Nomadismo mostruoso*, a composition for natural horn I wrote for Deepa Goonetilleke, with which I could collaborate thanks to a Virtual Partner Residency of the Goethe-Institut (Virtuelle Partner Residenz). The audio feedback subtle variations were employed during the process of changing the crooks. Deepa's movements of the instrument itself during the transitions between the different sections of the piece contributed to vary the frequency content and dynamic envelope of the audio feedback sound.

During a residency at the Experimentalstudio of the Südwestrundfunk (SWR) I investigated the effects of audio feedback between what is commonly referred to as sniffing circuit, thus simply an inductor, and sonic exciters on metal panels. After the residency I carried on the research and could test different types of inductors and combinations of discrete electric components to induce percussive pulses of different occurrence rate in accordance to the results obtained by Nicolas Collins (2020) in his work Mortal coils. My future research plans involve the inclusion of these circuits as interfaces and visual objects with strong symbolic references in a new project with sound-poet Kinga Tóth.

Conclusions

The research outlined above proves that audio feedback can be used successfully to transform metal panels, musical instruments and other objects into hybrid electro-acoustic instruments, with which musicians and non-musicians can develop free improvisations. A large variety of timbral situations originate from manually interacting with such objects, moving the devices involved in the feedback loops via motors and from a series of feedback algorithms implemented in the digital domain. The human-machine relationship can be further expanded with the use of machine learning for the classification of input stimuli and for selecting outputs. Web-applications extend that even to remote audience.

Table 1 shows how the works illustrated in the present paper refer to the parameters highlighted by Sanfilippo e Valle (2013).

Table 1. Parameters in feedback loops with regard to the works illustrated.

	Encoding analog/ digital	Rate audio/ control	Openness closed/open	Trigger internal/ external	Adaptivity adaptive/ non-adaptive	Human-machine interaction absent/present
Intermezzo 4	1	0	1	-1	1	0
AmotIon	1	0	1	-1	-1	1
Ni anverso ni reverso	1	1	1	-1	-1	1
Ai limiti delle soglie II: con moto trasversale	1	0	1	-1	1	1
Nomadismo mostruoso	1	0	1	-1	1	1

In all the works the encoding is digital, since the inputs and outputs are processed by a computer while the systems are definitely always open, since they communicate with a specific material environment, which consists of metal, membrane or AC devices such as ventilators. The flow of data is in all works hybrid, thus audio and control data are fed back, except in the case of *Ni anverso ni reverso*, where the audio input is always first analyzed and control data affect how the loop reacts to the input signal. Once the systems are active, they do not require to be fed since the input signals suffice to trigger the feedback. The works involving CNNs present adaptive properties, since the classification of different and always new audio files entails the feature extraction for the re-synthesis of audio or control outputs. All the works involve a human-machine interaction with the exception of the fully automated setting in *Intermezzo 4*.

References

AmotIon (2021) – Silvia Rosani n.d. "EMAP/EMARE." Accessed July 20, 2024. https://emare.eu/works/amotion.

Britt, N. Cameron, Snyder, Jeff, McPherson, Andrew 2012. "The EMvibe: An Electromagnetically Actuated Vibraphone." *Proceedings of the International Conference on New Interfaces for Musical Expression*. https://doi.org/10.5281/zenodo.1178221.

Collins, Nicolas 2020. "Immmortal coils - Toiling in Electromagnetic Fields." Accessed July 15, 2024. https://www.nicolascollins.com/texts/immortalcoils.pdf.

Collins, Nicolas 2002. "All This and Brains Too: 30 Years of Howling Round." *Resonance* IX, 2: 6-7. https://knut.klingt.org/docs/resonance_9_2_feedback.pdf.

Di Scipio, Agostino. 2022. "Relational ontology of feedback. Situated sound-making in the Audible Ecosystemics project." *Echo. A journal of music, thought and technology* 3. https://doi.org/10.47041/TKUL7223.

Landy, Landy 2011. "Sound-based Music 4 All." In *Oxford Handbook of Computer Music*, edited by Roger .T. Dean, 518-535. Oxford: Oxford University Press.

Nakamura, Toshimaru 2002. "A Few of My Waking Times." *Resonance* IX, 2: 4-5. https://knut.klingt.org/docs/resonance_9_2_feedback.pdf.

Puckette, Miller 2007. *The Theory and Techniques of Electronic Music*. University of San Diego: California. Available at: https://msp.ucsd.edu/techniques/v0.03/book.pdf. [Accessed 07/03/2025].

Rogalsky, Matt. 2002. "David Tudor's Untitled: Feeding Forward." *Resonance* IX, 2: 8-10. https://knut.klingt.org/docs/resonance_9_2_feedback.pdf.

Rosani, Silvia. "Space mapping through sonic islands of intimacy." InSonic Immersive Future Symposium: ZKM. December 10 , 2017 You Tube video, 23:40. https://www.youtube.com/watch?v=bf9ZjoMDeOc.

Rosani, Silvia 2018a. "An individual note of intersectional projects," 2017-2018, Special issue: 64-68. https://doi.org/10.25370/array.v2017253. ICMA Array. Available at: www.computermusic.org/media/documents/array/Array-2018-special.pdf [Accessed 12/07/2024].

Rosani, Silvia. "Voice sound analysis and visual art to engage with new audiences in public spaces." Bringing New Music to New Audiences International Conference. De Montfort

University. September 27, 2018. You Tube video, 27:59. https://www.youtube.com/watch?v=0aR1Lt8PmgM.

Rosani, Silvia 2020. "From new audiences to surprised performers." *Riffs* 2(4): 58-70.

Sanfilippo, D., Valle, A. (2013). "Feedback Systems: An Analytical Framework." *Computer Music Journal* 37(2): 12-27. https://doi.org/10.1162/COMJ_a_00176.

Space Echo. n.d. "DAVID TUDOR – Microphone." Accessed July 18, 2024. https://www.spaceecho.it/david-tudor-microphone.

SubnetAIR. n.d. "SubnetAIR: Meet the artists: Silvia Rosani und Tom Jacques." Accessed July 16, 2024. https://subnet.at/subnetair/subnetair-meet-the-artists-silvia-rosani-und-tom-jacques.

Vertixe Sonora. n.d. "Programa de man – New Music New Paths." Accessed July 16, 2024. https://vertixesonora.gal/wp-content/uploads/2014/07/Programa-de-man-New-Music-New-Paths.pdf.

"Virtuelle Partner Residenz." You Tube video, 1:37. Posted by Goethe-Institut March 18, 2021. https://www.youtube.com/watch?v=fGXyl2xgNW0.

Video material

"Silvia Rosani : Intermezzo 4 – Sounding Sculptures." You Tube video, 24:47. Posted by "New Art and Music Ensemble Salzburg," March 21, 2022. https://www.youtube.com/watch?v=VRtZ1Go7k6Y.

"Intermezzo 4." You Tube video, 0:33. Posted by "SR," August 18, 2021. https://www.youtube.com/watch?v=ahpzZV7c8AQ.

"AmotIon (2021, Silvia Rosani- EMAP/EMARE)." You Tube video, 0:49. Posted by "SR," February 6, 2023. https://www.youtube.com/watch?v=p7vd9R4Oo5Y.

"Ai Limiti delle soglie II: con moto trasversale (2020). Silvia Rosani." You Tube video, 22:16. Posted by "TRIO vis-à-vis," June 19, 2022. https://www.youtube.com/watch?v=0v8VWlpJlLA.

Vertixe Sonora. n.d. "REPOSITORIO." Accessed March 7, 2025. https://vertixesonora.gal/compositor/rosani-silvia.

Audio material

Rosani, Silvia 2025. Audio e video material. Zenodo. https://doi.org/10.5281/zenodo.15024042

Coding

The coding involved in *AmotIon* and *Ni anverso ni reverso* is publicly available here: https://github.com/xxx-xxx9/Remote-emotions.

Il feedback *nel contesto della dialettica tra suono e musica nella musica elettronica contemporanea*

Eric Maestri
Sorbonne-Université, Institut de recherche en musicologie (UMR 8223), Francia
eric.maestri@sorbonne-universite.fr

Abstract. Considered in the context of contemporary electronic music, musical practices employing feedback radicalise interactivity and reference to the environment and the world. Feedback enables a here-and-now experience through a mediation of sound experience. It thus proposes a performative mimesis of space and of the possible interactions that might take place. In this way it radicalises contemporary aesthetics and synthesises the current issues in musical writing. Simon Emmerson's thought frames this historical period in which feedback plays a special role. Through the analysis of four cases according to Emmerson's 'language grid' method, this study will contextualise feedback practices in relation to the history of electronic music.

Keywords: feedback, listening, language.

1. Situazione attuale delle musiche elettroniche

Due fasi caratterizzano la storia della musica elettronica del secondo dopoguerra. La prima consiste nell'irruzione[1] del suono elettronico, lo sviluppo delle sue tecnologie e delle sue strumentazioni peculiari (Battier, 2024; Chadabe, 1997; Schaeffer, 1966). Il compositore Herbert Eimert descriveva in maniera chiara tale rivoluzione:

> Per la natura radicale del suo apparato tecnico, la musica elettronica è costretta a confrontarsi con fenomeni sonori sconosciuti ai musicisti di un tempo. Lo sconvolgimento, da parte dell'elettronica, del mondo sonoro così come lo abbiamo conosciuto porta a nuove possibilità musicali, le cui conseguenze ultime non possono ancora essere apprezzate. (Eimert, 1958, p. 1)[2]

[1] Pierre Schaeffer impiega il termine "irruzione" per indicare, ispirandosi in questo a Hermann Scherchen, l'impatto che la musica elettronica ha avuto sulla musica strumentale. Qui Schaeffer traduce in maniera impropria *Umwandlung* utilizzato da Scherchen, con "irruzione"; la traduzione esatta è invece "conversione", "trasformazione". Il senso del termine impiegato da Scherchen interpreta in maniera diversa la relazione tra suoni strumentali ed elettronici: non si tratta di una irruzione, bensì, il suono strumentale si trova trasformato in suono elettronico tramite un processo di mutazione timbrica (Schaeffer, 1966, p. 405)

[2] Traduzione dell'autore. Il testo, nella traduzione inglese dall'originale tedesco pubblicato nel 1955, è il seguente: "By the radical nature of its technical apparatus, electronic music is compelled to deal with sound phenomena unknown to musicians of earlier times. The disruption by the electronic means, of the sound world as we have know it leads to new musical possibilities, the ultimate consequences of which can hardly yet be appreciated".

Musica/Tecnologia, 19 (2025), ISSN online 1974-0050, ISSN print 1974-0042, pp. 27-41
DOI: 10.36253/music_tec-15438 – http://www.fupress.com/mt

La seconda fase vede l'emergenza del repertorio della musica elettronica tramite il dialogo con la musica strumentale e le sue istituzioni (Demers, 2010; Smith, 1992). Durante questo processo di istituzionalizzazione e di affermazione, si crea una mutazione teorica e tecnologica che ha un impatto fondamentale sulla tradizione della scrittura della musica occidentale (Dufourt, 2014[33]; Levinas, 2002). Hugues Dufourt ha compreso in maniera chiara le implicazioni teoriche e compositive della rivoluzione della musica elettronica:

> Lo sconvolgimento più radicale della musica del XX secolo è stato senza dubbio quello tecnologico. È dovuto all'avvento improvviso e diffuso di piatti e membrane, che stanno gradualmente sostituendo i vecchi strumenti a corda e a canne. Gli idiofoni e i membranofoni delle percussioni e le conchiglie degli altoparlanti formano un complesso strumentale coerente e di impatto globale. La nuova organologia porta con sé una poetica dell'energia sonora. La tradizione dello strumento meccanico ha represso le istanze dinamiche della sonorità. Ora sono liberate dalle percussioni e dall'elettricità: si tratta di un fenomeno di civiltà su scala inedita. (Dufourt, 1991b, p. 289)[4]

Il suono elettronico è il risultato delle tecnologie di registrazione e di sintesi, che, irrompendo nella storia della musica, hanno "aperto la musica ad ogni suono"[5]. Questo cambiamento deriva dall'imporsi delle nuove tecnologie nel contesto culturale della musica europea e dall'impiego dei suoni complessi, i quali, al fine di evitare un "inventario di gesti metaforici della loro propria impotenza" (Dufourt, 1991c, p. 162), hanno favorito l'emergenza di nuovi approcci compositivi coerenti. Per Dufourt, la musica "non si definisce più per la sua opposizione al sonoro in generale, ma per la sua capacità di integrare in una organizzazione teorica un gioco di determinazioni complementari e contradditorie" (Dufourt, 1991a, p. 297)[6]. Questi approcci aboliscono "in maniera irreversibile ogni riferimento ai concetti e alle modalità provenienti dall'azione meccanica" (Dufourt, 1991a, p. 297), al fine di trasformare la scrittura tramite

[3] Il libro di Hugues Dufourt, *Musique, pouvoir, écriture*, non è più edito da Christian Bourgois Éditeur; il volume è stato ripubblicato da Delatour nel 2014. Mi riferisco a quest'ultima edizione per riferirmi al testo nella sua integralità; le citazioni provenienti dai capitoli del libro fanno invece riferimento alla prima edizione del 1991, edita da Christian Bourgois.

[4] Traduzione dell'autore. Il testo originale è il seguente: "Le bouleversement le plus radical qu'ait connu la musique du XXe siècle est sans doute d'ordre technologique. Il est dû à l'avènement brusque et généralisé des plaques et des membranes qui supplantent progressivement l'ancienne lutherie de cordes et de tuyaux. Les idiophones et membranophones de la percussion, les coques des haut-parleurs constituent un complexe instrumental cohérent, d'impact planétaire. Ce qu'apporte la nouvelle organologie, c'est une poétique de l'énergie sonore. La tradition de l'instrument mécanique refoulait les instances dynamiques de la sonorité. Les voilà libérées par la percussion et l'électricité : il s'agit là d'un phénomène de civilisation d'une ampleur sans précédents."

[5] Mi riferisco qui al capitolo di *Electric Sound. The Past and Promise of Electronic Music* che Joël Chadabe dedica al primo sviluppo della musica elettronica: "The Great Opening Up of Music to All Sounds" (Chadabe, 1997, p. 21).

[6] Traduzione dell'autore. Il testo originale è il seguente: "Le musical ne se définit plus par son opposition au sonore en général, il se définit désormais par sa capacité d'intégrer dans une organisation théorique un jeu de détermination complémentaires et contradictoires."

i modelli provenienti dalla musica elettronica. Questa trasformazione ha avuto luogo tra gli anni settanta e novanta del secolo scorso: la musica spettrale (Grisey, 2008) e la musica concreta strumentale (Lachenmann, 1996) sono gli esempi più conosciuti di una tale mutazione.

Nella fase storica attuale, le innovazioni estetiche e teoriche della musica elettronica sono acquisite e la produzione di musica strumentale e vocale è in calo in tutta Europa[7]. Tuttavia, nonostante un notevole spostamento della produzione musicale in favore della musica elettronica, l'ibridazione si è realizzata in entrambi i sensi: la musica elettronica ha trasformato la scrittura strumentale e vocale, ma quest'ultima ha lasciato le sue tracce sulle pratiche elettroacustiche (Maestri, 2023). L'effetto di questa trasformazione si può osservare nel cambiamento di valore del suono elettronico. Se fino ad un paio di decenni or sono la musica elettronica caratterizzava una novità, oggi la musica elettronica è ovunque e fa parte della normalità. Il suono elettronico, diventato paradigma, ha rotto la frontiera tra suono e musica, sovrapponendo composizione sonora e musicale, rendendo caduca tale distinzione. L'effetto di questa evoluzione si vede nelle pratiche musicali più recenti. Queste riconfigurano la frontiera tra suono e musica di continuo. Ne è un esempio l'approccio di Agostino Di Scipio, il quale concepisce il suono come una "interfaccia" attivata in tempo reale da agenti umani e non umani coabitanti in un ambiente (Di Scipio, 2003). La sonorità prodotta dai dispositivi inventati da Di Scipio è impiegata come un foglio sottile, impalpabile e multidimensionale tramite il quale le interazioni hanno luogo lasciando e registrando i segni del loro passaggio. Questo suono-interfaccia riduce al minimo la differenza tra esperienza sonora ed opera musicale, che in questo modo tendono a coincidere. In questa poetica vediamo chiaramente l'assottigliarsi tra musica e suono.

Negli ultimi tre decenni, c'è un rinnovato interesse per il corpo del musicista, la produzione sonora meccanica, il qui ed ora della performance (Di Scipio, 2021, p. 561)[8] e la materialità dei corpi sonori elettrificati (McLaughlin, 2022). Lo prova il grande successo delle nuove interfacce per l'espressione musicale, che trova nella comunità della conferenza internazionale *New Interfaces for Musical Expression* (NIME) il suo punto di riferimento, delle tematiche legate al gesto musicale (Schneider, 2013), della nozione di *Liveness* proposta da Philip Auslander (Auslander, 2008), dell'imporsi del modello della cognizione incarnata (Leman, 2007) e dell'evoluzione recente delle musiche miste, che si sono imposte come il modello per i concerti di musica contemporanea. In parallelo, gli interpreti si investono in maniera sempre più consapevole nell'invenzione di nuove tecniche e nella collaborazione con i compositori, creando un connubio di ricerca e pratica artistica che fa del lavoro sul suono il suo punto di

[7] Quest'affermazione si fonda sull'osservazione diretta del mondo musicale contemporaneo e in particolare la scena di Parigi. Le produzioni di musica puramente strumentale per gruppi, orchestre e opere è diventata più rara. In parallelo la produzione di musica mista ed elettronica o multimediale occupa lo spazio delle scene precedentemente dedicate alla musica vocale e strumentale contemporanee. Basta osservare le produzioni dei festival più importanti o anche la nomina recente alla Biennale di Venezia di una musicista proveniente dal mondo delle musiche elettroniche indipendenti.

[8] Agostino Di Scipio parla di "superamento della riproducibilità tecnica" (Di Scipio, 2021, p. 561).

forza. Tutti questi aspetti mostrano una vera e propria riattivazione della questione dell'essere umano nella sua relazione con il dispositivo elettroacustico. Il concetto della produzione sonora meccanica, che Dufourt presentava come obsoleto e ormai irreversibilmente consegnato al passato, ha ripreso forza e significato.

Le pratiche musicali che utilizzano il fenomeno del *feedback* si inseriscono in questo contesto di ritrovato interesse per l'imprevisto dell'interazione e l'incontro con l'altro, che mette in prospettiva critica i decenni di musica elettronica passati all'insegna della *schizophonia*[9] (Schafer, 1977, p. 90).

2. Analisi delle condizioni di questa situazione

Questa situazione storica si è creata grazie alla convergenza di un'evoluzione estetica e compositiva — che ha ibridato le piste tra strumento ed elettronica, scrittura ed improvvisazione (Adkins et al., 2016) reinvestendo di un senso nuovo la questione del corpo del musicista e della sua presenza in scena — e di un processo di miniaturizzazione della tecnologia con il conseguente aumento della velocità di calcolo dei macchinari unito alla trasformazione dello statuto della scrittura musicale. Questi due aspetti hanno modificato il rapporto tra scrittura ed opera nonché quello tra musica ed ambiente.

2.1. Mondo e musica

L'interazione si fonda sulla possibilità di avere un ritorno sonoro immediato da parte del dispositivo, sia esso in studio, in concerto o in qualsiasi altro luogo. L'andirivieni tra spazio, natura e scrittura caratterizza una buona parte della storia della musica elettronica. Fin dagli albori, questa pratica ha dato una importanza fondamentale al suono dell'ambiente, attribuendogli un ruolo musicale. Alla fine del terzo movimento del poema sinfonico *I pini del Gianicolo* (1924) di Ottorino Respighi, il clarinetto, l'arpa e gli archi sono immersi in un canto d'usignolo registrato. Il musicista utilizza questi suoni come materiale per la composizione. Tuttavia, come spesso è osservato, non si tratta di una semplice sovrapposizione dell'orchestra con un suono "trovato" (Chadabe, 1997, p. 23). Se si ascolta l'estratto e si osserva la partitura con attenzione, le note cantate dagli usignoli strutturano la parte strumentale, che le segue come un calco. La relazione tra l'elettronica e l'orchestra si fonda su degli elementi sonori comuni, in particolare le altezze intorno alla nota *Si*, che le parti strumentali fanno loro. Si tratta di un *feedback* in tempo differito, nel quale la registrazione non solo ispira la composizione strumentale, ma la struttura. *Déserts* (1954) di Edgard Varèse sviluppa dei legami timbrici e di altezze tra le parti elettroniche e quelle strumentali nonostante non siano eseguite in contemporanea ma in maniera successiva (Maestri,

[9] Impiego questa nozione data da Murray Schafer che mi sembra giusta e coerente per spiegare la questione della mancanza della sorgente sonora nel suono registrato rispetto al suono del musicista in concerto.

2023, p. 29-32)[10]. Nel periodo di prima maturità della musica elettronica, Karlheinz Stockhausen associava eventi sonori conosciuti e sconosciuti. In *Kontakte*, per suoni elettronici, percussioni e pianoforte (1958-60), questi hanno una funzione: i primi orientano la percezione, come dei "semafori", dice Stockhausen; gli altri, elettronici, rappresentano un "Nuovo Mondo"[11]. I suoni strumentali registrati e gli strumenti in scena danno un senso ai suoni elettronici ancorandoli ad un contesto conosciuto. Un tale processo di trasformazione accompagna tutta la musica elettronica. Nella sua storia, progressivamente, i suoni complessi di origine ambientale occupano un ruolo sempre maggiore, strutturano la musica e servono per ripensarne la scrittura. Da *Hétérozygote* (1964) di Luc Ferrari fino a lavori più vicini a noi, come *Weather Report* (2003) di Chris Watson, *Breaking News* (2022) di Hildegard Westerkamp, *London – Three Sound Pieces* (1994) di Katharine Norman o *Le festin* (2021) di Julie Faubert, musica e suono ambientale caratterizzano un processo di *feedback* simbolico e reale.

Simon Emmerson ritiene che la musica elettronica del secondo novecento sviluppi in maniera peculiare la nozione di mimesi (Emmerson, 1986). Se nelle musiche delle diverse epoche i suoni naturali sono imitati tramite strumenti e figure musicali, nelle musiche elettroniche questi suoni sono impiegati in quanto tali, così come i processi formali di strutturazione traggono ispirazione dall'imitazione della natura — per es. i processi di accumulazione, frammentazione o riduzione (Sciarrino, 1998) — dalla tecnologia e dalle teorie scientifiche contemporanee (Grabòcz, 2013). Per Emmerson, la musica elettronica sviluppa due tipi di mimesi: la mimesi timbrica e la mimesi sintattica (Emmerson, 1986, p. 18). La prima è definita dall'imitazione del timbro del suono naturale, mentre la seconda imita le relazioni che si pensa sussistano nei suoni naturali o ambientali. Queste due mimesi coabitano e si confondono. In questo senso, il discorso musicale può essere pensato come la relazione tra un approccio aurale e mimetico, così come tra una sintassi astratta (*abstract*) ed una sintassi estratta (*abstracted*) (Emmerson, 1986, p. 23); la prima si baserebbe sull'utilizzo delle note o di oggetti sonori combinati secondo logiche non provenienti direttamente dalla materia sonora (è il caso tipico del serialismo, sottolinea Emmerson), e la seconda su una sintassi che deriverebbe direttamente dall'esperienza sonora, estratta tramite l'ascolto, la registrazione e l'analisi — come è il caso di *Le son d'une voix* di François-Bernard Mâche, composto nel 1963, di *Désintégration* di Tristan Murail (1982), di certi brani di Xenakis che ricordano esperienze vissute, come *Diamorphoses* (1958) o evocano processi naturali complessi, come *Metastaseis* (1954) — e da processi descrivibili tramite modelli scientifici, come per esempio la musica stocastica (Di Scipio, 1998).

