COMPOSING WITH FEEDBACK

Silvia LANZALONE (info@silvialanzalone.it)[1, 2]

[1]**CRM - Centro Ricerche Musicali**, Rome, Italy
[2] **Latina State Conservatoire of Music 'Ottorino Respighi'**, Latina, Italy

ABSTRACT

The paper illustrates my compositional research aimed at the creation of musical works distinguished by the integration of computer, electronic and electroacoustic systems with instruments, or other acoustic-mechanical vibrating bodies, for the augmentation of musical sound and gesture through the feedback phenomenon.

The use of acoustic phenomena for compositional purposes, such as resonance, reflection, feedback, is part of a research area exploring the possibility of a tangible acoustic presence in the listening space.

The first part of the paper deals with historical and aesthetic considerations concerning on the creative use of feedback in music. Some previous research on augmented instruments embedding feedback systems is then presented. These studies have been carried out since the 1990s by the CRM - Centro Ricerche Musicali in Rome, where I designed and built my works and related systems.

The paper then focuses on my recent feedback augmented instrument ResoFlute, designed for the work *Èleghos*, for augmented flute, resonant pipe, and electronics (2014), and *Feedback for Two*, for 2 voices, 2 megaphones, and 2 feedback systems (2016-2018).

1. THE AESTHETICS OF FEEDBACK

The word "feedback" indicates a wide category of phenomena characterized by the effect of the action of a dynamic system on the system itself, up to the point of modifying its results. Feedback is used not only in electronics and computer science, but also in many other fields, such as biology, neurology, psychology, linguistics, acoustics, music. Feedback is essential in all traditional musical applications, from instrumental practice, including performance, interpretation, and improvisation, up to composition.

In the compositional field, the feedback was intended and produced in different ways, in the analogue and digital domain, starting from the temporal control of musical sound, up to signal processing. In *Solo* (1966) by Karlheinz Stockhausen, and in *I Am Sitting in a Room* (1969) by Alvin Lucier, for example, main compositional process consists of two different feedback systems based on tape delay, whereas in *Post-prae-ludium per Donau* (1987) by Luigi Nono, feedback delays are used in different types of digital algorithms, to create both polyphonic structures and sound processing. In art music, from the 1960s onwards, several composers have been able to use the principle of controlled audio feedback in their works, using generic or specific electroacoustic systems, often in conjunction with computer systems in more recent works. Examples of historical and recent compositions include, among others: *Electronic Music for Piano* (1964) by John Cage; *Pendulum Music* (1968) by Steve Reich; *Microphone* (1973) by David Tudor, *Pea Soup* (1974) by Nicolas Collins, *Bird and Person Dyning* (1975) and *Empty Vessels* (1997) by Alvin Lucier, *Wings* (2007-08) by Cathy van Eck, the cycle *Modi di interferenza* (2006-2010) by Agostino Di Scipio.

The development of computer systems has made possible the implementation of mathematical models for the composition of sound and music. Xenakis' insights into the application of the Gabor's model on the elementary acoustic signal, for example, bring the morphological correspondences of sounds with natural processes into music. Such correspondences are possible through the creative application of physical and mathematical theories, such as the kinetic theory of gases, or statistical theories, whose calculations require the use of computers [1]. The computer allows to create models or processes of dynamic composition of music, both in terms of sound and structural relationships between sounds. The computer becomes a real thinking 'tool', capable of establishing a feedback fast enough to ensure dynamic interaction between man and machine [2]. Feedback techniques are now often used for the implementation of self-generating systems, up to the most recent creation of music with adaptive features, as in the work of Michelangelo Lupone [3, 4]. Adaptivity is in fact possible when the system can store previous states and to react to external stimuli based on the content stored in the memory.

The interest of researchers and composers in the production and processing of sound, first analog and then digital, leads to the use of feedback for the implementation of filters and delays, at the basis of many complex digital algorithms. The use of feedback in audio digital processing also includes synthesis by physical models, developed between the 80s and 90s. See, for example: J. O. Smith and P. Cook's studies at Stanford University's CCRMA; Modalys, physical modeling synthesis program developed at IRCAM; Physical modelling synthesis of bowed strings, by L. Seno e M. Palumbi, developed at CRM-Centro Ricerche Musicali [5, 6].