[10] Ho analizzato questi passaggi in dettaglio in queste pagine del libro *Contacts. Essai sur la musique mixte*.

[11] Stockhausen, Karlheinz, libretto del CD *Zyklus, Refrain, Kontakte*, Stockhausen Verlag, CDO6: "In *Kontakte*, gli eventi sonori noti sono collegati con quelli sconosciuti; gli eventi sonori per i quali abbiamo un nome con quelli che non ce l'hanno. [...] I suoni familiari guidano la percezione; funzionano come semafori nello spazio illimitato del Nuovo Mondo Sonoro dei suoni elettronici." [Traduzione dell'autore] .

2.1.1. La "griglia del linguaggio"

Partendo da un tale assunto, Emmerson propone una "griglia del linguaggio". Questa griglia riassume i tipi di musica elettronica su nastro proponendo un insieme all'interno del quale l'analista può posizionarsi con le sfumature che ritiene più appropriate. Si tratta di un quadro teorico che ha il vantaggio di riassumere le tipologie sonore e sintattiche della musica elettronica (Emmerson, 1986, p. 24). Questa griglia interpreta la relazione tra mondo e musica mostrando come il linguaggio musicale sia contemporaneamente fondato sull'autoriferimento e sul riferimento a modelli extra-musicali (Tab. 1)[12]. Per questa ragione ritengo che sia particolarmente pertinente per analizzare le pratiche musicali che usano il fenomeno del *feedback*.

Questa riflessione, che si ricollega a quella svolta parallelamente da Denis Smalley (Smalley, 1996), il quale analizza il legame tra la morfologia sonora del gesto musicale e la sua astrazione dovuta ai trattamenti elettroacustici, è a lungo sviluppata da Emmerson. In *Living Electronic Music* (Emmerson, 2007) Emmerson stabilisce un legame diretto tra musica elettronica, natura e vita. Per il musicologo bisogna pensare la musica nella sua relazione con la presenza vivente (*living presence*) (Emmerson, 2007, p. 1). Il fatto che il legame meccanico e causale tra suono e sorgente sia interrotto dalla musica elettronica fondata sulla registrazione, esalta, invece di cancellarla o ridurla, la ricerca di una presenza. La musica elettronica gioca su questo meccanismo, come spiega Jacques Launay (Launay, 2015), il quale ha potuto analizzare l'agentività implicita e inferita nell'ascolto della musica acusmatica (Launay, 2015, p. 33)[13]. Seguendo l'antropologo Tim Ingold (Ingold & Palsson, 2013), Emmerson concepisce la differenza tra prodotto culturale e prodotto naturale in maniera olistica. In questo modo si avvicina alla teoria ecologica di Murray Schafer, per il quale la musica è un riflesso della relazione con l'ambiente. Emmerson ritiene allora che la pratica della musica elettronica dia la possibilità di un ravvicinamento e di un rinnovato contatto con la realtà: "[…] much of contemporary practice reveals a process of 'reanimation' – a reengagement by musicians in the 'flux of the world's processes'" (Emmerson, 2007, p. 35). In maniera controintuitiva, la musica elettronica svela degli aspetti nuovi della realtà, grazie alla registrazione e alle tecniche di microfonazione, avvicinando il musicista e l'ascoltatore alla realtà piuttosto che aumentandone il distacco. In questo senso la musica elettronica trasforma la relazione con l'ambiente, che, restituito, assume un senso nuovo. Le pratiche del feedback insistono su questo tipo di trasformazione aumentandone l'interattività tramite un'esperienza radicale della mediazione sonora.

[12] Nell'analisi che applica una tale griglia proposta al termine del paragrafo 3, indico la tipologia di sintassi e di discorso tramite uno schema sintetico associato al brano sul lato destro del testo, al fine di rappresentare in maniera chiara il tipo di discorso realizzato.

[13] "[...] when asked to describe a non-musical sound without being given other instruction the source of sound is prioritized rather than acoustic features such as loudness or pitch. While the source of non-musical sound appears to be the most relevant property to listeners, there is also a tendency to describe actions that might cause the sound more than the material that is being acted upon (e.g. the sound of paper being torn is more likely to be described as "tearing" than described as "paper"). This evidence suggests that we are in some way primed to identify *implied* agency (Ten Hoopen, 1994) even when it is not clearly detectable."

Tabella 1. Griglia del linguaggio proposta da Simon Emmerson.

	Discorso aurale predominante	Combinazione di discorso aurale e mimetico	Discorso mimetico predominante
Sintassi astratta	1	4	7
Combinazione di sintassi astratta ed estratta	2	5	8
Sintassi estratta	3	6	9

2.2. Suono e scrittura

In questo processo di rianimazione, fondato sulla riduzione all'osso della differenza tra esperienza sonora diretta e mediata dalla tecnologia (Born, 2005), lo sviluppo delle strumentazioni musicali ha giocato un ruolo fondamentale, diventando sempre più maneggevoli ed ergonomiche per adattarsi al corpo del musicista. I programmi che permettono di comporre l'interazione e di trasformare il suono in maniera immediata liberano la produzione musicale professionale dalla notazione. Le macchine che scrivono al posto del musicista fanno del suono, del suo trattamento e percezione, il ruolo che era del segno scritto. Il processo di mutazione dell'esperienza sonora, che riduce la differenza tra l'azione, l'ascolto e la loro mediazione tecnologica, va di pari passo con il cambiamento di statuto della scrittura musicale.

La partitura è sempre stata uno strumento per prescrivere una serie di azioni che permettono di dare luogo ad un'opera musicale, presentata ad un pubblico rispettandone i criteri indicati (Savouret, 2002). Dagli albori della scrittura musicale (Duchez, 1989) fino ai nostri giorni (Veitl, 2006), la notazione dà la possibilità di organizzare i gesti degli strumentisti per produrre dei suoni tramite gli strumenti. La scrittura sintetizzava in maniera efficace la percezione degli elementi sonori portatori di forma e la possibilità di combinarli in maniera astratta (McAdams, 1989). Con l'avvento dell'elettricità prima e dell'informatica poi, la scrittura musicale non solo ha permesso di prescrivere gesti, movimenti, azioni e coordinare musicisti, ma anche di generare i suoni tramite dei macchinari indipendentemente dallo sforzo meccanico umano. In quest'evoluzione tecnologica, il paradigma iniziale non è cambiato; il digitale ha radicalizzato la scrittura nella sua dimensione causale, trasformando il segno nello strumento che produce suono, senza bisogno di interfaccia strumentale fisica (Veitl, 2007). Questa causalità si fonda su dei linguaggi il cui obiettivo è quello di controllare il flusso elettrico e non di prescrivere movimenti e gesti strumentali. La musica elettronica è costruita sul controllo e la limitazione dell'energia. Il segno impiegato per fare musica è diventato sempre più sottile, fino a coincidere con l'hardware: dallo strumento e la partitura, si è passati a dei codici che sono invisibili e illeggibili a occhio nudo (se non tramite rappresentazioni digitali di alto livello). La sparizione della generazione meccanica del suono coincide con questa miniaturizzazione e sparizione della scrittura operata tramite l'informatica.

Le musiche che impiegano il *feedback* radicalizzano questa situazione. L'utilizzo del *feedback* crea un ibrido tra scrittura e dispositivo, fino a farli coincidere, permettendo al suono di indurre delle interazioni al fine di creare una natura artificiale. Si tratta di una scrittura che causa degli effetti in quanto realizza una traccia incorporata ad un dispositivo digitale che reagisce alle informazioni provenienti dal contesto. Questa scrittura miniaturizzata dà una nuova linfa all'esperienza sonora e alla sua percezione. Il segno, ritraendosi nel dispositivo, lascia risuonare lo spazio e le interazioni che quest'ultimo permette. L'opera musicale diventa un insieme di connessioni che danno luogo a prodotti diversi in funzione dell'input ricevuto. La scrittura organizza, in maniera cibernetica, la relazione tra gli attori che fanno parte del processo, del quale il suono è una possibile interfaccia. Secondo questa prospettiva, tramite il *feedback*, le partiture non sono più dei diagrammi da realizzare, ma l'occasione per una performance, un incontro, un ascolto e un dialogo (Small, 1998, p. 9)[14]. In questo modo, la configurazione della scrittura si è ribaltata. Il suono riprodotto dalle macchine può essere concepito come un'immagine (Bayle, 1993), o, per Di Scipio, come una interfaccia, cioè come uno strumento. Proprio là dove la relazione causale tra suono e segno è diventata più forte, cioè l'informatica musicale, è emersa una musica che cancella il segno stesso e così il dispositivo, proponendo un ritorno al suono in quanto oggetto di una interazione umana. Questa interazione emerge da un confronto con sistemi impalpabili ed estremamente complessi, che non possono essere percepiti in maniera immediata ma compresi nella loro sostanziale autonomia (Sanfilippo, 2023).

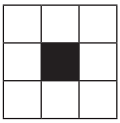
Il *feedback* sintetizza la problematica dell'interattività sorpassando la questione del dispositivo. Comporre significa costruire con l'ambiente. In questo modo, l'ambiente è restituito a sé stesso ed è donato all'ascoltatore-musicista. Se molta musica degli ultimi cinquant'anni può essere definita come la riattivazione del legame tra suono, musica ed ambiente, il *feedback* sviluppa in maniera unica una tale tendenza. Tramite questa pratica, la traccia appena lasciata è immediatamente restituita; ciò che resta del passaggio di qualcosa o di qualcuno, il passato, è reiniettato nel presente e a sua volta il passato appena prodotto agisce sull'esperienza attuale (Sanfilippo, 2023, p. 382). Per attivare questa interfaccia serve un movimento, una vita indipendente dal dispositivo: una presenza. I dispositivi sui quali queste pratiche si fondano hanno allora la funzione di una partitura invisibile: sono registrati e codificati su dei supporti informatici, ma la loro vocazione è di sparire lasciando emergere l'ambiente che li circonda. La mimesi che ha luogo in questo caso è istantanea e interattiva, tendendo a cancellare l'imitazione stessa fino a ridurla all'ambiente abitato.

[14] Parafraso qui l'idea di Christopher Small, che mi sembra molto pertinente per sintetizzare questa posizione: "To music is to take part, in any capacity, in a musical performance, whether by performing, by listening, by rehearsing or practising, by providing material for performance (what is called composing), or by dancing".

3. Il feedback *e il discorso*

Al fine di concepire le pratiche legate al *feedback* nel contesto dei linguaggi musicali contemporanei, cercherò di metterle in prospettiva ragionando su un'analisi che possa posizionarle nella griglia del linguaggio proposta da Emmerson. Il *feedback* è un procedimento elettroacustico che mette musicalmente in scena la relazione con l'ambiente inteso come un sistema complesso e indeterminato (Belgrad, 2014). I suoni prodotti tramite questa tecnica sono ampiamente conosciuti nell'esperienza elettronica. Quasi tutti possono essere riassunti in suoni complessi che possono essere classificati tra i suoni eccentrici e ridondanti della tipologia di Schaeffer (Schaeffer, 1966). Questa tipologia sonora ha caratterizzato una buona parte della produzione degli anni sessanta e settanta, dallo spettralismo al minimalismo fino alla computer music. Il *feedback* appartiene a questa tradizione ed oggi è spesso impiegato con finalità legate all'orchestrazione nei dispositivi misti o in sezioni di brani che valorizzano il gesto degli interpreti e la loro presenza in scena creando un'interazione immediata con lo strumento e lo spazio circostante, per esempio nella musica di Maurilio Cacciatore (per es. *Lost in Feedback*, 2014, e *Anche questo è silenzio*, 2020) (Cacciatore, 2018) e di Stefan Prins (per es. *inhabit_inhibit*, 2022).

Ora, il suono prodotto tramite le tecniche di *feedback* non aggiunge nulla di nuovo alla storia della musica elettronica, ma è il procedimento di produzione e il suo legame con il qui ed ora della performance che ne caratterizza la novità. Proprio il suo aspetto non sonoro, procedurale e compositivo è interessante. La musica prodotta tramite il *feedback* estrae degli elementi da un ambiente per reiniettarlo, producendo suono e interazioni. L'ambiente diventa parte di un processo che oltrepassa la dimensione puramente musicale lasciando le sue impronte timbriche. In questo modo sono composte le condizioni di possibilità dell'apparizione della musica stessa, come scrive correttamente François Bonnet definendo la creazione musicale (Bonnet, 2020, p. 31). Nel caso delle pratiche nelle quali il *feedback* gioca un ruolo importante, il discorso aurale e mimetico, cosi come la sintassi astratta e estratta, si sovrappongono.



Al fine di illustrare quest'interpretazione propongo una lettura di quattro brani che utilizzano il *feedback*. Mi concentro su due performances, una di Dario Sanfilippo e l'altra di Alice Eldridge e Chris Kiefer e due composizioni, *Lost in feedback* di Maurilio Cacciatore e *inhabit_inhibit* di Stefan Prins[15].

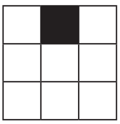
Nella performance live eseguita al Klub Moozak di Vienna nel 2019[16], Dario Sanfilippo impiega il suo ambiente performativo *Single-Fader Versatility*. Inizialmente,

[15] Dei link internet sono proposti al fine di preparare questa analisi. Purtroppo delle registrazioni commerciali non sono a disposizione, come spesso per le pratiche musicali più recenti. Sono allora obbligato ad indirizzare il lettore verso internet. Suggerisco di ascoltare le performance e i brani prima di proseguire nella lettura.

[16] Dario Sanfilippo @Klub Moozak, Vienna: https://www.youtube.com/watch?v=hIrqmDif5uQ. Link consultato il 3 marzo 2025.

un suono grave intorno alla nota *Sib* e delle note tenute realizzate tramite dei filtri risonanti creano un contesto di ascolto e di attesa, fino a cinque minuti circa. In seguito, degli elementi oscillanti appaiono e il rumore si fa più importante. A sei minuti un suono di vento, o potrebbe essere quello di un treno registrato, si inserisce nel tessuto sonoro. Nel frattempo il *Sib* continua a risuonare, accompagnato da bande sonore rumorose più dense. A sette minuti il suono diventa più forte. La nota *Re* appare oscillando con delle bande di rumore dense. A dieci minuti la musica ritorna alla situazione iniziale, caratterizzata da un bordone grave intorno alla nota *Sib*. Da undici minuti in poi una sezione estremamente densa, ricca di suoni complessi e rumori si fa sempre più forte. Questa lunga sezione si stempera a ventidue minuti restando su un rumore browniano prolungato come dei suoni di vento. A ventisei minuti ritorna la situazione iniziale, con una persistenza della nota *Sib*, fino a spegnersi progressivamente. La traiettoria formale di questo brano è caratterizzata da un cambiamento lento di stato della materia sonora, che dall'ambiente iniziale, nel quale la stabilità armonica e le bande risonanti prolungate sono stabili, arriva ad una massa sonora gigantesca che travolge l'uditore per fare ritorno allo stato iniziale. Questo tipo di forma è ciclica, caratterizzata da un processo di densificazione e di rarefazione. Nel momento di massima densità il suono satura lo spazio e lo assorbe in un vortice. Un tale procedimento porta ad una sorta di sordità elettronica – l'effetto è come quello di un camion che passa a grande velocità. Tutto sparisce, resta solo l'oggetto. La profondità sonora e spaziale è cancellata. Il gioco dinamico, che contrasta l'ascolto profondo e l'esperienza grezza del suono determina l'esperienza sonora che le tecniche di *feedback* tendono a proporre.

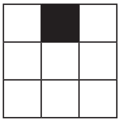
In questa performance il suono estratto diventa astratto. L'espressività di questa performance trascende la dimensione tecnica in una forma di esperienza di immersione violenta. La performance di Sanfilippo è intermedia nella classificazione di Emmerson. Se la sintassi è chiaramente estratta dalla captazione ambientale e dalle risorse digitali degli algoritmi impiegati, la presenza delle altezze, il controllo dei battimenti e delle risultanti sonore mostrano nel contempo la presenza di una scrittura di tipo astratto. Il discorso è aurale, fondato su un processo musicale chiaro e mimetico, ispirato da un processo naturale.



Nelle performance di Alice Eldridge e Chris Kiefer l'effetto risultante è in qualche modo simile[17]. Il violoncello è *feedback* ed autorisonante (*self-resonating feedback cello*), accompagnato da un sintetizzatore analogico controllato digitalmente tramite algoritmi di ascolto e di apprendimento profondo adattativi. Il suono è inizialmente tenuto; lo strumento suona su una fondamentale di *Sib*, come nel caso di Sanfilippo, cercando contemporaneamente gli armonici e i subarmonici. Il sintetizzatore analogico segue un percorso simile, partendo dal *Sib* grave. Al violoncello si aggiunge un'ombra sintetica in movimento, prima in maniera continua, poi con una improvvisazione sulle stesse note. La ricerca è dentro il suono; il risultato è delicato, al limite di una

[17] Alice Eldridge e Chris Kiefer (aka Feedback Cell), *FeedbackFeedforward*: https://www.youtube.com/watch?v=c03_84_P7PQ. Link consultato il 3 marzo 2025.

possibilità di dialogo tra la complessità dello strumento e del dispositivo elettronico. Il *feedback* è ricercato, controllato. Il fenomeno emerge da una ricerca sensibile sulle corde e tra i musicisti. Il mantenimento di questo stato di tensione, alla ricerca del punto di contatto con questo fenomeno elettroacustico come una vibrazione, una sensazione prossima all'allucinazione, determina il contenuto di questa musica. Il suono del violoncello è accompagnato da un alone persistente, che cambia secondo la modalità di esecuzione. Lo strumento è trasformato e l'esecuzione permette l'emergenza del fenomeno elettroacustico. Il brano ha una predominanza di sintassi astratta, in quanto il suono proviene dal violoncello e dal sintetizzatore intorno a delle altezze ben definite. Tuttavia, una estrazione è ben presente perché il suono risultante replica il modello morfologico dello strumento combinando così discorso aurale e mimetico.



Nella musica di Maurilio Cacciatore il *feedback* ha un ruolo estremamente importante per generare delle sonorità dense, che ricordano quelle create da Dario Sanfilippo. In *Lost in Feedback*[18] il compositore cerca delle sonorità continue, ricche ed espressive. Il *feedback* permette di creare tali risonanze partendo da modalità esecutive sperimentali e tecniche estese. Il brano è articolato e complesso. Per questa ragione analizzo in particolare i primi dodici minuti, su una durata complessiva di trenta. L'inizio del brano è caratterizzato da un suono continuo alimentato dalla *Spring Drum* suonata dal musicista. I suoni gravi si succedono. A tre minuti il percussionista suona un *ride* e una placca metallica. Il suono grave persiste, sin dall'inizio. A quattro minuti e trenta secondi, il suono continuo si arresta e lascia emergere lo sfregamento sulla lastra metallica. A cinque minuti, delle percussioni metalliche, suonate con un rasoio elettrico sono accompagnate da delle risonanze derivanti dal *Larsen* del sistema di *feedback* utilizzato. In seguito, al minuto sette, delle campanelle risuonano con l'elettronica. Il suono continuo nel registro grave prosegue evolvendo in suono continuo, granulare e metallico al minuto otto. A nove minuti il vibrafono predomina suonando la nota *Sib* arrivando al climax al decimo minuto. La sezione seguente è caratterizzata da suoni frammentati e inframmezzati da silenzio; in seguito, il rumore degli archetti sul polistirolo introduce una nuova sezione, fondata su dei suoni continui e delle note tenute intorno al *Si* e al *Sib*. *Lost in Feedback* presenta un utilizzo del *feedback* legato agli interpreti, amplificando in maniera espressiva il potenziale strumentale. La musica alterna sezioni dense sul piano timbrico e spettrale a parti più rarefatte. Le altezze strutturano questo brano. La sintassi del brano è astratta e il discorso riunisce un approccio aurale e mimetico.

[18] Maurilio Cacciatore, *Lost in Feedback*, per ensemble e elettronica: https://www.youtube.com/watch?v=QP2m2XcNDOg&t=919s. Link consultato il 3 marzo 2025.

In *inhabit_inhibit* di Stefan Prins[19] il *feedback* è impiegato durante tutto il brano. Al termine della prima sezione, al minuto dodici, la relazione tra gesto e suono elettronico si fa più chiara. Inizialmente, il brano è caratterizzato da tecniche estese suonate da degli strumenti, che producono suoni complessi nel registro acuto. La tensione sonora è fortissima. A tre minuti una fascia sonora elettronica emerge, accompagnando gli strumenti. Delle note in crescendo suonate dagli ottoni caratterizzano l'evoluzione del brano fino al minuto cinque. A sei minuti la musica è definita da un tessuto più tenue di note tenute; degli interventi puntuali caratterizzano la sezione seguente, fino al minuto otto. In questa parte la relazione tra strumento ed effetto *Larsen* si fa più evidente: il clarinetto esegue dei rumori di chiave che attivano il *feedback*. Delle note ripetute e tenute definiscono il materiale della sezione seguente, fino al minuto quattordici. Il clarinetto, dal minuto dodici e trenta secondi, gioca con l'effetto del *feedback* associato al corpo del suo strumento. In questa sezione, che conclude la prima parte del brano, gli strumentisti a fiato, muovendo il loro strumento, mettono in risonanza il sistema di *feedback*. Il movimento ed il suono elettronico sono direttamente connessi. La microfonazione degli strumenti permette una tale interazione. In questo caso la mimesi riunisce una sintassi astratta, proveniente dalle figure strumentali e dal gesto dell'interprete, ed estratta, dalla forma acustica dello strumento. Il discorso combina l'aurale ed il mimetico come avviene anche nel brano di Cacciatore *Anche questo è silenzio*. In questo brano il gesto del musicista attiva il suono del *feedback* in maniera molto chiara, segnalando all'ascoltatore la presenza del dispositivo tramite l'interazione diretta.

Conclusioni

Nella performance di Dario Sanfilippo, l'algoritmo interattivo impiegato genera delle fasce sonore dense, armonicamente ricche ed espressive. Organizzate all'interno di un processo lineare di espansione e di contrazione, il suono è caratterizzato da fasce sonore continue, che occupano progressivamente lo spazio acustico. In questo caso il brano combina una sintassi astratta ed estratta, cosi come un discorso aurale e mimetico contemporaneamente. L'improvvisazione di *Feedback Cell* presenta una più grande varietà di figure musicali. Se nella prima parte i suoni tenuti permettono di esaltare le risonanze dell'elettronica anche grazie all'accompagnamento del sintetizzatore, progressivamente delle figure più frammentate caratterizzano il brano. In questo caso la sintassi è astratta, fondata sulla nota, ma il discorso è tra l'aurale ed il mimetico strumentale, proprio perché lo strumento dà forma al suono elettronico e ne è modello. Nel brano *Lost in Feedback*, di Maurilio Cacciatore, l'elettronica emerge direttamente dagli strumenti creando sonorità dense ed estremamente varie. La logica astratta prevale così come il discorso aurale. *Inhabit_inhibit* di Stefan Prins sviluppa una sintassi ed un discorso estratto ed astratto, aurale e mimetico, fondando la musica

[19] Stefan Prins, *inhabit_inhibit*, per ensemble e elettronica: https://www.youtube.com/watch?v=PkVCB_kq1Lc. Link consultato il 3 marzo 2025.

sulle proprietà acustiche degli strumenti. In questo senso il linguaggio proposto rappresenta una via intermedia tra quelli presentati.

L'utilizzo del *feedback* negli esempi presi in considerazione, ed in particolare nelle musiche per ensemble ed elettronica, si concentra sullo strumento come attuatore del processo di risonanza elettroacustica. Questo aspetto pone degli interrogativi alla griglia del linguaggio di Emmerson, perché lo strumento in questo caso presta il suo corpo al dispositivo lasciando tracce timbriche e gestuali nelle traiettorie sonore dell'elettronica. Nel modello di Emmerson, benché non sia chiaro nei suoi presupposti, lo strumento si fa portatore di un approccio astratto, fondato sulle note. Si tratta di un segno del mondo musicale che non fa riferimento ad una dimensione non musicale sulla quale il mimetismo della composizione si costruisce. Tuttavia, se si concepisce lo sfondo sul quale questa astrazione ha luogo, lo strumento non è un corpo sonoro senza contesto. Al contrario, fa riferimento a tutta la musica e quindi alla sua storia. La nozione di paesaggio di Wishart è in questo senso di aiuto: il "paesaggio" nella musica strumentale è lo strumento stesso e la musica prodotta in quel contesto culturale di cui si fa segno (Wishart, 1986, p. 44). L'interrogativo allora concerne la validità della distinzione tra sintassi astratta ed estratta. Malgrado questa criticità, che renderebbe più sottile la distinzione tra le sintassi astratte e estratte così come quella del discorso mimetico e aurale, un tale approccio permette di esplicitare la relazione tra musica e mondo in maniera sintetica. Lo abbiamo potuto così applicare.

Le molteplici pratiche del *feedback* radicalizzano la mutazione dell'estetica musicale recente, riducendo all'osso la distanza tra dispositivo, ascoltatore, metodi di scrittura e di interazione. Nella dialettica tra suono e musica, si tratta di un sostanziale stravolgimento delle regole del gioco, perché pongono l'ambiente e l'interazione al centro ponendo la scrittura ai suoi margini. In quanto interfaccia impalpabile che produce delle tracce sonore, nello spazio e nel dispositivo, il suono lascia agli ascoltatori la scoperta di un ambiente. Proprio questa natura aperta fa del *feedback* una sorta di macchina per scrivere sonora ed effimera. Se il *feedback* restituisce l'ambiente tramite l'esperienza mediata dal suono, non lo può che fare ritraendosi in quanto musica e in quanto scrittura. Se il testo è il suono, allora tale testo può essere scritto e inventato in continuo tramite il movimento, la presenza e la vita. In questo modo lascia all'ascoltatore la scelta.

Bibliografia

Adkins, M., Scott, R., & Tremblay, P. A. (2016). Post-Acousmatic Practice : Re-evaluating Schaeffer's heritage. *Organised Sound*, *21*(2), 106-116. https://doi.org/10.1017/S1355771816000030.

Auslander, P. (2008). *Liveness. Performance in a mediatized culture*. Routledge.

Battier, M. (2024). *Esthétique du son artificiel. Genèse des musiques électroniques*. Vrin.

Bayle, F. (1993). L'image de son, ou « i-son » : Métaphore/métaforme. In *Musique acousmatique, propositions... ...Positions* (pp. 93-101). INA-GRM, Editions Buchet/Chastel.

Belgrad, D. (2014). Improvisation, Democracy, and Feedback. In G. E. Lewis & B. Piekut (Eds.), *The Oxford Handbook of Critical Improvisation Studies* (Vol. 1, pp. 289-306). Oxford University Press.

Bonnet, F. J. (2020). *La musique à venir*. Shelter Press.

Born, G. (2005). On Musical Mediation: Ontology, Technology and Creativity. *Twentieth Century Music*, *2*(1), 7-36. https://doi.org/10.1017/S147857220500023X.

Cacciatore, M. (2018). Lost in feedback (2014): Soluzioni personali di musica mista tra il teatro musicale e la performance visuale. *Musica/Tecnologia*, *11/12*, 29-44. https://doi.org/10.13128/Music_Tec-23798.

Carpentier, G. (2008). *Approche computationnelle de l'orchestration musicale Optimisation multicritère sous contraintes de combinaisons instrumentales dans de grandes banques de sons*. Pierre et Marie Curie, Paris VI – IRCAM.

Chadabe, J. (1997). *Electric Sound. The Past and Promise of Electronic Music*. Prentice Hall.

Demers, J. (2010). *Listening through the Noise: The Aesthetics of Experimental Electronic Music*. Oxford University Press.

Di Scipio, A. (1998). Compositional Models in Xenakis's Electroacoustic Music. *Perspectives of New Music*, *36*(2), 201-243. https://doi.org/10.2307/833529.

Di Scipio, A. (2003). 'Sound is the interface': From interactive to ecosystemic signal processing. *Organised Sound*, *8*(3), 269-277. https://doi.org/10.1017/S1355771803000244.

Di Scipio, A. (2021). *Circuiti del tempo. Un percorso storico-critico nella creatività musicale elettroacustica e informatica*. Libreria Musicale Italiana.

Duchez, M.-E. (1989). An historical and epistemological approach to the musical notion of "form-bearing" element. *Contemporary Music Review*, *4*(1), 199-212. https://doi.org/10.1080/07494468900640291.

Dufourt, H. (1991a). La dialectique du son usiné. In *Musique, pouvoir, écriture* (pp. 295-300). Christian Bourgois Éditeur.

Dufourt, H. (1991b). Musique spectrale. In *Musique, pouvoir, écriture* (pp. 289-294). Christian Bourgois Éditeur.

Dufourt, H. (1991c). L'ordre du sensible. In *Musique, pouvoir, écriture* (pp. 161-175). Christian Bourgois Éditeur.

Dufourt, H. (2014). *Musique, pouvoir, écriture*. Delatour.

Eimert, H. (1958). What is Electronic Music? *die Reihe*, *1*, 1-10.

Emmerson, S. (1986). The Relation of Language to Materials. In S. Emmerson (Ed.), *The Language of Electroacoustic Music* (pp. 17-39). Palgrave Macmillan.

Emmerson, S. (2007). *Living Electronic Music*. Ashgate.

Grabòcz, M. (2013). *Entre naturalisme sonore et synthèse en temps réel. Images et formes expressives dans la musique contemporaine*. EAC.

Grisey, G. (2008). A propos de la synthèse instrumentale. In G. Lelong (Ed.), *Ecrits, ou l'invention de la musique spectrale* (pp. 35-37). Musica Falsa.

Ingold, T., & Palsson, G. (2013). *Biosocial Becomings. Integrating Social and Biological Anthropology* (Ingold, Tim and Palsson, Gisli). Cambridge University Press.

Lachenmann, H. (1996). Klanktypen der Neuen Musik. In *Musik als existentielle Erfahrung. Schriften 1966-1995* (pp. 1-20). Breitkopf & Haertel.

Launay, J. (2015). Musical Sounds, Motor Resonance, and Detectable Agency. *Empirical Musicology*, *10*(1), 30-40. https://doi.org/10.18061/emr.v10i1-2.

Lemaitre, G. (2016). *Everyday sound. A journey through perception, cognition, interaction, and imitation of sounds that surround us* [HDR]. Pierre et Marie Curie.

Leman, M. (2007). *Embodied Music Cognition and Mediation Technology*. MIT Press.

Levinas, M. (2002). Les sons d'hybridation et les transitoires d'attaque: Vers les nouvelles mixités. In P. A. Castanet & D. Cohen-Levinas (Eds.), *Le compositeur trouvère. Écrits et entretiens (1982-2002)* (pp. 89-99). L'Harmattan/L'Itineraire.

Maestri, E. (2023). *Contacts. Essai sur la musique mixte*. EME Éditions.

McAdams, S. (1989). Psychological constraints on form-bearing dimensions in music. *Contemporary Music Review*, *4*(1). https://doi.org/10.1080/07494468900640281.

McLaughlin, S. (2022). Feedback and materiality on the spatial and energetic planes. *ECHO*, *3*. https://doi.org/10.47041/ECHO.3.

Sanfilippo, D. (2023). The Aesthetics of Musical Complex Systems. *Organised Sound*, *28*(3), 381-391. https://doi.org/10.1017/S1355771823000523.

Savouret, A. (2002). Électroacoustique et perspective phonoculturelle. *Circuit: musiques contemporaines*, *13 L'électroacoustique: à la croisée des chemins? 1*, 9-20. https://doi.org/10.7202/902260ar.

Schaeffer, P. (1966). *Traité des objets musicaux. Essais interdisciplines*. Editions du Seuil.

Schafer, R. M. (1977). *The Soundscape. Our Sonic Environment and the Soundscape*. Destiny Book.

Schneider, A. (2013). Music and Gestures. A Historical Introduction and Survey of Earlier Research. In *Musical Gestures. Sound, Mouvement, and Meaning* (Rolf Inge Godoy et Marc Leman, p. 69-100). Routledge, New York.

Sciarrino, S. (1998). *Le figure della musica. Da beethoven a oggi*. Ricordi.

Small, C. (1998). *Musicking. The Meaning of Performing and Listening*. Wesleyan University Press.

Smalley, D. (1996). The Listening Imagination: Listening in the electroacoustic era. *Contemporary Music Review*, *13:02*, 77-107. https://doi.org/10.1080/07494469600640071.

Smith, J. O. (1992). Viewpoints on the History of Digital Synthesis. *Keynote Paper, Proceedings of the International Computer Music Conference, Montreal*, pp. 1-10, Oct. 1991. Revised with Curtis Roads for publication in Cahiers de l'IRCAM.

Veitl, A. (2006). Musique, causalité et écriture: Mathews, Risset, Cadoz et les recherches en synthèse numérique des sons. In *Musique, Instruments, Machines* (pp. 235-251). Bruno Bossis, Anne Veitl et Marc Battier.

Veitl, A. (2007, 14 avril). *Notation écrite et musique contemporaine: Quelles grandes caractéristiques des technologies numériques d'écriture musicale*. JIM07 (Journées d'Informatique Musicale). http://www.tscimuse.org/biblios/veitl/technologiesecrituremusicale.pdf.

Wishart, T. (1986). Sound Symbols and Landscapes. In S. Emmerson (Ed.), *The Language of Electroacustic Music* (pp. 41-61). Palgrave Macmillan.

Feedback Instruments and Spaces

Daniele Pozzi
University of Music and Performing Arts Graz, Gustav Mahler University of Music Klagenfurt, Austria
danepozzi@gmail.com

Abstract. In my compositional practice, I view feedback as an instrument to address spaces of situated sound inquiry. Such spaces are practically intertwined with, and often mutually defining, the material space in which feedback operates. Feedback instruments as such develop at the intersection of these spaces, becoming mediators between artistic concerns and the material affordances that form and inform them. The first part of this article introduces some of these concepts – instrument, medium, material space – by contextualizing them in the current artistic research discourse, and by situating them in selected examples of historical and contemporary feedback-based productions. In the second part I make use of these ideas to illustrate some of my recent works, focusing in particular on the productive intersections between notions of instruments, media, and spaces in feedback practice.

Keywords: feedback experimentation, electroacoustic instruments, collaborative composition.

Medium / Mediation

In the arts of sound, feedback is a practice of mediation: feedback is always situated in, and *lives* through, a specific medium. Larsen tones, for example, arise from the amplified resonances of sound waves propagating through the medium of air. In a vacuum chamber, feedback cannot occur because there is no air for the sound waves to travel through. In the absence of its medium, feedback dies. From this perspective, the relationship between feedback and the medium it lives in comes close to the notion of a living organism. In the biological sciences, the «medium – or milieu or environment – is the material space in which the organism lives, which keeps it going and through which it keeps going»[1]. Similarly, feedback is always coupled to a medium, an environment, a material space that sustains it. This material space is often composed of different subtrates. If we take a closer look at the Larsen effect, for example, the sonic qualities of the resulting howl are determined not only by the compression and rarefaction of air molecules, but also by the resonance frequencies in the microphone, amplifier, and loudspeaker, the acoustics of the room, the directional patterns of the microphone and loudspeaker, the distance between them, and the phase relationship between their diaphragms. In feedback practice, the material space is a milieu in which sound is mediated and remediated through a situated network of media.

In the arts of sound, feedback is a practice of mediation, in a double sense. For the sound artist, feedback can become an investigative instrument for making sense of the complex material spaces in which it situates. From this perspective, feedback is an instrument in the sense of a medium or mediator: it mediates between the artist and the

[1] Rheinberger, 2016, pp. 161-162.

Musica/Tecnologia, 19 (2025), ISSN online 1974-0050, ISSN print 1974-0042, pp. 43-77
DOI: 10.36253/music_tec-15484 – http://www.fupress.com/mt

material space which is under artistic investigation. It can act as an amplifier, making the aesthetic affordances of a particular material space visible, tangible, or audible. It allows to zoom into that space, acting as a sort of sonic microscope. Through the lens of feedback, material spaces become spaces of aesthetic inquiry.

I guess my fascination with feedback is precisely related to its dual nature. It *demands* a medium, an environment, a material space that sustains it, and at the same time it allows to investigate that medium, becoming a medium in itself, a mediator, an instrument through which artistic and technical concerns are brought to the surface, are shaped and acquire contours. Feedback is thus the instrument with which I approach material spaces of situated sound inquiry: it mediates between me and a context, a site, or a situation that I want to artistically investigate. It informs about the peculiar affordances of that space, and it forms situated interventions specific to, dependent on, and situated in, that very space, shaping a compositional "research process driven from behind"[2,3].

The following sections present some historical and contemporary examples of feedback-based works in electronic music and sound art[4]. These examples are chosen to frame a certain *experimental* compositional approach and to contextualize an understanding of instrumentality and mediation that expands the general notion of feedback instruments. Particular attention is paid to the productive interferences between ideas of instruments, media, and spaces in feedback practice. This approach is then elaborated through the lens of my astistic practice, drawing in particular on the experiences of: the *sun til threads* project, an experiment in feedback instrument composition; *Klangnetze*, an adaptive audio network for public space; *Observatorium*, a site-specific electroacoustic feedback circuit in San Cesario di Lecce, Italy.

Instrument / Space

My Affairs with Feedback is a short text, featured in the 9th Volume of Resonance Magazine, in which Alvin Lucier[5] writes about some of his feedback-based works. It also includes a retrospective report on the genesis of his piece called *Bird and Dyning Person*. The report is particularly interesting because it hints at how feedback, before being embedded into a musical context – that is, before becoming a *musical* instrument – can take on the role of a mediator, with a generative character that comes close to the role of a *scientific* instrument in a laboratory setting: fostering sudden discoveries and generating unexpected results, opening up spaces of inquiry[6]. The report is set

[2] Dombois, 2019.

[3] Rheinberger 2018, pp. 1-20.

[4] The examples selected are not exhaustive or representative of the rich history of feedback practice. For a comprehensive overview see Sanfilippo and Valle, 2013, p. 12.

[5] Lucier, 2002.

[6] This relates to a view of scientific research as experimental activity. In this specific understanding, research instruments and objects of investigation undergo processes of mutual definition, as Rheinberger

in the Electronic Music Lab of the Wesleyan University. On Thanksgiving Day 1975, "with nothing better to do", Lucier was experimenting with panning the sound of an electronic birdcall between two loudspeakers. The birdcall, actually a Christmas tree ornament, emitted endless repetitions of a downward glissando and a series of repeated chirps. At the same time he was wearing a pair of miniature Sennheiser binaural microphones, trying to produce short time delays by moving his head rapidly back and forth, although he commented that "since that seemed unlikely, perhaps I would discover some other interesting phenomenon".

> At one point, as I was standing in the middle of the room, feedback started to sound. Before I could get to the amplifier and lower the volume control I began hearing phantom images of the birdcall, which seemed to come from inside my head and at the same time to be located in various parts of the room. They were amazing[7].

What he was hearing was heterodyining in the audio range, produced by the interaction between the continuous strands of feedback and the sounds of the birdcall, resulting in phantom shapes of various kinds:

> Whatever these phenomena might be called, including resultant tones, heterodyne components or inter-aural harmonics occurring only in the brain of the listeners, the results are spectacular. Listeners can hear them vividly[8].

After this discovery, Lucier developed a simple setup to bring *Bird and Person Dyning* to the stage. It consists of a birdcall mounted on a microphone stand and positioned in the front middle of the space, flanked by two stereo loudspeakers. The birdcall is not mixed into the sound system. The performer wears binaural microphones, routed through long cables to a mixer with compressors-limiters and amplifiers to the two loudspeakers. The performance revolves entirely around the process of acoustically discovering the performance space through this simple feedback device:

> Before the performance the performer, with the help of the sound technician, searches the spaces for room reconances whose sonic manifestations as feedback, cause heterodyning. The spatial relationships between the binaural microphones and the loudspeakers determine the geographical locations of the phantom birdcalls. Sometimes the results are vivid. At other times, however, the room just outputs a few unwanted resonances. The performer accepts the task of finding the appropriate strands of feedback that create phantom images of the birdcall[9].

points out: "In the development of research technologies, it can often be observed that the formation of an instrument goes hand in hand, indeed is almost intertwined with the process in which an epistemic object takes shape." See Rheinberger, 2008.

[7] Lucier, 2002, pp. 24-25.

[8] *Ibidem*.

[9] *Ibidem*.

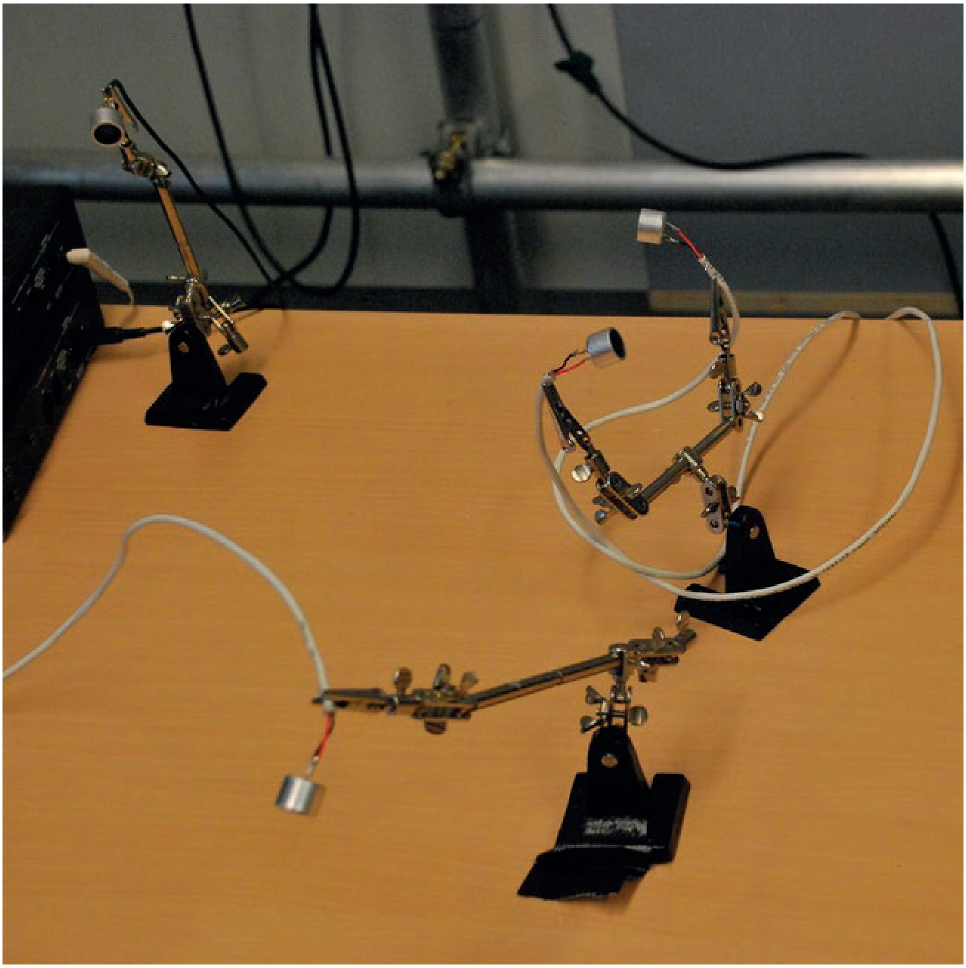


Figure 1. Ultrasound transmitters and receivers in Kuivila's setup for *Listening to the Air*.

A more recent piece that combines feedback with heterodyning, this time in the ultrasound domain, was developed by Ron Kuivila during a residency embedded in the artistic research project *Algorithms that Matter*, hosted 2018-2021 at the Institute for Electronic Music and Acoustics in Graz[10]. The piece, entitled *Listening to the Air*, seeks to expose the shaping influence of air currents on sound waves in the inaudible range. Kuivila assembled a setup of ultrasound transmitters and receivers and connected them in a feedback network of intermodulation (Fig. 1). The setup relies on precise positioning of the ultrasonic units, where audio feedback – similar to an

[10] Algorithms that Matter (Almat) is an artistic research project by Hanns Holger Rutz and David Pirrò. The project Almat ran from 2017 to 2020 within the framework of the Austrian Science Fund (FWF) – PEEK AR 403-GBL – and was funded by the Austrian National Foundation for Research, Technology and Development (FTE) and by the State of Styria. It was hosted by the Institute of Electronic Music and Acoustics (IEM) at the University of Music and Performing Arts Graz. https://almat.iem.at/

ultrasonic microscope – amplifies the interference of air currents – such as the air convection created by a tea light candle – with sound waves in the ultrasonic range. Heterodyning is then applied to transpose signals into the audible range, which are then reproduced through full-range loudspeakers. In this work, too, prior to becoming a musical instrument, feedback is first and foremost a tool for sonic exploration and discovery: it makes audible and accessible the interferences that occur in the otherwise intangible ultrasonic space, and it opens them up to direct, physical manipulation in performance[11].

Both *Bird and Dyning Person* and *Listening to the Air* could be considered outcomes of a compositional approach rooted in an experimental spirit in which feedback acts as an instrument, in the sense of medium or mediator, between the sound artist and the material space under investigation. Feedback lives in, and through, that very material space, and mediates the perception of that space by informing aesthetic choices and shaping further developments. As Nicholas Collins has noted, «feedback reveales links between electronics and acoustics, between circuitry and instruments, between structure and sound»[12].

Electroacoustic Feedback / Acoustic Space

Like Kuvila, Nicolas Collins was a student at Weslyan University in the mid-70s, where Lucier was teaching. It was around this time that he began to work with feedback. In a recent article published on Resonance Journal[13], Collins reconstructs the genesis of his famous feedback work *Pea Soup*, a piece that creates a site-specific "architectural raga" out of a room's resonant frequencies, in which the phrasing is a function of the space reverberation time. The piece stems from the discovery that when a loudspeaker and microphone are connected through a phase shifter, varying the delay (degrees of phase shift) emulates moving the microphone toward and away from the loudspeaker, which in turn causes the feedback to break at different frequencies. Controlling this virtual movement with the loudness of the signal "mimicked a nervous sound engineer jerking a microphone away from the speaker as soon as it starts to feed back". The text provides a few interesting insights. The first one is a hint at how Collins arrived at the setup he would then use for all the *Pea Soup* realizations (Fig. 2).

> Back in Middletown, I adapted my patch to the task of using a similar loudness tracking of feedback to "move" a live microphone, instead of panning Lucier's recordings. Over a period of weeks I whittled away modules until I was left with the simplest of

[11] A recording of *Listening To The Air* is available at https://www.researchcatalogue.net/view/386118/431742. Accessed March 15, 2025.

[12] Collins, 2002.

[13] Collins, 2021, pp. 168-181.

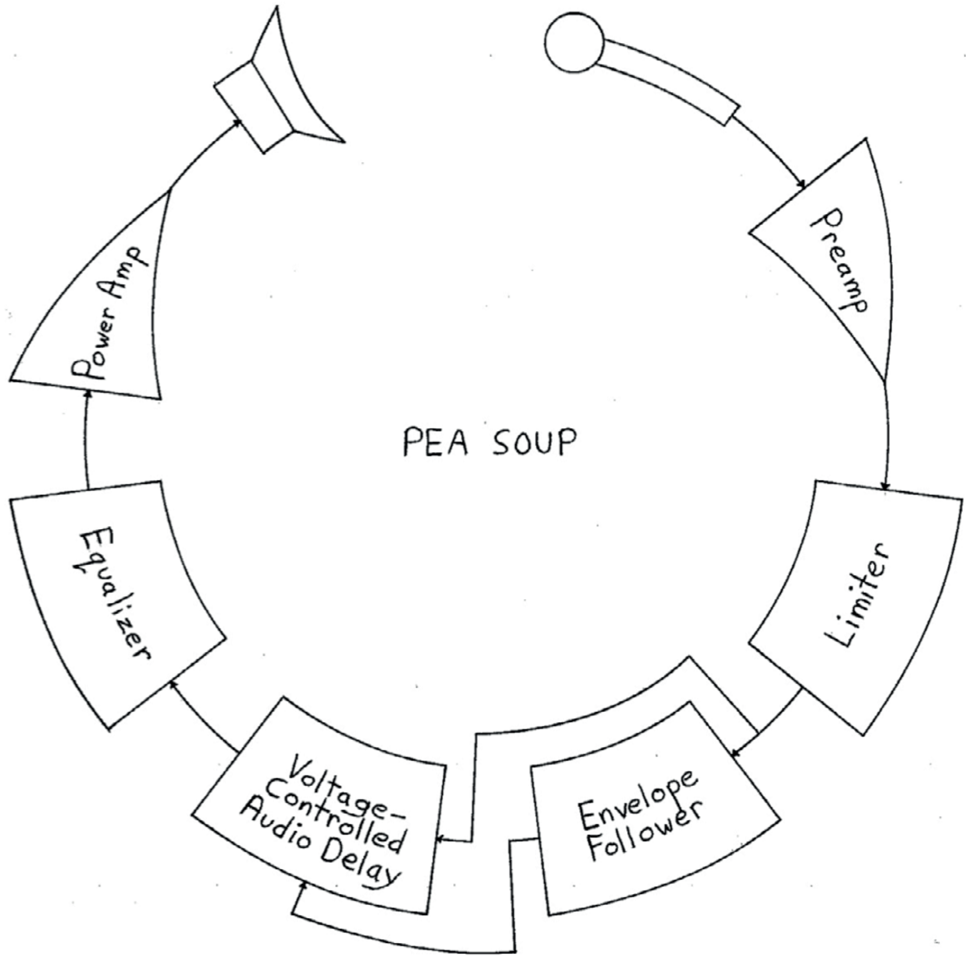


Figure 2. *Pea Soup* original patch diagram (Collins, 2021).

> configurations: microphone > preamplifier > limiter > phase shifter > amplifier > speaker, with optional equalization[14].

The article also highlights how each element in the feedback chain depicted in Fig. 2 affects the overall process of sound remediation. Collins provides insight into the aesthetic decisions that guided the technical development of *Pea Soup*. For example, he stresses how the choice of microphone is a crucial compositional decision in such systems:

> By experimenting with the various microphones in the studio I discovered that omnidirectional mikes produced a much wider, less shrieky range of pitches than the

[14] *Ibidem*.

> more common unidirectional cardioid microphones (even the best cardioid mikes have rather irregular off-axis frequency response, which I suspect affects their feedback characteristics)[15].

Different limiters also greatly affect the sound qualities of the feedback chain. He found that the limiter built into the Sony 152SD portable stereo cassette recorder "did a wonderful job of taming feedback's shriek, reducing it to a mellow sine wave".

As a result, *Pea Soup*'s feedback system is highly sensitive to any movement in the performance space.

> Perhaps the most elegant aspect was the responsiveness of the sound itself: one "played" this system not by twiddling knobs or pushing buttons, but by moving or making sounds within field of the feedback. I began to visualize people and objects in a room in terms of their disruption of the flow of sound waves through the space, like blocks placed in the water of the wave-tank used in physics experiments[16].

Pea Soup is thus an example of how feedback instruments and their material spaces can get so entangled to the point of becoming indivisible. In *Pea Soup* the performance space is as much an instrument as the electroacoustic chain developed to study its acoustic properties and to make its resonances audible. But what also emerges from the report is that the development of the *Pea Soup* instrument – the specific technical configuration that Collins used in performance – opened up just as many spaces of technical-aesthetic inquiry. This suggests that the composition of a feedback instrument is not a linear process, a problem to be solved with a single solution: developing a feedback instrument is as much about forming as it is about being informed, and the end result, the *work*, is to be found somewhere at this intersection.

Many musicians and sound artists choose room-scale acoustic feedback as a site of aesthetic inquiry. A recent example is the *utrumque* project, which since 2018 combines rooms scale feedback with digital modeling of physical acoustics in a layered approach to site-specificity[17]. *rotoscillombrage* is a concert performance and installation by *utrumque* centered around a moving loudspeaker that rotates at the end of a seven meter long arm, which in turn also rotates (see Fig. 3). The work was premiered in 2024 in the Aktionsraum at the Toni-Areal, Zurich University of the Arts (ZHdK). In *rotoscillombrage*:

> The arm allows for precise spatialization of sounds by moving and rotating the speaker to engage resonances and delay patterns in the performance space. By using microphones and digital signal processing, room-scale acoustic feedback is employed as a synthesis method, charging the slightest variation in the loudspeaker position with the power to change the music completely. Both rotating joints are driven by computer

[15] *Ibidem*.

[16] *Ibidem*.

[17] Elblaus and Eckel, 2020, pp. 69-76.

Figure 3. Rotating arm and loudspeaker in rotoscillombrage by *utrumque*, Aktionsraum, Toni-Areal, ZhdK.

> controlled motors and the movements of the whole construction correspond to features extracted in real-time from the music. As the character of the feedback changes as the speaker moves, the resulting sounds change as a consequence, which in turn changes the audio analysis resulting in a change in the position of the speaker[18].

The original idea was first tested through a computer simulation which, based on a set of binaural impulse response measurements of the Aktionsraum, allowed to listen to different room responses relative to specific arm and loudspeaker rotations with respect to a static microphone, placed on one side of the room. The simulation informed the concrete implementation of the robotic arm, developed by *utrumque* in collaboration with Peter Färber of the Institute for the Computer Music and Sound Technology (ICST), ZHdK.

Rotoscillombrage and *Pea Soup* share some similarities: both works engage with the acoustic phenomena that occur when a sound medium – an electroacoustic transducer – is slightly displaced through the acoustic space in which feedback takes place. In *Pea Soup* the sound medium is a "virtual microphone", whose movement is simulated by a time-variable phase shifter. In *rotoscillombrage* it is a loudspeaker, whose movement was first simulated by digital modeling and then implemented in the form of a seven-meter-long robotic arm in order to achieve the slowest possible movement. In both pieces, feedback is employed as a situated instrument to research acoustic phenomena and their compositional affordances in a specific space: an instrument that operates at the intersection of the *simulated* and the *concrete*, allowing to specifically isolate a single variable of a complex system and to experiment with its manipulation.

Zooming further into feedback instruments and their spaces of simulation, the next section discusses examples of purely digital systems in the computational domain.

[18] Elblaus and Eckel, 2023.

Digital Feedback / Computational Space

The computational space has been defined as the conceptual space that resides temporarily in the magnetic, semiconductor locations during the execution phases of computational processes that deal with the manipulation of computer symbols as numbers (integers, floating point, double precision, etc.), dimensioned arrays, and matrices[19]. Digital feedback–processes that apply recursive operations to computer symbols and signals–can provide an alternative access to this space in the sound domain. A concrete example in this direction is the work by Timothy Schmele, who uses internal feedback as an *investigative device* to highlight peculiarities of the Ambisonics spatialiation format. His work *Spherical Glitch Study* is a composition for one laptop performer and a spherical loudspeaker setup. It consists of only two sound sources that reproduce basic sine tones and manipulates them using spatial means. First, they are rotated at extreme velocities, which evokes spectral splits per dimension and decorrelates the generated harmonics in space. The entire spherical sound scene is then folded onto itself by means of an internal spatial feedback loop. This approach evokes and highlights glitches present in the spatialisation approaches, so that «the medium in which the process is situated becomes audible and comes to the foreground»[20]. Feedback is thus used as a tool to zoom into the ambisonics computational space and to bring out its concrete implementations as compositional material. Schmele's work is concerned with an introspection of the media in which the Ambisonics format is formulated, and makes of its specific technical, conceptual and functional aspects a central compositional principle.

A similar approach can be taken to zoom into the workings of a particular software, or even to foreground or make audible the ways in which sound processing is concretely performed – calculated – by computers. This could be understood as a form of *site-specific practice*, where the site is the computational space defined by a specific software environment. An example from my own work is the *strip* synthesizer, a digital instrument based on recursive phase modulation in which feedback amplifies the quantization noise of the software it is written in (SuperCollider). *Strip* is built around two infrasound sine oscillators that cross-modulate each other's phase with single-sample feedback. At each new sample, the phase of the two oscillators is computed by adding the current phase of each oscillator to the one sample old output of the two oscillators, as follows:

$$x(t) = cos(wt + Ax(t-1) + By(t-1))$$

$$y(t) = cos(wt + Cx(t-1) + Dy(t-1))$$

[19] Ahamed, 2014, pp. 171-189, and 2017, pp. 431-450.

[20] Schmele, 2024.

In phase modulation (PM) synthesis *A*, *B*, *C* and *D* are commonly referred to as modulation indices and their value determines the amount of modulation that is applied to the signal. Because the frequency of the two oscillators is well below the human auditory threshold, they remain inaudible without modulation and feedback. In particular, the two oscillators are tuned to a frequency between 0.0002 and 0.00008 Hertz that corresponds to a sine wave with a period between 77 minutes and 3 hours and 28 minutes. Due to the specific implementation of the SinOsc Ugen and to the limitations of floating-point representation, these oscillations cannot be properly computed. The difference between successive samples is too small to be represented, and quantization noise arises from the rounding errors, introducing noticeable distortion and aliasing. In *strip*, feedback amplifies these digital artifacts, turning numerical overruns and underruns into generative seeds for the feedback system itself. As such, the *strip* synthesizer could be understood as an example of a system- and software-specific feedback instrument, which centers around the specific way the SinOsc Ugen deals with numbers it cannot represent. Instead of relying on traditional noise generators, noise is found through a recursive amplification of the numerical indeterminacies produced around these oscillatory liminal regions. The *strip* synthesizer was originally developed as a closed digital feedback system, but it now also includes the possibility of routing external signals (microphone / line inputs), in order to be able to play and improvise with other musicians[21].

A similar approach to digital feedback instrument composition can be heard, for instance, in *Fantasia On A Single Number* by Stelios Manousakis. The piece is performed by playing an «instrument based on digital feedback, set in motion by one single number. No other sound sources are used but real-time manipulation of the number's path within a synthetic space»[22]. Of particular relevance is the work of Dario Sanfilippo, who has worked extensively on closed-loop digital feedback systems, applying concepts and techniques from general systems theory to digital signal processing[23]. His generative piece *Constructing Realities*:

> Shows the performance as a closed self-oscillating system that is triggered by a Dirac impulse, and the entire piece is the complex system's response to a single impulse without human intervention. This closed-system configuration results in a development that spontaneously decays to silence after about 26 minutes, determining the end of the piece[24].

[21] In the 7th episode of the *End of Text* recording series, *strip* was coupled with two hybrid systems (SuperCollider and modular synth) by Luc Döbereiner and Ludvig Elblaus https://endoftext.org/. Excerpts from *strip*, in the form of quantization noise studies, are collected here: https://www.researchcatalogue.net/view/2944513/2944514. Accessed March 15, 2025.

[22] https://modularbrains.net/portfolio/fantasia-on-a-single-number/. Accessed March 15, 2025.

[23] Sanfilippo, 2020.

[24] Sanfilippo, 2021.

Sanfilippo builds on Agostino Di Scipio's research in *ecosystemic digital signal processing*[25]. In particular, Di Scipio theorized a holistic approach to live-electronic music composition that transcends traditional paradigms of "interaction" in computer music and live electronics, framing it rather as a relational property established between sound materials. As Meric and Solomon note in Di Scipio's *Audible Ecosystems* series:

> The emergence of sound structures is possible because of the fact that the composer develops systems (in the sense of cybernetics) close to living systems, which are characterized by their capacity for auto-organization. To make sure that the system is auto-organized, Di Scipio uses "circular causality", which extends the idea of feedback[26].

In *Background Noise Study*, part of the *Audible Ecosystems* series, the delayed background noise of the room is recursively amplified, «likely to be perceived, at the beginning of the performance, as the hiss of a somewhat cheap, low-fi electroacoustic setup. Listeners are deliberately presented with something usually foreign to all music, the trace of the equipment amplifying the ambience sound, magnifying something we usually do not pay attention to»[27]. Here, again, feedback zooms into the media in which sound takes place, and the noise found through recursive amplification is employed as a generative seed that paves the way for the emergence of high-level sonic structures.

Feedback, as contextualized so far, can thus be understood as an instrument in a dual sense: as a vehicle for exploring specific spaces, materials, or phenomena, and as a compositional technique for placing them at the center of sound works. However, it is also possible to reverse this relationship and consider feedback instruments as sites of inquiry in themselves, encouraging reflection on the idiosyncrasies of specific compositional practices. This approach underlies the genesis of the *sun til threads* project presented in the next section.

sun til threads*: a Collaborative Experiment in Feedback Instrument Composition*

The compositional research I am conducting with sound artist and composer Ludvig Elblaus as *sun til threads* centers around the development of shared electroacoustic feedback instruments for live electronic music performance. The project orginates from an experiment in feedback instrument composition, conducted in the framework of the artistic research project *Simultaneous Arrivals* (*simularr*)[28], of which Elblaus was guest artist in April-May 2023. The experiment, rooted in the practice of

[25] Di Scipio, 2003, pp. 269-277.

[26] Meric and Solomos, 2014, pp. 4-17.

[27] Di Scipio, 2011, pp. 97-108.

[28] *simularr* investigates how different types of spaces – thought spaces, aesthetic spaces, architectural spaces – and their corresponding modes of spatiality interact and interfere in artistic collaborations. https://simularr.net.

digital liuthery, questioned whether the process of developing a feedback instrument could be collaboratively designed to interfere and interact with one's own compositional preferences, fostering reflections that challenge established habits and techniques. It consisted of (1) a preparatory stage, where we formulated a rigid set of rules that informed (2) a development phase, in which we independently developed a set of new digital feedback instruments. This was then followed by (3) a period of rehearsal and music production in which we played and adjusted the instruments together in a pre-selected location.

Preparation

Prior to the development phase, we formulated a set of rules for the design of two new feedback instruments, with the purpose of limiting and constraining some of the compositional techniques we are accustomed to. Both Elblaus and I have a long practice of writing digital instruments in the SuperCollider language. The disposition we defined constrained the way an instrument could be conceived, imposing a strict digital scaffolding that reduced both the techniques that could be used and the number of operations that could be expressed. It turned instrument design into an experimental process in which we were forced to approach problems differently and to rethink our own habits, techniques, and preferences[29].

The set of rules defined the instruments in terms of code, control interfaces, and acoustic relationship to the performance space, as follows[30]:

- Code
  - Each SuperCollider instrument may not exceed 80 lines of code, and no line may exceed 80 characters.
  - There are no limitations to what characters are put into the 80x80 grid of characters that make up each instrument.
  - The instrument code cannot call any class or function not available in vanilla SuperCollider.
- Controls
  - The instrument can be controlled using a maximum of 16 rotary encoders.
  - Each controlling encoder may only control levels of audio rate signals in the instrument.
  - The controls are connected with the instrument Synth through the audio buffers 100-116.

[29] As a practical example, when developing feedback instruments I often make use of external plug-ins (UGens I developed that extend the SuperCollider core), while Elblaus relies on a large set of compositional tools, in the form of SuperCollider abstraction, which are part of a large compositional system he built over years. Limiting the development phase to vanilla SuperCollider excluded the usage of both external UGens and libraries.

[30] The code, produced within the project *simularr* and licensed under the GNU Affero General Public License v3+, is available here: https://codeberg.org/simularr/808016. Accessed March 15, 2025.

- Input / Output
  – Each instrument has only one input (microphone).
  – Each instrument has only one output (loudspeaker).

Development: Feedback Node Ring

Throughout the development phase, we regularly confronted each other, reporting on progress and compositional strategies for approaching the constraints of the experiment. Elblaus formulated a rather compact but expressive Digital Signal Processing structure based on a circular digital feedback network of twelve nodes. Each node in the network consists of a simple DSP process with one input and one output. The output of each node is then routed to the input of four other nodes within the circular structure. Two routing paths are fixed: each node always feeds its output back to its input and to the input of its diametrically opposite node. In addition, two other paths route the output signal clockwise and counterclockwise around the circumference. These two routing paths can be parameterized to achieve different feedback structures by defining individual routing rules for clockwise and counterclockwise feedback (Fig. 4). Modifying the feedback structure of the network alters the temporal relationships between DSP processes, resulting in different patterns and long-term oscillations with a rich sonic character ranging from drone-like textures to short melodic phrases. These can be monitored by specifying a listening point along the circumference, which is then output to a loudspeaker. A microphone signal is also summed to the input of each node, completing the setup and allowing to acoustically couple the digital feedback space with a concrete physical space.

What is distinctive about Elblaus' approach is that his feedback instrument relies on an idea of spatiality that makes the relative displacements of the nodes along the circumference, as well as the distances between them, a central generative principle. The notion of distance is crucial here in constructing different structures, and achieving different patterns and textures. In fact, the ring structure in Elblaus' instrument is reminiscent of some of the loudspeaker configurations sometimes found in feedback performances. One example is Christopher Burns' realization of *Electronic Music for Piano*[31] by John Cage (Burns 2004). Burns implemented a system based on a network of eight delay lines in a bi-directional circular audio

[31] Another realization of this work by Cage, recorded by Di Scipio and Ciro Longobardi in 2011, is available on Stradivarius. See Longobardi and Di Scipio, 2012. Di Scipio's electro-acoustic setup greatly differs from that of Burns. From the liner notes of the work: "The sound transformations […] are fed by four piezo-electric discs set in direct contact with woodenand metal surfaces of the piano. Due to these very cheap and low-quality analog tranducers (instead of professional microphones), here the piano sound often takes on rather unusual timbre colors. The goal was a mix of creative amplification and selective equalization of the piano sound; the (welcomed) side-effect was a kind of technically and rather lo-fi timbral connotation […] The sound resulting from the signal processing is heard through two loudspeakers, placed beneath the piano. Therefore, the terminals of the electroacustic chain (piezos and speakers) are rather close among them, the body of the piano acting as an interface between the input and the output terminals."

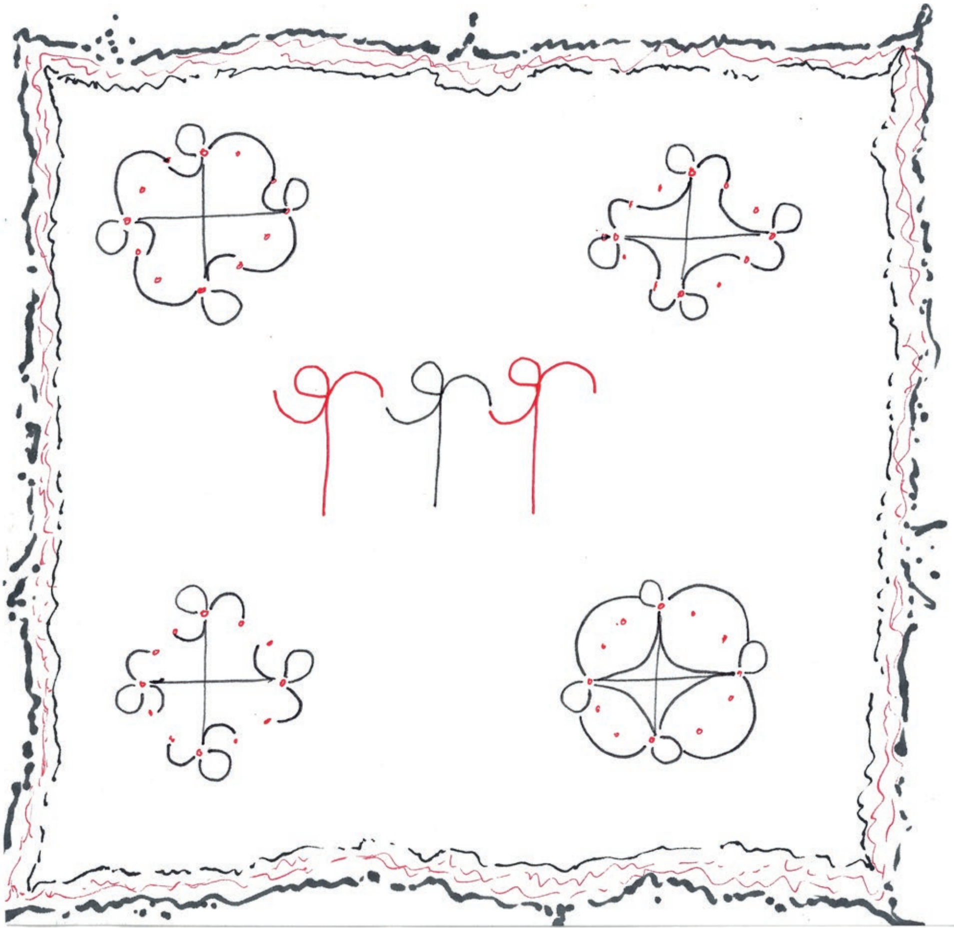


Figure 4. Four node rings with different feedback structures. Nodes are drawn in red, clockwise (CW) and counterclockwise (CCW) routings in black. Top left: 1 CCW, 2 CW. Top right: 2 CCW, 1 CW. Bottom left: 1 CCW, 1 CW. Bottom right: 3 CCW, 3 CW. For visual clarity, only the routing of four nodes is displayed. Original drawing: Ludvig Elblaus 2023.

feedback configuration. Two microphones are connected to two of the eight delay lines, feeding the network with the sound from the piano, and each node's output is connected to a loudspeaker (Fig. 5).

Intuitively, although conceptually similar, a feebdack ring structure in the acoustic space radically differs from its implementation in the digital space. In the acoustic space, it is practically impossible to isolate the outputs of the nodes from the rest of the system: in the configuration shown in Figure 5, the two microphones will pick up all the loudspeakers at once, mediated by the room acoustics. Elblaus's system, on the other hand, makes it possible to selectively isolate, and experiment with, single node-to-node relationships, constructing a virtual space that allows to engage with some properties of feedback that can only be explored in the digital domain.

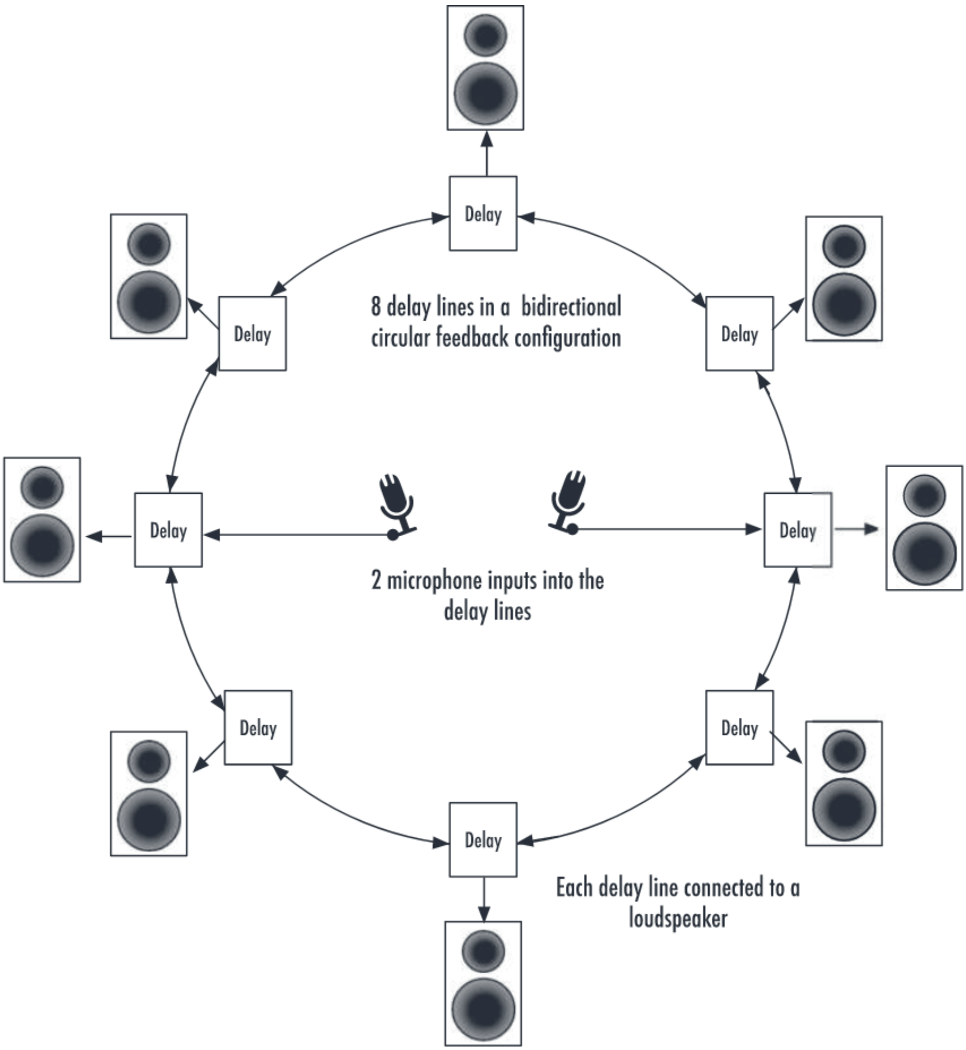


Figure 5. Burn's setup for Cage's Electronic Music for Piano (Sanfilippo and Valle, 2013).

The temporal qualities of the patterns and textures emerging out of the node ring, combined with its high sensitivity to the parametrization of its geometries, demanded a deeper, joint experimentation: we both adopted the node ring as a common scaffold to continue the development phase. I branched off from Elblaus' experiment by writing specific DSP processes that would explore the temporal qualities of the ring. By the end of this phase, I had a total of twelve instruments based on the node ring, and Elblaus had a set of four.

Performance / Rehearsals Space

The second stage of the experiment, centered on rehearsals and music production, took place at Hotel Pupik[32] – an old farmhouse, now converted into an art space, in Scheifling, Austria. Here the main shed (see Fig. 6) was chosen as the rehearsal space, primarily for its acoustic characteristics: six equally spaced columns support twelve arched vaults that create a highly reverberant and sonically rich environment. In addition, it has three doors on the west wall (a large central one and two smaller ones on either side) and three large windows on the north and south walls. This special construction means that the shed is in constant acoustic exchange with the outside environment (a rural area located in the region of Styria, Austria). Various types of birdcalls find their way into the room, but church bells and distant train whistles have also been frequent visitors.

We installed two loudspeakers facing two adjacent walls, to take full advantage of the resonances and reverberation of the space. Two microphones were placed asymmetrically, more toward the center of the room (see Fig. 6). These corresponded, respectively, to the outputs and inputs of our two instruments, creating a complex feedback space in which they could interact sonically, mediated by the acoustics of the shed. When playing together, the instruments fed back into each other, sometimes interlocking, sometimes pushing each other into other sonic regions. As a result, one had the feeling of interacting with a third instrumental space that was reminiscent of a "third voice"[33]: neither under the complete control of one performer or the other, but rather emerging from the complex ecosystemic relationships between the performers, the instruments, and the acoustic space.

During the second week of the residency in Schrattenberg, we rehearsed extensively with the two instruments in the shed. We focused in particular on balancing the coupling between the two instruments, constructing the conditions for them to interlock and interfere with each other, and attuning the influence of the space, the instruments, and us as performers on the resulting sonic textures. At the end of the residency, we released two tracks that capture this particular situation. Especially in the second recording, short term interlocking phenomena and interferences are particularly audible, while the first track works on longer time scales. The tracks are released as *sun til threads*[34], which is the name we have been using to perform together ever since.

Coupling

The *sun til threads* project could be conceived as a form of *performance ecosystem* composition[35], a term that has gained momentum in recent years to frame practices

[32] https://hotelpupik.org/. Accessed March 15, 2025.

[33] Peters, 2017, pp. 67-78.

[34] https://suntilthreads.bandcamp.com/album/pupik-dreams. Accessed March 15, 2025.

[35] Waters, 2007.

Figure 6. Left: Pupik's main shed with the double door open (west facade). Right: Microphones and loudspeakers placement (original shed plan by Franziska Hederer).

that "treat performance as a complex dynamical system in which the feedback loops and interpenetrations between performer, instrument, and environment are fully recognized"[36]. Among the musicians related to this ecological approach to performance, the *Machine Milieu* project by Agostino Di Scipio and Dario Sanfilippo is worth mentioning, as it shares some structural similarities – both in terms of setup and performance approach – with the *sun til threads* project. The *Machine Milieu* project «includes two performers with their computer units, microphones, and loudspeakers, to be placed at strategic positions in the performance space» in which «the idea is to consider the human performer, equipment, and performance space as three sites of agency mutually connected in the medium of sound, capable of developing an integral and possibly autonomous performance ecosystem based on site-specific sonic information only»[37]. In the liner notes to their self-titled release, Di Scipio and Sanfilippo describe the complex, situated sonic interactions that take place in performance as follows:

> By influencing (driving, supporting, inhibiting) each other's behaviour, each system also acts back upon itself, but through the other and the local room acoustics. The project […] creates a hybrid assemblage where both perfomers and machines lean on the shared sound environment as a medium of energetic and informational exchange, thus as a source of real-time situated musical behaviour[38].

In an article published in the journal *Array*, building on the concrete practice of the *Machine Milieu* project, they highlight in particular how a reflection on the nature of *ecosystemic agency* might be relevant to further understanding the performance ecologies of similar projects. In particular, they note that «a viable definition of eco-

[36] Waters, 2013.

[37] Di Scipio and Sanfilippo, 2019, pp. 28-43.

[38] Di Scipio and Sanfilippo, 2021.

systemic agency is better delineated by rethinking the notion of interactivity in light of the more encompassing notion of *structural coupling*»[39].

Structural coupling[40] is a concept rooted in general systems theory[41] to define the process by which two or more systems influence each other's structure over time as they interact and maintain a relationship. In collaborative performance systems such as the *Machine Milieu* or the *sun til threads* project, this notion is often fruitful for thinking about the compositional strategies that can bring musical feedback systems into mutual interaction. Feedback practitioners and musicians often draw inspiration from principles of cybernetics and systems theory. The next section describes *Klangnetze*, a collaborative sound art project for public spaces that implements an electroacoustic system conceived around some of the central principles of complex systems.

Klangnetze*: Adaptive Audio Networks for the Public Space*

The project *Klangnetze*, a distributed sound art intervention in the public space, took place simultaneously in five Austrian cities (Eisenerz, Gleisdorf, Leibnitz, Ligist, Spielberg) in the summer of 2022. *Klangnetze* was carried out by myself and David Pirrò, and featured works by sound artists Luc Döbereiner (*The Small Learning*), Veronika Mayer (*Jodel Poliphonie*), Margarethe Maierhofer-Lischka (*Nachtahn*), Hanns Holger Rutz (*Tagfalter*) and Ina Thomann (*Seated In Bells*). The project took the cybernetic concepts of feedback and network as its aesthetic and conceptual starting point to formulate interventions in the public space that would embed ecologically in their acoustic environment, coming into contact with its sonic properties, approaching them and growing together with them.

Background

Klangnetze draws on ideas from the field of complex systems[42] to explore how these can inform the composition of situated sound interventions in the public space. In

[39] Di Scipio and Sanfilippo, 2019, pp. 28-43.

[40] The notion of coupling is found also in physics: in classical mechanics, coupled oscillators are systems in which two or more oscillators (e.g., pendulums, masses on springs) are connected so that their motions are interdependent. Coupling in these systems can result in interesting behaviors like resonance, energy transfer between oscillators, and collective modes of motion. This form of coupling can also be creatively investigated in the sound domain, as seen, for example, in the *Contingency and Synchronization* series of works by Luc Döbereiner and David Pirrò. See Döbereiner and Pirrò, 2023.

[41] Maturana and Varela, 1991.

[42] The study of networks of interacting components with nontrivial behaviors dates back to the 1940s with the advent of modern cybernetics, which initially began as a discipline connecting areas such as mechanical engineering, network theory, cognition and psychology, and evolutionary biology. For a detailed overview of the development of this field of study, as well as musical works implementing complex Adaptive mechanism, see Sanfilippo, 2021.

Figure 7. *Klangnetz* installed in Leibnitz main square. Left: agents 1 and 2, balcony of the town hall. Right: agents 3 and 4, Maibaum. Highlighted in red: solar panels; in pink: loudspeakers; in green: microphones.

complex systems, the concepts of network, interaction, feedback and agents are deeply interconnected. Networks provide the structural framework within which agents interact, and these interactions drive the system dynamics and emergent behaviors. Such interactions are typically modelled as feedback relationships between agents, and among agents and their environment. Complex systems, which are ubiquitous in physics, nature, society, and biology, inspired the construction of a network of sound agents (in German: *Klangnetz*) that can interact sonically with its surroundings (Fig. 7). Each *Klangnetze* agent (Fig. 8) consists of a small photovoltaic computer equipped with a MEMS microphone and a compact loudspeaker. When multiple agents are installed in close proximity, they form a sonic topology (Fig. 9) in which they simultaneously listen to each other and to the local soundscape. In June 2022, five *Klangnetze* – each consisting of five agents – were distributed to five cities in Styria (Eisenerz, Gleisdorf, Leibnitz, Ligist, Spielberg) and installed in the public space – as an example, Figure 10 shows one sound network installed in the main square of Gleisdorf. Six sound interventions, composed by the invited artists, rotated every two weeks over the *Klangnetze* system, so that at the end of August each of the them was performed at every location.

Situated Sound Networks

In *Klangnetze*, the acoustic environment – the specific soundscape of each city – is the material space in which the sound agents live and through which they communicate. The *Klangentze* system itself can be seen as a site-adaptive instrument that allows to compose site-specific network topologies, and to experiment with different feedback relationships between the network and the environment. Indeed, the aim of the project was to formulate individual aesthetic positions at the intersection of the *Klangnetze* system and the public space, reflecting on mutual sound interactions to create forms of situated sonic interdependence between site and work. Each sound

Figure 8. Klangnetze agents. Left: prototype, May 2022. Center: first version, July 2022. Right: revised version, October 2022.

artist involved in the project was invited to compose a sound intervention in response to this proposal. The following sections describe three such approaches in more detail.

The Small Learning *by Luc Döbereiner: the Network as Sonic Community*

The Small Learning by Luc Döbereiner interprets the network in terms of a sonic community. The title *The Small Learning* refers to the part *Paragraph 7* of Cornelius Cardew's piece *The Great Learning* (1971), a composition for vocal ensemble that consists of a set of rules for each musician to follow, resulting in a kind of emergent harmony. *The Small Learning* also consists of an ensemble of sound agents, all following the same rules. In this case, there are five algorithmic systems that generate synthesized sounds, record ambient sounds, analyze them, and compare them to the synthesized sounds.

From the author's notes:

> *The Small Learning* aims at the emergence of a sonic community, a form of ecology, that connects algorithmic processes, the sonic environment, and musical ideas. Density, pitch, timbre, and musical development emerge from the interactions of the various processes and agents, their materialities, and the ways in which they represent and transmit one another. The sound-generating agents are chaotic systems that, although very simply constructed, have a large space of possibility. It fascinates me aesthetically to experience and trace this space. Interaction with this system often results in surprising patterns, sudden transitions, and sound structures that change and dissolve. I am interested in how this complexity in the small and quasi-ideal domain of digital sound synthesis, can be connected to the sonic environment, i.e. how algorithmic chaos and the unpredictability of the external environment can encounter each other. This is done through a machine learning process that, in a sense, translates data and sounds into each other, adaptively adjusting sound synthesis to the results of an analysis of the environment[43].

In *The Small Learning* sounds are synthesized in SuperCollider using a feedback wavefolder, a type of distortion device used especially in analog synthesizers. The general operation of a wavefolder can be described as folding – reflecting or inverting – an

[43] Döbereiner, 2022, pp. 95-116.

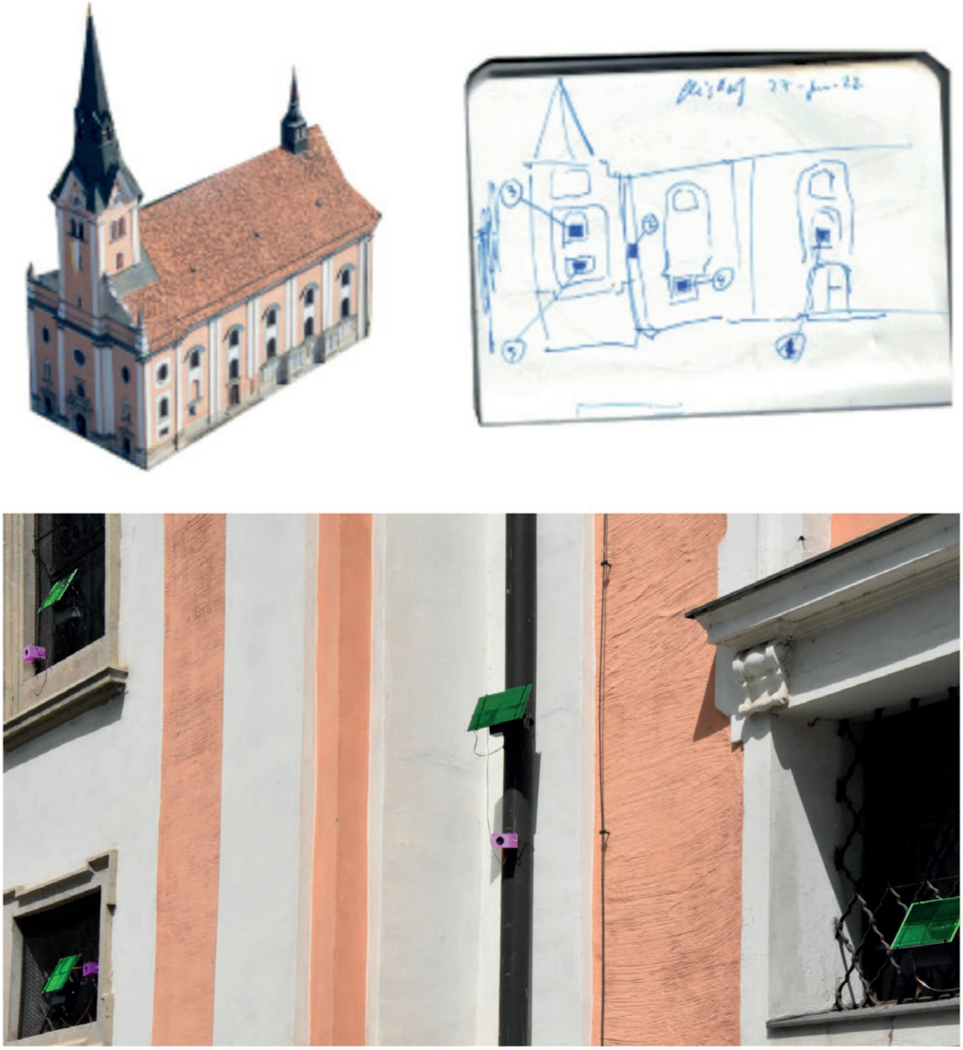


Figure 9. Klangnetz installed on the South facade of St. Laurentius Church in Gleisdorf main square. Top: aerial view and installation plan. Bottom: agents 2, 3, 4 and 5. Highlighted in green: solar panels; in pink: loudspeakers.

input signal as its magnitude exceeds a certain threshold (see Fig. 10, left). In addition, the wave can be shifted, resulting in asymmetric folding (see Fig. 10, right).

Döbereiner points out that:

> Wavefolders become especially interesting in feedback systems, because they can thus form an essential part of chaotic systems as a parameterized nonlinear function. Feedback wavefolders can produce both periodic and chaotic timbral states. The system

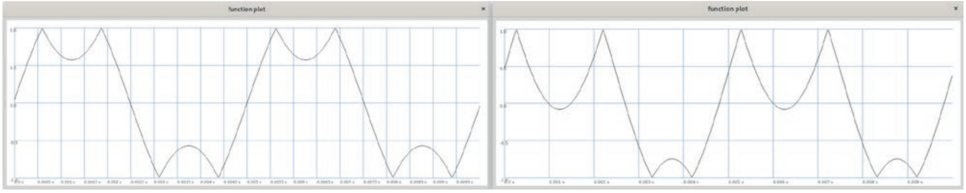


Figure 10. Left: A sine wave folded at amplitude 0.7. Right: Asymmetric folding (Döbereiner, 2022).

used here, while very simple in its components (the feedback input wave is folded at certain thresholds), exhibits very diverse behavior that is difficult to understand[44].

Each of the five agents generates sounds using a feedback wave folder, alternating between sound generation and silence. During their periods of silence, they analyze both their own sounds and the ambient sounds picked up by the microphone. This alternating pattern of playing and pausing directs the analysis inward (self-generated sounds) and outward (environmental sounds), respectively. The analysis yields Mel-frequency Cepstral Coefficients (MFCCs), represented by 13 numbers that capture essential properties of the frequency spectrum at a given moment.

After each iteration, the agents evaluate how closely their generated sounds match the environmental sounds – recorded and analyzed during their last pause – by comparing their respective MFCCs through a k-nearest neighbor (kNN) machine learning algorithm. New parameters are then generated based on a calculation of the distances between the analysis data. Using this algorithm, the agents aim to produce sounds that approximate the sounds of the environment, which includes the sounds of other agents. In the process, they also learn to generate more accurate parameter settings for specific timbres by interpreting their own chaotic behavior.

The agents' adaptation varies with their proximity to the surrounding sounds: the further away they are, the more erratically they explore different possibilities. As they become better adapted, their curiosity diminishes, leading to the production of longer sounds. Rhythmic structures, musical density, and variability emerge from this adaptation process. Throughout, the agents listen to each other and to external environmental sounds, collect data, and strive to adapt, forming a sonic community with each other and their environment.

Tagfalter *by Hanns Holger Rutz: the Public Space as Environment for Sound Communication*

Hanns Holger Rutz approached the network from a different perspective. He composed sound processes inspired by the way living organisms interact and communicate with their environment. In particular, he draws inspiration from the world of insects:

[44] Döbereiner, 2022, pp. 95-116.

> Tagfalter is German for a day-active butterfly (where Nachtfalter would be the night-active moth). Falten is not only 'to fold', as in the flapping of the butterfly's wings, but also the technical term for 'convolution', a digital signal process that is applied repeatedly in the piece. Each of the five nodes enacts a cycle of different modes, usually following the order of 'crypsis', 'detect-space', 'space-timbre', and 'accelerate', interspersed with random occurrences of 'silence' and 'joy'[45].

As shown in Fig. 11, a state machine cycles through the five modes. The *detect-space* mode is particularly interesting: it is the stage in which an agent gathers spatial information about its environment. *Detect-space* emits a series of sweeps: chirps lasting a few seconds, moving from lower to higher frequencies. By observing the echoes of this sound, the agent generates a geometric image of the physical space around it, translated into distances of reflecting surfaces. This image then informs the parameters of all the other modes, most perceptible in the *space-timbre*, which translates these distances into frequencies, creating an internally modulated harmonic or inharmonic sphere. When multiple agents happen to be in the *space-timbre* mode at the same time, one can easily notice the different harmonic spheres obtained from the individual locations of the agents.

Agents also sonically communicate their intention to start an acoustic scan of their environment, so that all other agents remain silent during this operation. This sound signal is also inspired by the way in which living organisms communicate with each other:

> The nodes are meant to communicate among each other using a simple technique called frequency-keying. A pair of frequencies understood by all nodes is used by a node to inform the others that it is about to run its space detection, and to communicate its identity (another pair of frequencies) resulting from the detected space. Then using these individual frequencies, sometimes bursts of joy can be heard, as a similar sounding communication signal, but at these distinct frequencies. If another node notices this, it will reply with its own burst[46].

Trópos*: Soundscape-Modulated Sound Synthesis*

I also composed a sound intervention called *Trópos*, based on the *strip* synthesizer previously described. A central idea in *Trópos* is to work with sounds that might be confused with those already present in the public space. A process of mimesis is synthesized in real time, and the surrounding soundscape directly modulates this process. Each sound that reaches the microphone is embedded in the synthesis program, and sonic and temporal qualities emerge that are specific to the place – and moment – in

45 Rutz, 2022.

46 *Ibidem*.

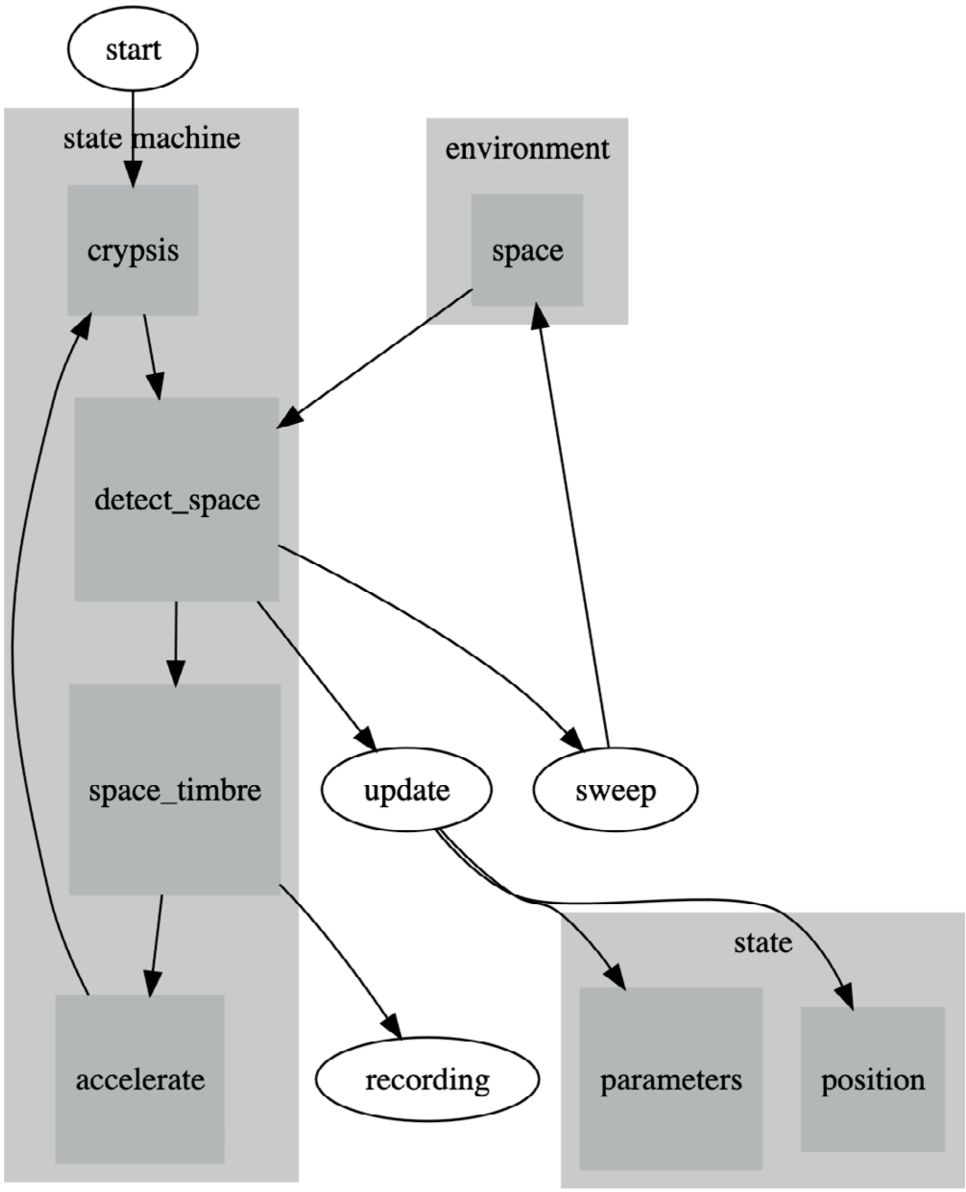


Figure 11. *Tagfalter* state machine. Original drawing: Hanns Holger Rutz (Rutz, 2022a).

which the synthesis takes place. The work is loosely inspired by the biological phenomenon of tropism that indicates growth or turning movement of an organism, usually a plant, in response to an environmental stimulus. Tropisms occur in three sequential steps. First, there is a sensation to a stimulus. Next, signal transduction occurs. Finally, the directional growth response occurs.

> Borrowing this metaphore, I considered the acoustic environment as the source of acoustic stimuli. These are (1) sensed through the built-in microphone and (2) transduced into filtered amplitude values. These values then (3) provoke deviations in a generative sound process, which adapts by modifying its timbral and rythmical qualities according to such acoustic stimuli. This mechanism creates an ever-growing, real-time process of acoustic adaptation in which sound processes concretely take shape from their environment, generating a lively sound situation in which the work is in a direct aesthetic interdependence with the place in which it is installed[47].

Trópos is described in detail in an article that is part of the xCoAx 2023 proceedings[48].

Documentation and Resources

Audio recordings of the six interventions are available on the *Klangnetze* website[49], which also offers an overview of the entire project and a documentation video (in German). The *Klangnetze* hardware is documented in a dedicated instructable[50] and the software is available in the *Klangetze* online repository[51]. The diversity of interpretations and approaches in the project testifies to the generative potential of approaching an electroacoustic system, and the ideas specific to its development, as an instrument for exploring the liminal region between an aesthetic proposition and the concrete space in which it takes shape.

A similar compositional approach was taken in *Observatorium*, an electroacoustic feedback circuit described in the next section. A key difference, however, is that the *Observatorium* feedback system was developed in situ, and the specific acoustic characteristics of its site are central compositional elements of the work.

Observatorium*: a Site-Specific Electroacoustic Feedback Circuit*

Observatorium is a site-specific sound intervention that applies general electroacoustic feedback principles to frame listening as an act of observation, and to draw attention to the productive interferences between observer and observed. In particular, it creates a contrast between the individual listening space and the collective listening space, making the friction between the two a central compositional element of the work. It was developed during the *simularr* artistic research residency at Palazzo Russo, San Cesario di Lecce, Italy, April 2024, and it consists of a distributed electroacoustic

[47] Pozzi, 2022b.

[48] Pozzi, 2023, pp. 378-382.

[49] Pirrò et al., 2022a.

[50] Pozzi, 2022a.

[51] Pirrò et al. 2022b.

Figure 12. View of the specola from the West rooftop.

feedback circuit, connecting several rooftops and terraces of the historic palace. A plan of the whole circuit is shown in Fig. 18.

The circuit is composed around three main listening points, one of which – the *specola*[52] – is placed on the highest point of the main rooftop, facing East (see Fig. 12). The *specola* is a special listening point in the feedback circuit because it creates a private listening space that can only be occupied by one person at a time. Sitting on an old wooden chair, one must carefully move one's head to align one's ears with the two openings at the end of the tubes. This peculiar listening space is built around two old bed ornaments made of brass, which I found in a deposit in the palace. These were turned into two feedback resonators by inserting two lavalier microphones (see l1 and l2 in Fig. 18) inside the cavities at the end of each ornament, and by screwing two transducers (t1, t2) at the opposite end.

Walking towards the center of the rooftop, one encounters the *collettore* (italian for water collector), a large stone basin hosting a PA loduspeaker (p1), an old antenna and a cardioid microphone (m1). The *collettore* is the second listening point (see Fig. 13). A third listening point is the *parapetto*, which coincides with the rampart that limits the palace rooftop (see Fig. 14). Here a second loudspeaker (p2) is placed on the neighbouring roof, next to the wall that limits the two buildings: it is not visible, it can only be heard.

52 In italian, *specola* means observatory, hill or summit. It is generally a lookout post. It derives its name from the latin *spècere*, verb for "observing" which also originates *speculum*, the mirror (*specchio*, in italian) – literally, the 'instrument for observing'.

Figure 13. Collettore. Left: view from the West rooftop. Right: detail of the old antenna, with microphone inserted in the tube.

Figure 14. Parapetto. Left: stone wall and water pipe. Center: neighbouring rooftop, not accessible. Right: water pipe holding the two bed ornaments, view from the neighbouring rooftop.

One floor below, on a small terrace, two more microphones are installed next to a water pipe (m1) and on the small chimney (c1) for exhausting steam from the boiler that heats the water in Palazzo Russo. These include a cardioid and a contact microphone, respectively, as shown in Fig. 15.

Listening Points

The three listening points have very different acoustic characteristics, offering three distinct perspectives on the relationship between the work and its surroundings, encouraging visitors to engage with various modes of listening. The *parapetto*, situated along the low stone wall that encloses the rooftop, is the point where the soundscape of San Cesario[53] is more present.The *parapetto* is located at the edge of the building, far from any reflective source, and thus achieves a wide open-air acoustic. The loudspeaker l2 is placed *outside* the Palazzo Russo, on the roof of the neighboring building (see Fig. 14). The neighboring roof is several meters below the *parapetto*: from the visitor's perspective, l2 is therefore both visually and acoustically shielded by the stone wall constructions. As a result, its sound is distant and muffled, mixed with the traffic

53 The soundscape of San Cesario consists of a mixture of rural and urban elements.

Figure 15. Kitchen terrace. Left: microphone positioned next to the water pipe. Right: contact microphone mounted on the chimney connected to the boiler.

and chatter coming from the adjacent street. On the same vertical axis, the water pipe that is installed on top of the stone wall also vibrates. The water pipe runs around the entire perimeter of the roof, and towards the north terrace it is used as a structural element to keep the two bed ornaments in place (see Fig. 14). Being mechanically coupled, when the ornaments are set into vibration by the transducers, the vibration is transmitted all along the water pipe. Due to the curvature of the roof, this becomes especially audible when standing in front of the *parapetto*.

The *collettore*, located in the center of the rooftop, is more isolated from the traffic and chatter of the piazza below. The stone basin creates an acoustic niche with quite strong reflections that color the sound of the loudspeaker l1 with a bathtub-like reverb. At one end, the old antenna leans directly against the loudspeaker, causing it to vibrate at some very low frequencies. A cardioid microphone is inserted at the other end of the antenna, using its 4 meter metal tube as a long and narrow resonator. Due to the special coloration of the stone basin, which stands out acoustically from the surrounding soundscape, the *collettore* favors a more direct listening experience, as opposed to the more nuanced one of the *parapetto*.

The *specola* is the privileged listening point of the *Observatorium*. It is centered around two brass resonators that act as a kind of ear prosthesis: when a visitor sits between them, the surrounding acoustic environment is heavily filtered by the brass tubes, favoring an immersive, contemplative form of listening that focuses on some particular sonic aspects of the San Cesario soundscape. One of these is the wind, an almost ubiquitous element on the rooftops in the small town. The two brass ornaments are positioned at an angle that allows the wind to blow through them, producing whistling and blowing effects that are sometimes reminiscent of more traditional wind instruments. Each of the two ornaments is also modified by inserting a DPA 4060 omnidirectional microphone and a Visaton BS76 transducer at the opposite ends (see Fig. 16). The DPAs are mounted using generic plastic valves from a local hardware store, which have the dual function of holding the microphones in place and blocking sounds coming from the sides. In other words, the valves modifies the directional characteristics of the lavaliers, so that they pick up mostly sounds coming from the listening cavities themselves. In the *specola*, the two lavaliers are in a feedback relationship with the two transducers, meaning that the microphone signals are recursively amplified to the point of producing static Larsen tones. Due to the specific construction of the listening space, when a visitor sits between the two ornaments, the slightest head movement dramatically affects the feedback process itself (see Fig. 17). The head,

Figure 16. Left: DPA 4060 in black plastic valve. Right: Visaton BS76.

and the act of listening itself, essentially becomes a filter that materially affects the sound being heard. The exploration of such tiny movements is also facilitated by the spcecific shape of the cavities of the bed ornaments: various resonance frequencies can be discovered by simply tilting the head back and forth at different angles.

Feedback Circuits

The *specola* is not the only audio feedback loop in *Observatorium*. In fact, there are several of them, both local (for example, the microphone in the antenna feeds back into the loudspeaker in the *collettore*) and distributed all over the roofs and terraces. Based on on-site experimentation, I composed two sets of circuits, as shown in Fig. 19. The two circuits differ mainly in the balance between *local* and *distributed* feedback loops. In circuit B feedback loops take place in contained spaces, over short distances, working mostly with Larsen tones. In circuit A microphones are much farther away from the loudspeakers, turning the feedback relationship into a kind of distributed amplification of the sounds of – and around – the palace, and using its architectural features as resonators. In other words, both circuit A and circuit B explore the building as a walkable, distributed feedback instrument, although they emphasize different acoustic aspects of its construction.

The two feedback circuits are implemented in a SuperCollider patch that allows to crossover between them. In *Observatorium*, the balance between the circuits is directly coupled to a rough analysis of the sounds picked up by the two DPA microphones (see l1 and l2 in Fig. 18), in a double inverse relationship which combines both negative and positive feedback principles. In particular, the patch calculates the spectral centroid of the signals coming from the two lavaliers mounted in the *specola*. When

Figure 17. Specola listening space.

the spectral centroid moves towards the high register, the connections in circuit A are amplified, while those in circuit B are suppressed. A darker spectrum will have the opposite effect, amplifying circuit B and suppressing circuit A. This creates a situation where the two circuits are in a constant crossover relationship, that depends on the precise conditions which are found in the listening space of the *specola*. Consequently, when one sits in the *specola* and listens between the two bed ornaments, the very act of listening directly recomposes the current feedback circuit. In other words, the visitor's head itself acts as a concrete low-pass filter between the two lavalier microphones, and the slightest movement at this precise location causes dramatic changes both locally (in the audio feedback taking place between the ornaments) and throughout the building. Thus, visitors listen to the sound work and the building, but the sound work also listens to its visitors and adapts to their listening[54].

In *Observatorium*, then, feedback is used, at various levels, as an instrument to investigate spaces of listening. The Palazzo Russo itself, in this context, is both a sounding instrument *and* a listening site. Its network of feedback relationships is constantly reshaped by its visitors, in a hybrid feedback loop in which the two are in a mutual listening relationship. Listening is thus framed not as a passive act, but rather as an active form of attending that is never neutral, inviting to reflect on the relationship between the (listening) self and its (acoustic) environment.

Outlook

This article discussed feedback from a multiplicity of perspectives: as a vehicle for exploring specific spaces, materials, or phenomena; as a compositional technique for placing such spaces, materials and phenomena at the center of sound works; as a structural element that expands to compositional notions of network and adaptivity. Feedback instruments have been framed as mediators between artistic concerns and material contingencies, but also as site of inquiry in themselves. Although feedback

[54] *Observatorium* sound and video recordings are available here: https://www.researchcatalogue.net/view/2908423/2908424. Accessed March 15, 2025.

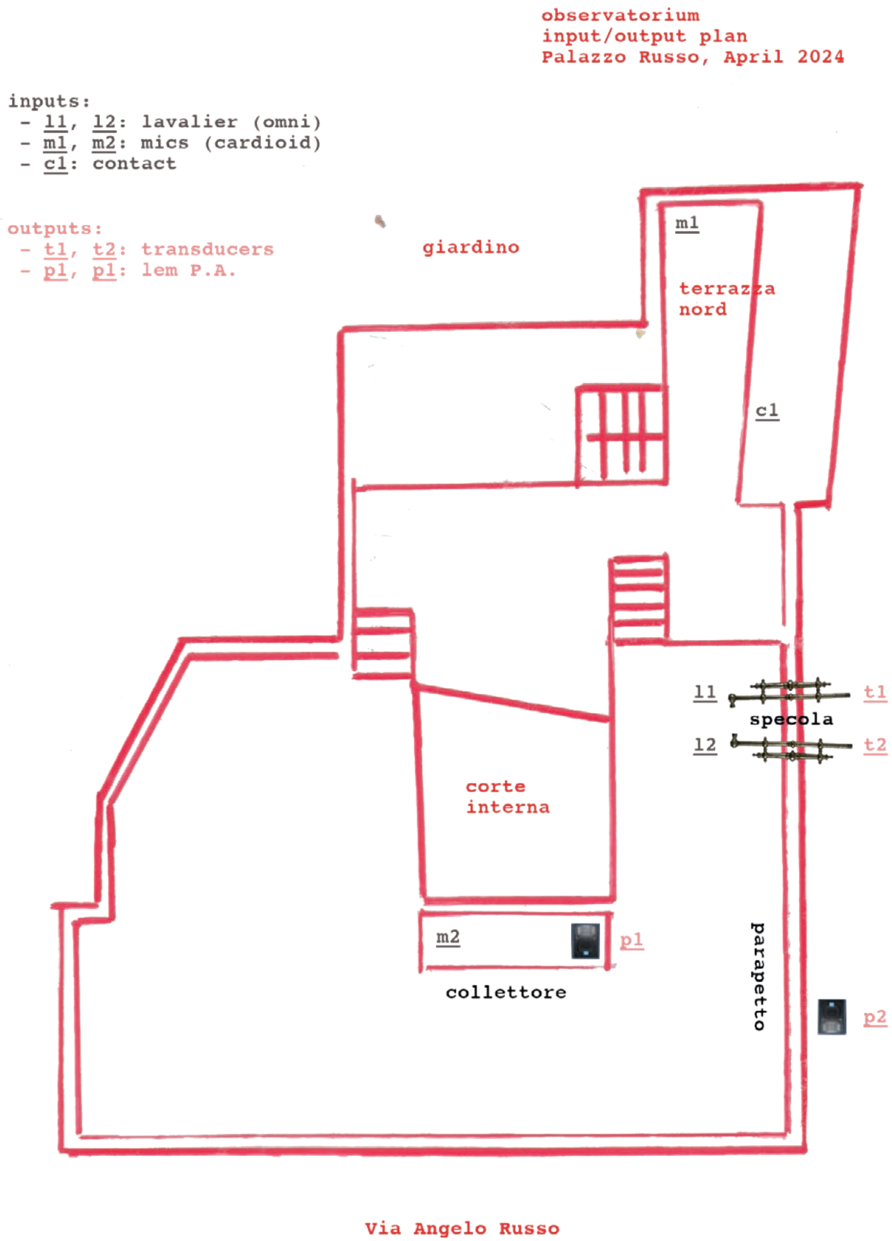


Figure 18. *Observatorium*: input / output plan.

seems to resist a univocal definition – it rather tends to diffract into a variety of fields and applications – all of the approaches presented in this text share a certain experimental spirit, that feedback seems to inspire, animate and sustain. This text is written with the intention of encouraging further reflection on the instruments, media and

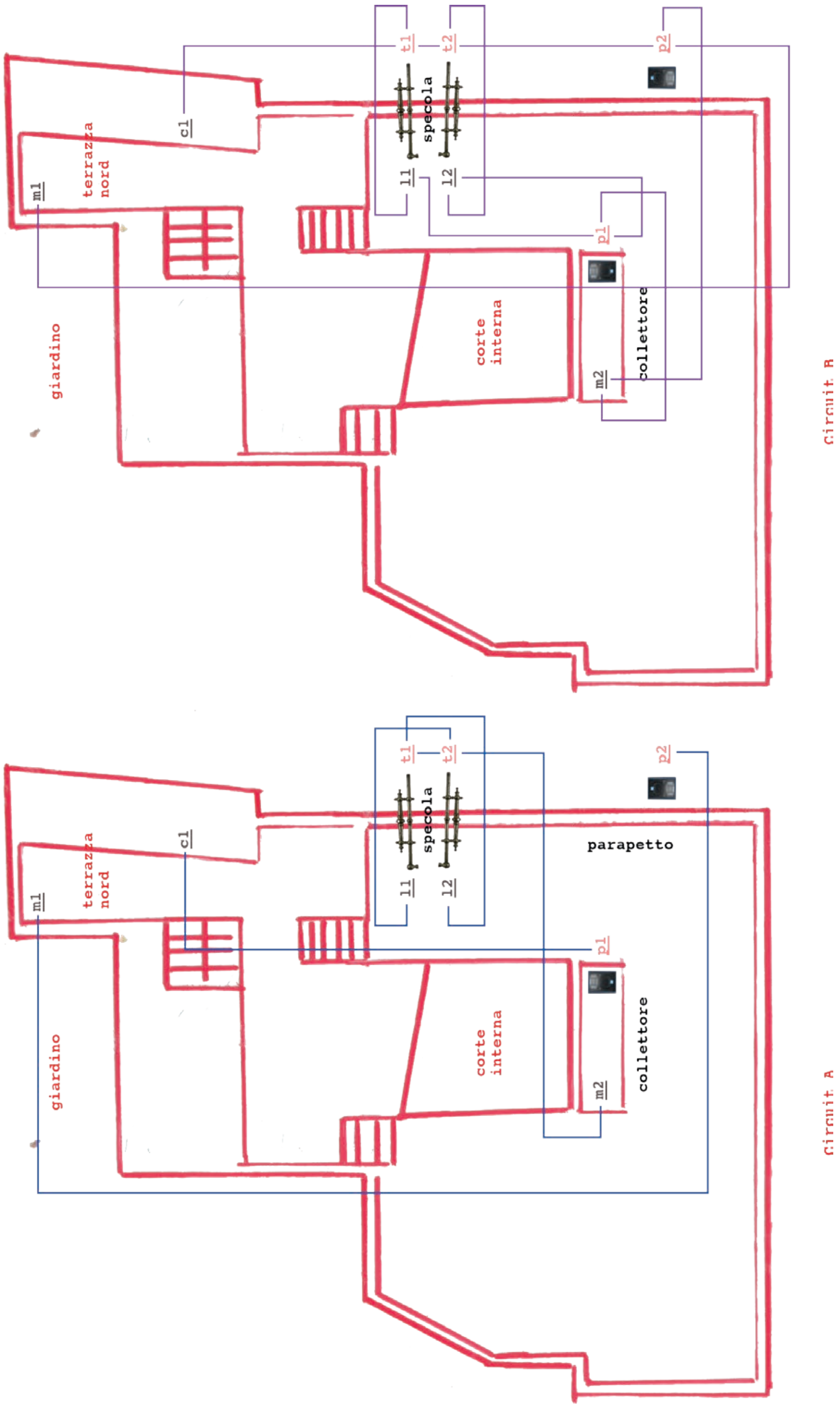


Figure 19. *Observatorium*: feedback circuits A and B.

spaces of feedback experimentation, in the hope that feedback's enigmatic status will nevertheless remain intact.

Acknowledgements

Part of the research presented in this text is supported by the artistic research project *simularr*, within the PEEK framework of the Austrian Science Fund FWF (AR 714-G). *simularr* is hosted 2023 – 2025 at the Gustav Mahler Private University for Music (GMPU) in Klagenfurt. *Klangnetze* was jointly funded by Department 9 Culture, Europe, Sport of the State of Styria (Abteilung 9 Kultur, Europa, Sport) and the Austrian Federal Ministry for Arts, Culture, Public Service and Sport (Bundesministerium für Kunst, Kultur, öffentlichen Dienst und Sport).

References

Ahamed, Syed V. 2014. "Foundations of Knowledge." In *Next Generation Knowledge Machines*, edited by Syed V. Ahamed, (pp. 171-189). Oxford: Elsevier. https://doi.org/10.1016/B978-0-12-416629-5.00007-4.

Ahamed, Syed, V. 2017. "Real Space, Knowledge Space and Computational Space." In *Evolution of Knowledge Science*, edited by Syed V. Ahamed, (pp. 431-450). Boston: Morgan Kaufmann. https://doi.org/10.1016/B978-0-12-805478-9.00027-3.

Burns, Christopher. 2004. "Designing for Emergent Behavior: A John Cage Realization." In *International Computer Music Conference*. San Francisco: International Computer Music Association.

Collins, Nicolas. 2002. "All This and Brains Too." *Resonance Magazine* 9(2): 6-7, edited by Knut Aufermann.

Collins, Nicolas. 2021. "Improvising with Architecture. Pea Soup and Related Work with Audio Feedback." *Resonance* 2(2): 168-181. https://doi.org/10.1525/res.2021.2.2.168.

Di Scipio, Agostino (ORCID iD: https://orcid.org/0000-0001-7953-9508). 2003. "'Sound Is the Interface': From Interactive to Ecosystemic Signal Processing." *Organised Sound* 8(3): 269-277. https://doi.org/10.1017/S1355771803000244.

Di Scipio, Agostino. 2011. "Listening to Yourself Through the Otherself: On Background Noise Study and Other Works." *Organised Sound* 16 (2): 97-108. https://doi.org/10.1017/S1355771811000033.

Di Scipio, Agostino, and Dario Sanfilippo. 2019. "Defining Ecosystemic Agency in Live Performance." *Array.* 2019: 28-43. https://doi.org/10.25370/array.v20192655.

Di Scipio, Agostino, and Dario Sanfilippo. 2021. "Machine Milieu." Toxo Records.

Döbereiner, Luc. 2022. "The Small Learning." https://klangnetze.mur.at/en/works/das-kleine-lernen/. Accessed March 15, 2025.

Döbereiner, Luc, and David Pirrò. 2023. "Contingency and Synchronization: Conceptual Framework, Artistic Experiments and Speculative Syn-theses." *Musica/Tecnologia* XVII: 95-116, edited by Giulia Vismara. https://doi.org/10.36253/music_tec-15198.

Dombois, Florian (ORCID iD: https://orcid.org/0009-0002-4637-7842). 2019. "Art with a T." In *Between / Beyond / Hybrid. New Essays on Transdisciplinarity*. Diaphanes.

Elblaus, Ludvig (ORCID iD: https://orcid.org/0000-0002-4422-5223), and Gerhard Eckel (ORCID iD: https://orcid.org/0000-0002-7061-0897). 2020. "Acoustic Modelling as a Strategy for Composing Site-Specific Music." In *AM '20: Proceedings of the 15th International Audio Mostly Conference*, pp. 69-76. Graz, Austria. https://doi.org/10.1145/3411109.3411141.

Elblaus, Ludvig. 2023. "Rotoscillombrage." https://www.utrumque.com/. Accessed March 15, 2025.

Longobardi, Ciro, and Agostino Di Scipio. 2012. "John Cage. Electronic Music for Piano." Stradivarius STR33927.

Lucier, Alvin. 2002. "My Affairs with Feedback." *Resonance Magazine* 9(2): 24-25, edited by Knut Aufermann.

Maturana, H. R., and F. J. Varela. 1991. *Autopoiesis and Cognition: The Realization of the Living*. Springer.

Meric, Renaud, and Makis Solomos. 2014. "Analysing Audible Ecosystems and Emergent Sound Structures in Di Scipio's Music." *Contemporary Music Review* 33(1): 4-17. https://doi.org/10.1080/07494467.2014.906690.

Peters, Deniz. 2017. "Instrumentality as Distributed, Interpersonal, and Self-Agential: Aesthetic Implications of an Instrumental Assemblage and Its Fortuitous Voice." In *Musical Instruments in the 21st Century: Identities, Configurations, Practices*, edited by Till Bovermann, Alberto de Campo, Hauke Egermann, Sarah-Indriyati Hardjowirogo, and Stefan Weinzierl, (pp. 67-78). Singapore: Springer. https://doi.org/10.1007/978-981-10-2951-6_6.

Pirrò, David, Daniele Pozzi, Luc Döbereiner, Margarethe Maierhofer-Lischka, Veronika Mayer, and Hanns Holger Rutz. 2022a. "Klangnetze." *Project Website*. https://klangnetze.mur.at/en/. Accessed March 15, 2025.

Pirrò, David. 2022b. "Klangnetze." *Gitlab Repository*. https://gitlab.mur.at/pirro/klangnetze/. Accessed March 15, 2025.

Pozzi, Daniele (ORCID iD: https://orcid.org/0009-0006-3478-4757). 2022a. "A Solar-powered Embedded System for Ecological Audio Signal Processing." *Instructables*. https://www.instructables.com/A-Solar-powered-Embedded-System-for-Ecological-Aud/. Accessed March 15, 2025.

Pozzi, Daniele. 2022b. "Trópos." https://klangnetze.mur.at/en/works/tropos/. Accessed March 15, 2025.

Pozzi, Daniele. 2023. "Trópos." In *xCoAx 2023 11th Conference on Computation, Communication, Aesthetics & X*, edited by Luísa Ribas, André Rangel, Miguel Carvalhais, and Mario Verdicchio, (pp. 378-382). Weimar, Germany. https://doi.org/10.34626/xcoax.2023.11th.378.

Rheinberger, Hans-Jörg. 2008. "Schnittstellen. Instrumente und Objekte im experimentellen Kontext der Wissenschaften vom Leben." In *Schnittstellen. Instrumente und Objekte im experimentellen Kontext der Wissenschaften vom Leben*, (pp. 1-20). De Gruyter. https://doi.org/10.1515/9783110199949.1.

Rheinberger, Hans-Jörg. 2016. "Afterword: Instruments as Media, Media as Instruments." *Studies in History and Philosophy of Biological and Biomedical Sciences* 57: 161-162. https://doi.org/10.1016/j.shpsc.2016.03.002.

Rheinberger, Hans-Jörg. 2018. *Historische Epistemologie zur Einführung*. Junius Verlag.

Rutz, Hanns Holger. 2022. “Tagfalter by Hanns Holger Rutz.” https://www.researchcatalogue.net/view/1506240/1644761. Accessed March 15, 2025.

Sanfilippo, Dario (ORCID iD: https://orcid.org/0000-0002-4036-2079). 2020. “Complex Musical Behaviours via Time-Variant Audio Feedback Networks and Distributed Adaptation: A Study of Autopoietic Infrastructures for Real-Time Performance Systems.” Edinburgh Research Archive. https://doi.org/10.7488/era/491.

Sanfilippo, Dario. 2021. “Complex Adaptation in Audio Feedback Networks for the Synthesis of Music and Sounds.” *Computer Music Journal* 45(1): 6-23. https://doi.org/10.1162/comj_a_00591.

Sanfilippo, Dario, and Andrea Valle. 2013. “Feedback Systems: An Analytical Framework.” *Computer Music Journal* 37(2): 12-27. https://doi.org/10.1162/COMJ_a_00176.

Schmele, Timothy. 2024. “Spherical Glitch Study.” In *Speculative Sound Synthesis Symposium*. Graz, Austria. Accessed March 15, 2025.

Waters, Simon. (ORCID iD: https://orcid.org/0000-0002-7668-1880). 2007. “Performance Ecosystems: Ecological Approaches to Musical Interaction.” http://www.ems-network.org/IMG/pdf_WatersEMS07.pdf.

Waters, Simon. 2013. “Touching at a Distance: Resistance, Tactility, Proxemics and the Development of a Hybrid Virtual/Physical Performance System.” *Contemporary Music Review* 32(2-03): 119-134. https://doi.org/10.1080/07494467.2013.775818.

Feedback System and Performative Expression in Totem

Giovanni Verga
Accademia di Belle Arti di Frosinone, Accademia di Belle Arti di Brera, Italia
giovanniverga76@gmail.com

Abstract. This paper delves into the compositional process and performance of the work *Totem*, a piece I composed in 2019 triggered by the desire to explore and manage the unpredictability of feedback system. The paper outlines the development of the created system that leverages physical feedback, by incorporating acoustic instruments and exploring their resonant properties. An analysis of instruments preparation, system components, and the performative gestures highlights the symbiotic relationship between the musician and the feedback mechanism. The dramaturgical aspect emphasizes the ritualistic interactions of the performer with the feedback system, symbolizing a journey towards self-acceptance and challenging societal norms. The paper also discusses the technical setup, including the system in Reaper and Max, score, spatialization technique, and the collaborative dynamics between the performers. Insights from the performer's experience further contextualize the performative and sonic exploration within *Totem,* offering a comprehensive overview of the piece's approach to live electronic music performance.

Keywords: feedback system, live electroacoustic music, performative gesture.

About Totem *and its Context*

Totem is a composition created in 2019 to explore and manage the unpredictability of feedback systems through a blend of performative gesture, live electronics, and spatialization. The piece was premiered at the Studiosaal of the HFM Hanns Eisler Berlin as part of the concert program of the Berliner Lautsprecherorchester (BLO), with performer Dustin Zorn on stage and spatialization by Wolfgang Heiniger.

The BLO, developed by Wolfgang Heiniger and Kirsten Reese, features an orchestra of approximately 40 individually controllable loudspeakers, each adjustable in volume. These loudspeakers range from standard models, familiar from home stereo systems and sound reinforcement setups, to exotic transducers and structure-borne sound transducers.

The loudspeakers, built into unique resonators, transform from mere sound projectors into musical instruments. Unlike conventional setups that aim for perfect reproduction of a virtual sound field, the BLO emphasizes the unique sounds of the loudspeaker instruments, creating an interplay of sounds within an artificial space (Heiniger, Wolfgang. "Mehr! Kleines Handbuch des Lautsprecherorchesters." Draft version, Unpublished, April 9, 2015). Live recording is avalaible at this link[1].

My particular interest in physical feedback lies in its ability to generate complex sounds. Unlike electronic feedback, which involves digital circuits and processes,

[1] https://www.youtube.com/watch?v=UnsXmSA2tug&t=81s.

Musica/Tecnologia, 19 (2025), ISSN online 1974-0050, ISSN print 1974-0042, pp. 79-93
DOI: 10.36253/music_tec-15470 – http://www.fupress.com/mt

physical feedback utilizes the sound produced by acoustic instruments or other sound sources.

Before composing *Totem*, I selected the instruments to be used. I chose a snare drum, a tom-tom, and a plastic construction tube, each prepared with a speaker attached inside. To understand their frequency and resonance responses, I used a dynamic microphone moving it closer and further away in order to generate feedback.

The tom-tom, with its deep shell and wooden construction, produced a resonance that emphasized low frequencies. The plastic construction tube, on the other hand, had a sharp, piercing quality and behaved similarly to a notch filter. The snare drum added a vibrant, cutting timbre, rich with harmonics due to its metal shell and tensioned snares.

By combining these instruments, I achieved a complex interplay of timbres. The low-frequency resonance of the tom-tom contrasted with the sharpness of the plastic tube, while the harmonic richness of the snare drum further enriched the soundscape.

Finally, to address any unwanted sound effects, I defined the parameters for a limiter applied to the input volume and preamp, ensuring a better control over the sound dynamics within the system.

By transforming these instruments from their traditional roles into 'sound objects', I aimed to explore their resonant properties and timbral characteristics independently of their conventional uses. This approach allowed for a more experimental exploration of sound.

Another reason *Totem* relies on physical feedback is that, instead of concentrating on the performer's manipulation of the feedback, exploring the resonant properties of the prepared instruments allows for greater flexibility in gesture.

In *Totem*, the gesture is primarily one of impulse, characterized by a strong theatricality that serves as a fundamental key to the work's meaning. This theatricality manifests through the dynamic interplay between the musician and the prepared instruments, creating a performance environment that emphasizes spontaneity and interaction. The gestures involved are not merely mechanical but are infused with intention and expressiveness.

Simon Emmerson discusses the significance of gesture in live performance, highlighting how physical movements can shape the auditory landscape and influence the listener's perception. In *Living Electronic Music*, Emmerson explores how physical gestures interact with electronic sound to create a performative dialogue, thereby enhancing the overall artistic expression (Emmerson, 2007, pp. 93-95). He introduces the distinction between 'local' and 'field' functions, where 'local' refers to a direct, perceivable relationship between a performer's action and the resulting sound, while 'field' encompasses broader sonic processes that establish a sense of space or wider context beyond the performer's immediate actions (Emmerson, 2007, pp. 94-95).

In *Totem*, this concept is particularly evident as each impulsive gesture triggers a sonic response, reinforcing the idea that the physical actions of the performer are intrinsically linked to the resultant sound. Furthermore, the field function is embodied through the role of the second performer, who is positioned not on stage but at the mixing console. This 'hidden' performer manages the spatialization of sound, effectively 'playing the space' and shaping the listening environment through complex sonic processes. This approach aligns with Emmerson's notion that field functions can involve activities not directly localized to the main performer but contribute to establishing a dynamic and evolving auditory landscape (Emmerson, 2007, pp. 94-97).

The relationship between local and field not only enriches the listening experience but also deepens the emotional resonance of the piece, inviting reflection on the nature of sound and performance itself. By engaging with these impulses and spatial manipulations, *Totem* becomes a living entity, continuously evolving through the interactions of the main performer, the second hidden performer at the mixing console, the feedback system, and the performative space, embodying Emmerson's theories on the interplay between local and field functions.

Technical Setup: Instruments Preparation and System Configuration

The setup for *Totem* includes three main instruments, each chosen for its distinct sonic properties:

- Snare Drum
- Tom-Tom
- Plastic Construction Tube

Each instrument is modified with speakers placed inside to exploit their resonant characteristics. The performer uses a dynamic microphone to interact with the instruments, generating feedback by varying the distance and angle of the microphone through specific gestures, such as sweeping motions, rotations, or sudden changes in proximity. These gestures allow the performer to shape the timbre, intensity, and duration of the sound in real time. The captured sound is processed through the system described in detail later in this paper, then diffused and refined by the second performer, who manages the spatialization. The sound is then reintegrated into the performance space, allowing the exploration of a wide range of sonic textures, from subtle resonances to powerful and dynamic sounds.

The sound processing is controlled through a combination of Max and Reaper. The Reaper MIDI score sends control messages to the Max patch, which manages various parameters, including pitch, delay, and auto-gain. The patch processes the sound in real time and routes the output to six distinct channels. These channels are then sent to the second performer located in the control room, who manages the spatialization by distributing the sound across a larger multi-channel system, shaping the listening environment dynamically.

Dramaturgy

As shown in Fig. 1, the assemblage of the three instruments on stage represents a phallocentric totem.

Figure 1. The setup of *Totem*.

Over the course of the piece, the performer's interactions become more deliberate, almost ritualistic, symbolizing the process of self-discovery that comes with confronting societal taboos and embody the tumultuous journey of self-acceptance.

The performer's interactions with the feedback become a bold declaration of embracing one's authentic sexuality, regardless of societal norms or judgments. The piece challenges both performer and audience to confront the discomfort of crossing boundaries and questioning norms.

It is in this scenario that the performative gesture assumes a very important role: it does not shape, it does not manipulate the feedback but is subject to it and is aware of it.

As if the feedback were imposed by a hierarchical system, the performer seeks freedom.

The gesture, in its being an impulse, draws when it seeks and dreams of its freedom of expression, it asks for confirmation in its dialogue with the space, it becomes inflamed when it wants to break out of the norms until, by throwing the microphone into the tube, it rejects them totally, finally arriving at self-acceptance (when the performer sits down and the light in the room goes out).

Description of the system

The first step was to establish a hierarchical system that could manage or at least reduce the unpredictability of feedback. I wrote a patch in Max and a MIDI score in Reaper.

The function of the Reaper project is to send information, while the patch operates on this information. Between these two functions lies the gesture of the performer, whose role is to direct the microphone to generate the sound event. Without this precise gesture, the desired sound event would not be generated.

In *Totem*, the musician on stage does not manipulate or control the feedback but merely generates the sound event through their gesture. These gestures are written in a score that consists of graphics and text describing the type of gesture to be performed.

On the opposite side of the room, at the mixing console and not on stage, is the second performer, who spatializes what is generated. The spatial movements are not written but are agreed upon at the time of the performance, allowing for spontaneous interpretation by the performer and establishing a dialogue between the two performers. This might be perceived as a manipulation of the gesture performed by the first performer, but in reality, the second performer, provides an image and add color to the sound in the performance space.

MIDI Score, Max Patch and Score

The piece consists of:
- Reaper MIDI score
- Max Patch:
- Graphic score with textual annotations

As shown in Fig. 2, the CC messages written in the Reaper MIDI Score are sent to the Max Patch which executes.

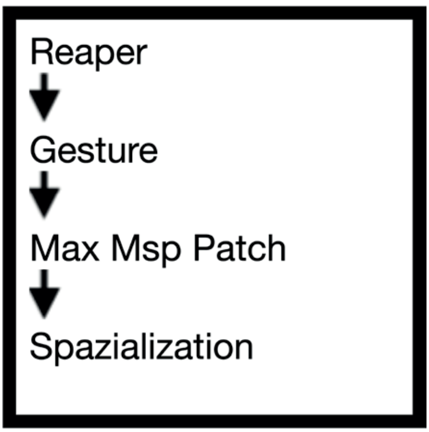


Figure 2. The data flow in *Totem*.

Messages		Parameters
Reaper		*Max*
Velocity	→	Random Pitches On
Velocity OFF	→	Random Delays On
07 Volume MSB	→	Fader Pitches
08 Balance MSB	→	Volume Microphone
CC 09	→	Volume Delay
10 PAN POSITION	→	Volume Pink Noise
12 Control 1 MSB	→	Volume AutoGain
16 GP SLIDER 1	→	Feedback Chords
CC 30	→	AutoGain speed (rallentando and accelerando)
39 Volume LSB	→	Filter Cutoff
CC 53	→	Preamp Volume
CC 60	→	AutoGain Speed

Figure 3. Correspondance between software controllers and audio parameters.

The list in Fig. 3 explains the relation between software controllers and audio parameters.

In Fig. 4 are two examples of Reaper MIDI score.

The Max patch can be explained by breaking it down into several sections:

- Input Section: this section handles the incoming audio signals from the microphone. It ensures that the input level is set correctly and prepares the signals for further processing.
- Pitch section: it allows for versatile control and variation of the generated frequencies in two ways:
  1. it generates a sequence comprising six distinct pitches that are randomly distributed across six distinct outputs;
  2. the pitch series can ascend and descend while preserving the relationships between the frequencies.
- Delay section: delay effects are used to enhance depth, spatialization, and rhythmic complexity. As in the pitch section, delay sequences are distributed across

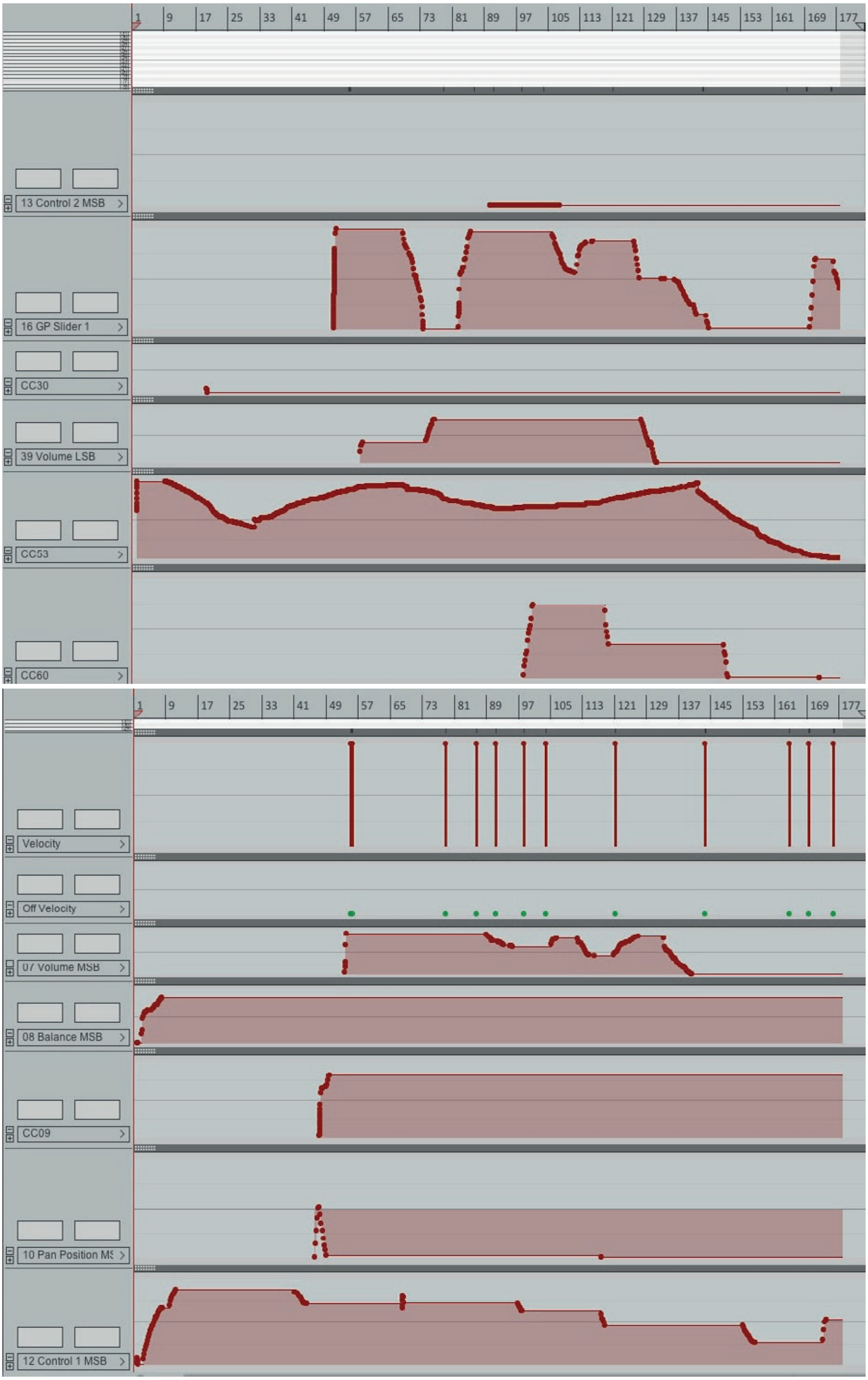


Figure 4. Reaper MIDI score.

six distinct outputs, contributing to the creation of randomly generated rhythmic structures.
- Autogain Section: governed by automatic gain control, this section dynamically adjusts the amplitude of the audio signals to maintain consistent volume levels. It has a speed feature that can introduce rhythmic variations and vibrato effects.
- Color Section: this section modifies the timbre and the quality of the audio signals. It includes pink noise that is produced inside the instruments and interacts with the feedback sound, and a cutoff filter which contributes to add color and cut undesired frequencies.
- Routing Section: it manages the distribution of audio signals to different six outputs. It ensures that each processed signal is correctly routed to six outputs.

Score

The score provides detailed instructions while allowing room for the performer‘s creative interpretation, particularly in aspects like dynamics and tempo. This approach aligns with Simon Emmerson's concept of "control intimacy," which builds on F. Richard Moore's (1988) idea that effective mappings between performer actions and sound results are essential in live electronic music. Moore argues that "control intimacy" enables performers to achieve subtle and nuanced control over sound, a quality that is often compromised in electronic performances due to the limitations of loudspeakers and amplification (Moore, 1988, p. 21). Emmerson (2007) further elaborates that maintaining this intimacy is crucial for preserving the sensitivity and expressiveness associated with traditional instruments, even within technologically mediated performances (p. 95).

In *Totem*, the score‘s instructions for gestures – such as moving a microphone toward or away from an instrument – are precise but not rigid, allowing the performer to adapt in real-time to the evolving soundscape. This flexibility supports a dynamic relationship between performer and sound, ensuring that the performance remains coherent and expressive, as Emmerson suggests. This approach helps to bridge the gap between "real" and "imaginary" soundscapes, as discussed by Trevor Wishart (1986), who distinguishes between sonic landscapes that are real, imagined, or a combination of both, shaped by the performer's actions and the spatial context (pp. 146-147).

The score‘s aleatory elements, including variations in repetition and timing, are designed to accommodate gestures that initiate sound events, which are then processed and spatialized. The timeline‘s alignment with specific sound events ensures a structured flow, while allowing for the expressive freedom necessary for the performer to navigate the unpredictability of the feedback system. This openness facilitates a dialogue with the second performer in the control room, responsible for spatializing the sound. Within the dramaturgy of *Totem*, this interaction between the two performers is crucial for achieving a sense of performative freedom and enriching the expressive potential of the piece.

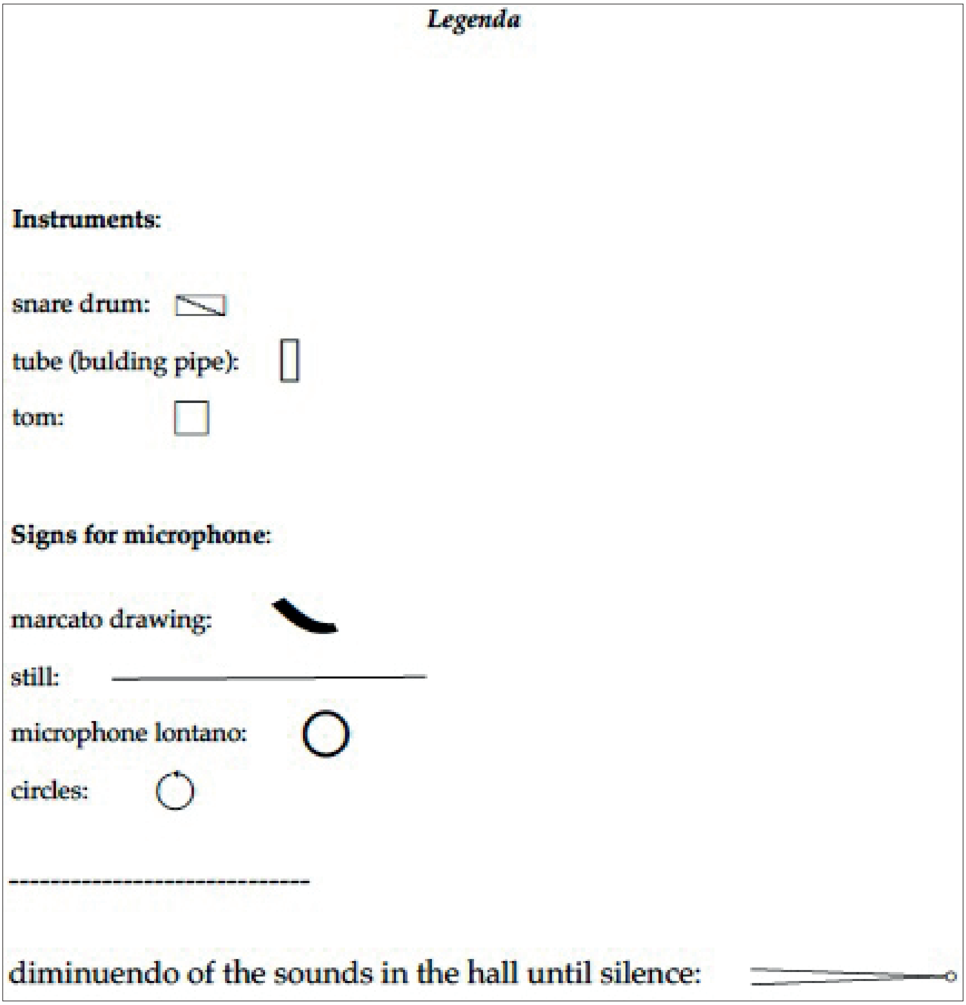


Figure 5. Score legenda.

Spazialization

Spatialization occurs on two levels. At a micro level, it stems from the routing within the Max patch, which distributes the sounds toward six distinct outputs. At a macro level, it involves the interaction of the second performer at the mixing console, who assigns these six outputs to multiple channels (based on technical feasibility) and can distribute them further across various channels. The design of the sound space rests with the spatializer, allowing for freedom of choice. This macro-level approach eliminates staticness, imbuing the piece with a certain freedom through improvisation.

The hierarchical system's role gradually diminishes, reinforced by the quality of the feedback's sound. Through the interaction between pitch and delay, the transformed

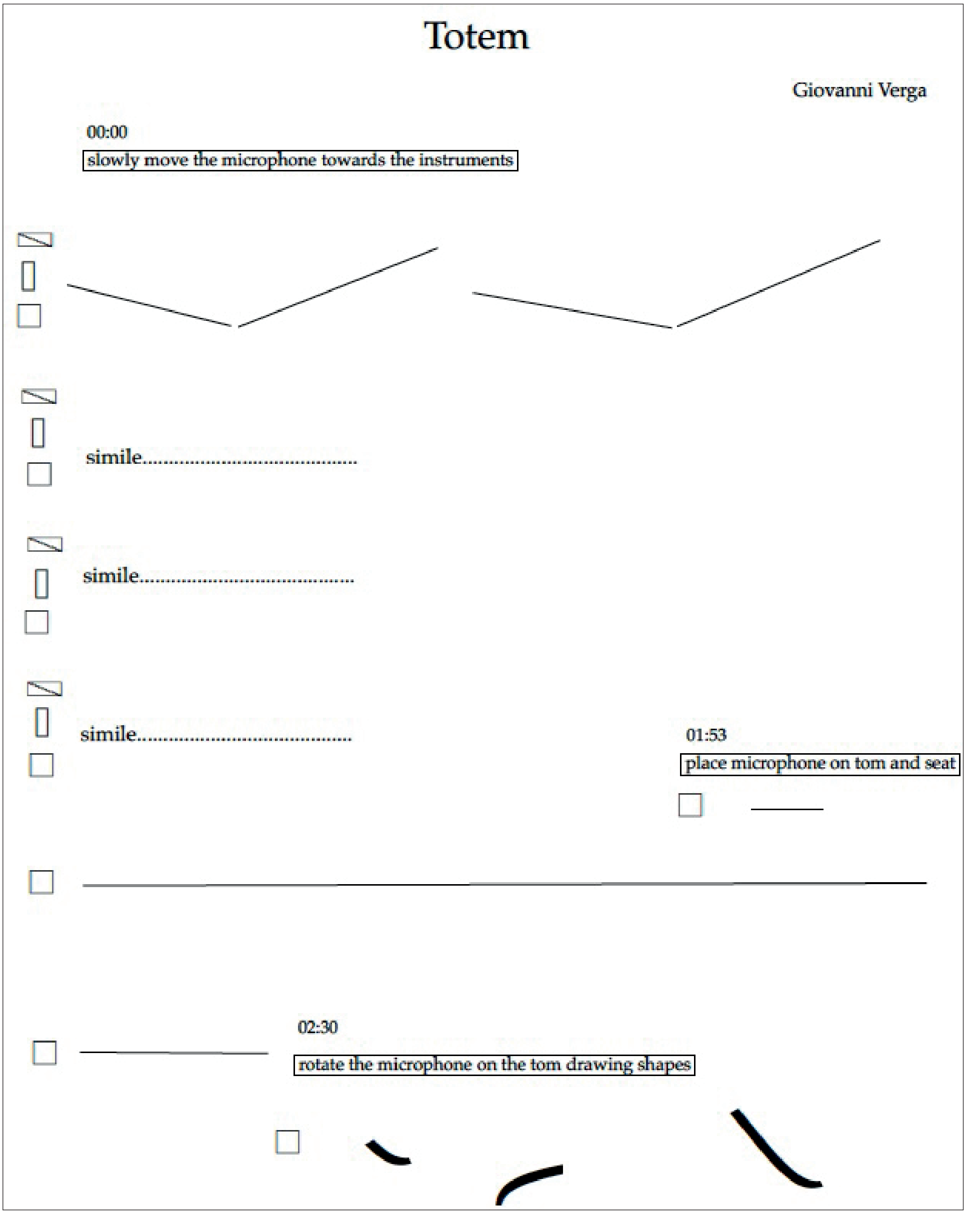


Figure 6. Score excerpts.

feedback becomes vibrant and colorful, resonating throughout the hall and complementing the performers expressive intent. This interaction expands the dialogue between the performer and the spatializer, enriching the performance space.

Improvisation in the spatialization process of *Totem* aligns with Agostino Di Scipio's idea of the performative and adaptive nature of the performance space. Di Scipio in *Sound is the Interface: From Interactive to Ecosystemic Signal Processing*,

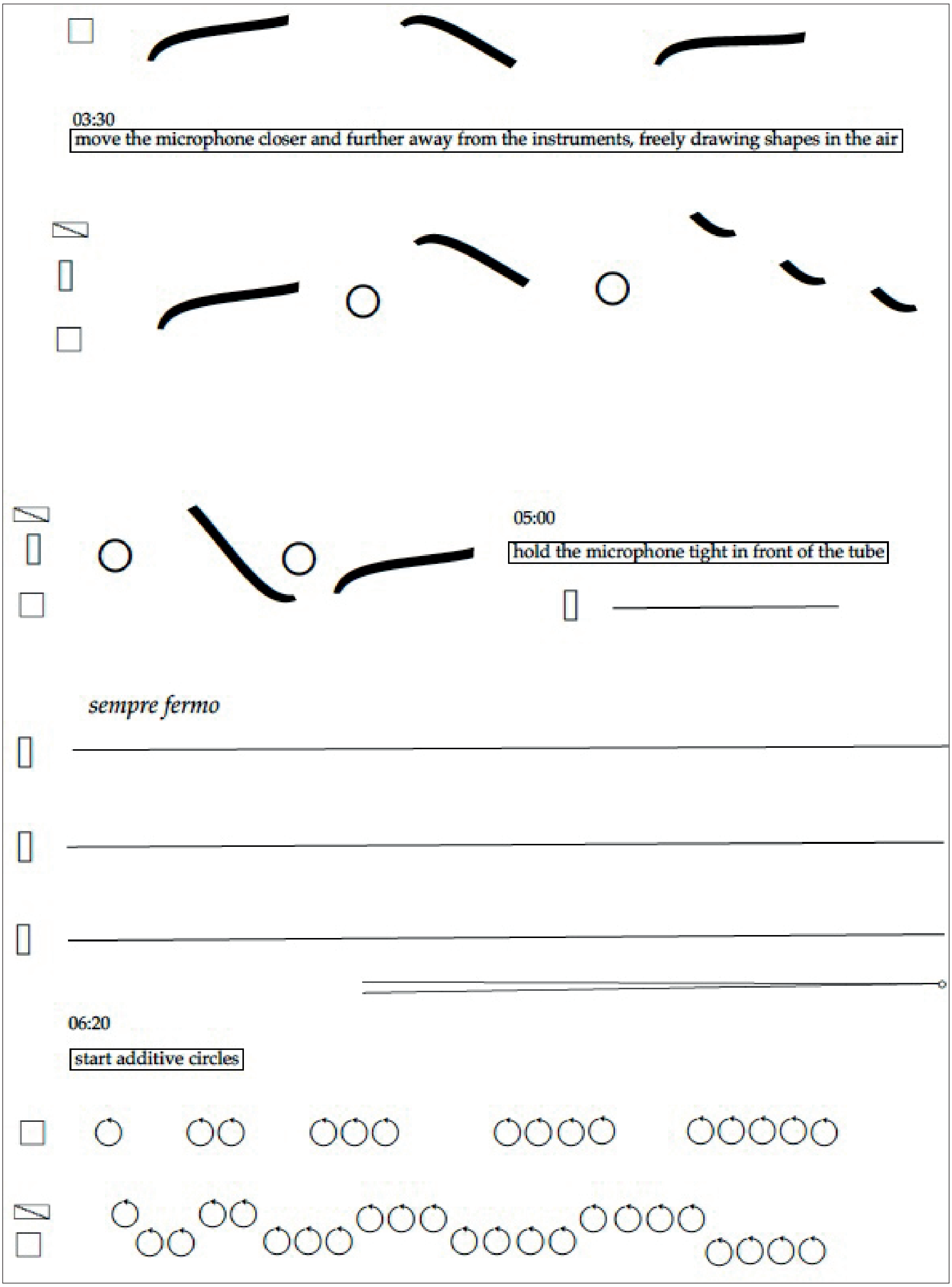


Figure 7. Score excerpts.

argues that the performance space acts not merely as a passive environment but as an active, generative element that interacts with and transforms sound. He describes this approach as a shift from traditional interactive music systems to an ecosystemic

Figure 8. Score excerpts.

perspective, where sound generation and processing are tightly coupled with the surrounding acoustic environment, forming a recursive relationship between the system and its ambiance (Di Scipio, 2003, pp. 271-273). By allowing the spatializer to improvise, *Totem* leverages this adaptive characteristic of the space, enabling real-time adjustments and enhancements to the sonic landscape. The dynamic interaction between the performer‘s gestures and the spatializers control of sound distribution creates a responsive dialogue with the acoustic environment, making the space an active participant in the evolution of the feedback sound. This approach resonates with Di Scipio's concept of a self-organizing system, where feedback from the environment continually shapes the unfolding sonic processes, reinforcing his view that the performance space plays a crucial role in shaping the sonic event (Di Scipio, 2003, pp. 272-274).

Performance and Performer

In *Totem*, the performer‘s gesture is not proprioceptive, meaning it does not directly correspond to the generation of sound or fulfill the performer‘s expectation, as described by Denis Smalley in his article *Spectromorphology: Explaining Sound-Shapes* (1997). Smalley explains that ‚proprioceptive gestures‘ are characteristic of instrumental music, where the physical action of the performer has a direct and predictable connection to the sound produced, creating ‚the feel of the sound‘ as an extension of the musician‘s body movements. This relationship allows for an anticipation of the sonic outcome based on the gesture[2].

However, in *Totem*, the musician does not experience such direct control or predictability over the sound, as the feedback system introduces an element of uncertainty. The performer is not always aware of what they are creating, making each gesture more about interaction with the system than executing a predetermined sonic intention. Despite this unpredictability, the gesture maintains a theatrical quality visible to the audience, providing the performer with a form of expressive security. This expressive quality allows the performer to contextualize and differentiate their actions, even when the feedback does not respond as expected, while still resonating with Smalley‘s notion that in electroacoustic music, gestures can serve expressive and communicative roles beyond their functional aspects.[3]

In this regard, I asked the performer Dustin Zorn some questions which I think are interesting to report here:

me: Could you please describe your experience as performer?

D. Zorn: Performing Totem was a profoundly physical experience. The inherent unpredictability of the feedback required heightened situational awareness, where the sound became directly connected to my movements. The feedback guided my hands and body, influencing where they needed or wanted to go. Decisive performative actions, whether dictated by the MIDI score, the spatialization, or my own impulses, posed a challenge: how quickly could I regain control over the sonic outcome or ‘ride‘ the chaos? This interplay between control and unpredictability created a dynamic and engaging performance environment.

me: How did you interact with the spatialization? Did it influence the performance?

D. Zorn: The spatialization fundamentally transformed the context of my performance. I became acutely aware of the changes, feeling as though I was performing in a duo situation. When the sound expanded into the hall, it felt like my auditory and situational awareness had to similarly expand. This shifting auditory landscape required me to adapt continuously, making the performance feel more collaborative and dynamic.

[2] Smalley, 1997, pp. 113-115.

[3] *Ibidem*.

me: Since your role was of merely about generating sound do you feel as co-creator of the piece ?

D. Zorn: In terms of feeling like a co-creator of the piece, I do not. The context for my actions was so meticulously detailed that my role felt more like that of an interpreter rather than a creator. The structure and instructions of the piece always guided me to where I needed to go, so my creative contribution was more about interpretation. I lent the piece my body and ears to be present in the room, bringing the composition to life through my performance. My involvement was about embodying the work and responding to its demands, rather than contributing to its creation.

Conclusion

In the compositional context of *Totem*, my intention was to blend performative gesture with feedback generation and spatialization. Rather than treating the performer as a mere manipulator of sound, I sought to elevate the significance of their gestures as creative acts that directly influence the ongoing sonic narrative. Consequently, the unpredictable nature of the feedback was intentionally left un-manipulated by the performer, entrusting this function to the software. Encouraging exploration and experimentation in sound production, this approach invites performers to engage dynamically with the sonic environment they create, adding an expressive function to their gestures. This dynamic engagement not only enriches the sonic landscape but also deepens the expressive potential of the performance, allowing the performer to interact meaningfully with the feedback and spatialization processes.

Bibliography

Di Scipio, A. (2003). Sound is the Interface: From Interactive to Ecosystemic Signal Processing. *Organised Sound*, 8(3), 269-277. https://doi.org/10.1017/S1355771803000244.

Emmerson, S. (2007). *Living Electronic Music*. Ashgate Publishing. https://doi.org/10.4324/9781351217866.

Heiniger, Wolfgang. “Mehr! Kleines Handbuch des Lautsprecherorchesters.” Draft version, Unpublished, April 9, 2015.

Moore, F. R. (1988). The Dysfunctions of MIDI. *Computer Music Journal*, 12(1), 19-28. https://doi.org/10.2307/3679834.

Saladin, Matthieu (2017). Electroacoustic Feedback and the Emergence of Sound Installation: Remarks on a Line of Flight in the Live Electronic Music by Alvin Lucier and Max Neuhaus. *Organised Sound*, 22(2), 268-275. https://doi.org/10.1017/S1355771817000176.

Smalley, D. (1997). Spectromorphology: Explaining Sound-Shapes. *Organised Sound*, 2, 107-126. https://doi.org/10.1017/S1355771897009059.

Smalley, D. (2007). Space-Form and the Acousmatic Image. *Organised Sound*, 12, 35-58. https://doi.org/10.1017/S1355771807001665.

Teruggi, D. (2007). Technology and Musique Concrète: The Technical Developments of the Groupe de Recherches Musicales and Their Implication in Musical Composition. *Organised Sound*, 12(3), 213-231. https://doi.org/10.1017/S1355771807001665.

Van Eck, C. (2017). *Between Air and Electricity: Microphones and Loudspeakers as Musical Instruments*. Chapter 4: "Movement, Material, and Space: Interacting with Microphones and Loudspeakers." Bloomsbury, (pp. 83-138). https://doi.org/10.5040/9781501327636.

Weibel, P., ed. (2019). *Sound Art: Sound As a Medium of Art*. Karlsruhe, Germany: ZKM/ Center for Art and Media.

Williamon, A. (2004). "Feedback learning of musical expressivity", in A. Williamon (ed.), *Musical Excellence: Strategies and Techniques to Enhance Performance*. Oxford: Oxford Academic, (pp. 247-270). https://doi.org/10.1093/acprof:oso/9780198525356.003.0013.

Wishart, T. (1986). *On Sonic Art*. Harwood Academic Publishers, (pp. 146-147).

Biographies

Eric Maestri is an Italian composer and musicologist based in France, whose music transcends borders. His works span instrumental, vocal and electroacoustic compositions. His creative approach is rooted in the interplay of time and writing, drawing inspiration from the concept of archi-writing. Notable works include *La musica che non ho in mente, Visioni* (premiered at the Venice Biennale 2013), *Le Cose* and *"Sound"*. He is member and founder of the composers' collective /nu/thing. Eric collaborates with groups like Quatuor Diotima, Ensemble musikFabrik, l'itinéraire and L'Imaginaire, which he founded and directs. His music has been performed at prestigious venues, including Tokyo Opera City, Muziekgebouw Amsterdam, IRCAM and Présences Festival. He has published extensively about electronic and 21st-century music. He is associate professor in contemporary music at Sorbonne University. His monographic album *Le Cose* was released by Stradivarius in 2016. In 2025 his album *Flowing* will be released by Elli Records.

Daniele Pozzi is an Italian sound artist, electronic musician and researcher based in Austria. His work ranges from sound installations and electronic improvisations to sound walks and sound interventions in public space, often using cybernetic notions of feedback, network and system as central compositional principles.

In Austria and Italy he collaborates in scientific and artistic research projects on experimental computer music (*Algorithms that Matter*, Institute of Electronic Music and Acoustics Graz), cross-disciplinary collaborative practices (*Simultaneous Arrivals*, Gustav Mahler University of Music Klagenfurt / Technical University Graz), digital tools for artistic research (*Enacting Artistic Research*, University of Fine Arts Rome / Technical University Marche).

Daniele is a doctoral candidate at the University of Music and Performing Arts in Graz (KUG), focusing on feedback experimentation in electroacoustic composition. He works at the Gustav Mahler University of Music in Klagenfurt (GMPU) and collaborates with the Society for Artistic Research (SAR) as part of the management team of the Research Catalogue platform.

Musica/Tecnologia, 19 (2025), ISSN online 1974-0050, ISSN print 1974-0042, pp. 95-96
DOI: 10.36253/music_tec-xxxxx – http://www.fupress.com/mt

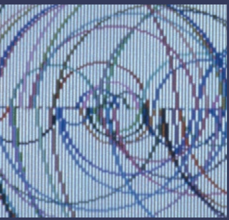
Silvia Rosani studied composition at the conservatoire in Italy and, later, at Mozarteum Universität in Salzburg, while completing a degree in electronic engineering. She holds a PhD from Goldsmiths, University of London, where she works as Associate Lecturer. Her music is performed internationally by ensembles such as Neue Vocalsolisten and Ensemble NAMES, and soloists such as pianist Xenia Pestova. Silvia performs with electroacoustic instruments she designs and produces herself. She was in a EASTN-DC residency at ZKM, at the Experimentalstudio of the SWR and at the new media centre RIXC (Riga, Latvia) through the EMAP/EMARE platform. More recently she was in residence at the Studio für Elektronische Musik (SEM) of the Akademie der Künste (Berlin, Germany) and in Stuttgart when she was awarded the Hannsmann-Poethen Literaturstipendium along with poet Kinga Tóth to produce a multimedia music theatre performance. Silvia currently teaches compoter music at the Conservatoire "B. Marcello" in Venice.

Giovanni Verga was born in Palermo, Italy, in 1976 and earned a master's degree in Art History and Musicology from the University of Palermo. Since 2011, he has lived in Berlin, where he studied electroacoustic music at HFM Hanns Eisler, completing his master's under Wolfgang Heiniger's direction.

Verga is a multidisciplinary artist whose work spans performance, composition, sound art, and contemporary theater. Specializing in electroacoustic and acousmatic music, his practice extends to site-specific installations and collaborative performative works, often integrating choreography and exploring spatial sound. His compositions frequently employ unconventional loudspeaker setups and advanced spatialization techniques.

In addition to his artistic endeavors, Verga serves as Professor of Sound Design at the Accademia di Belle Arti of Frosinone and the Accademia di Belle Arti of Brera in Milan.

Finito di stampare presso:
Logo s.r.l. Borgoricco (PD)



19 • 2025

Musica / Tecnologia

Music / Technology

Indice