Research was aimed not only at imitating instrumental sound, but above all at its reinvention, to create new virtual models. Therefore, also in this case, "speed" is fundamental, because allows the computer to perform calculations fast enough to simulate "real time" and, with suitable control tools, allows the user to "play the machine" as a musical instrument. The creation of virtual instruments is therefore also connected to the production of specific controllers, or interfaces for controlling digital algorithms. The interfaces are ergonomically designed to achieve speed and precision for calibrated data processing, as well as comfort and naturalness of gesture for expressive music performance. Research on the improvement of tactile feedback, by using force-feedback on haptic technologies, aims to make the gesture musically effective, bringing it closer to the gesture used on traditional instruments. A category of interfaces, called "hyperinstruments", picks up the articulatory characteristics of the instrumental gesture directly on the instrument itself, during performance. Some hyperinstruments are, for example: MIT's Media Lab Hyperstring Project (1990-93); STEIM Overtone Violin (2004); IRCAM Augmented Violin (2003-2006); InfoMus Lab Iperviolino (2008); STEIM Meta-trumpet (1994) Softwind MIDI Synthophone (1986); McGill University's CIRMMT Hyper-flute (1999); ICST SABRe-Sens or Augmented Bass Clarinet Research (2012); KMH of Stockholm's Hyper-Hurdy-Gurdy (2015); CCRMA's Hybrid Lutheries Project (2018). To enable the performer himself to control the electronic part, sensors are applied inside, above, and around the instrument, or on the body of the performer. The sensors detect the gestures normally used to play, or the ancillary gestures that occur while playing, or even additional utilitarian gestures, specifically identified by the composer. The ergonomic and technological choices of the type of control or sensor, the decoding of the data and the mapping of the parameters, contribute to the expressive characterization of the music. The gesture can be considered in an ergonomic / instrumental context, if linked to physiology, or a compositional / musical context, if linked to sound. The difficulty of playing an instrument is directly proportional to the possibility of the instrument itself to respond appropriately to the complexity of our physical system. However, the extension of the "gesture" does not completely solve the augmentation of the instrument, which uses computer and electro-acoustic technologies inside its vibrating body, to increase generation, processing, and diffusion of the sound. The substantial dissociation between the production of sound and music and its propagation is a condition common to a large part of electroacoustic music production. In music for instruments and live electronics, the sound diffused by the loudspeakers remains unrelated to the instrumental sound, even with respect to perceptual identification in the space of its diffusion. Electronic sound, whether instrumental, concrete, synthetic, or processed, is perceived as 'disembodied', because it is presented in a 'virtual' context, separated from the perceptual reference of the body that causes, generates, and spreads acoustic vibrations. The dissociation between the generation of music and its propagation in the space of performance is common to many contemporary music, from the first works of acousmatic music to the so-called "liquid music". The need to restore the close connection between the vibrating body and the related acoustic phenomena is intertwined with the aesthetic need to manipulate the sound material. The research area dealing with augmented instruments has a strong point in the integration of electro-acoustic and digital technologies to the mechanical structure of the acoustic instrument [7].

Feedback has been widely studied and implemented by both researchers and electronic component industries, for example in operational amplifiers and in power amplifiers (negative feedback)[1], or in oscillating circuits (positive feedback)[2], which were the basis to produce many electronic instruments and sound processing systems. Some of these are, for example: Synket, o Syn-ket, o Synthesiser-Ketoff, by Paolo Ketoff, (1963); Moog, o Moog Synthesiser, by Robert Moog (1964); Chua oscillator, o Chua circuit, by Leon O. Chua (1983).

The instrumental sound comes from the close interaction between exciter, resonator, and radiator. In "solid body" electric guitars and violins, the contribution of the sound box is replaced by an analogue or digital sound processing system and by an electroacoustic amplification system. The first electric guitar, called "frying pan", by Georges Beauchamp (1934), produced by Adolf Rickenbacker, was immediately followed by the production of "solid body" guitars, such as the Telecaster and Stratocaster models by Fender, or Les Paul by Gibson, introduced in the 1950s and still in production; the first electric violin prototypes were mainly acoustic instruments with contact microphones inside the sound box, such as the Giant-Tone Radio Violin by R.F. Starzl (1927), or electromagnetic pickups placed under the bridge, often without a sound box, as VioLectric, by Fredray H. Kislingbury (1939). Traditional sound box amplification is the cause of "annoying" feedback and its elimination allows the sound of the strings to be picked up directly, making the system much more stable. The acoustic phenomenon known as "Larsen effect"[3] is in fact considered an unwanted "accident", to be avoided, or minimized, through the production and use of specific hw/sw technologies, especially in the professional audio sector [7].

In the 1960s, Jimi Hendrix also produced feedback for expressive purposes by bringing the pickups of the electric guitar closer to the amplifier cone, consolidating a musical practice that was spreading into rock and jazz, and more generally into the context of pop music. The need to prolong the sound, has also stimulated the development of several inventions, some of which use feedback, as well as other properties of electromagnets. Some experiments were done on the piano, resulting in early prototypes, such as: Electrophonischen Apparat (1886) by Richard Eisenmann; Electrochord and Neo-Bechstein, by Oskar

[1] Feedback is defined as negative when output attenuation and system stabilization occurs.

[2] Feedback is defined as positive when output increases exponentially, up to the instability of the system.

[3] Positive feedback discovered by Søren Absalon Larsen (1871–1957).

Vierling in the 30s, at Heinrich Hertz Institute in Berlin. Some research was also done on the electric guitar, resulting in some prototypes still used today, such as: E-Bow (1969) by Greg Heet; Guitar resonator, of Vibesware Company, Fernandes system, patented in the 90s; Moog Guitar (2008) by Paul Vo. An important step in the research on augmented instruments was given by the possibility of implementing audio feedback in combination with digital signal processing systems that allow, with appropriate signal conditioning, to modify the structure of the feedback and to manipulate the sound. See, for example: Metasaxophone, by Matthew Burtner, at Stanford University's CCRMA (1997); Magnetic Resonator Piano, by Andrew McPherson, at Centre for Digital Music of Queen's Mary University of London (2010); Halldorophone, by Halldór Úlfarsson at EMuTe Lab - Experimental Music Technologies Lab, University of Sussex, UK (2018) [7].

The use of controlled audio feedback for the creation of augmented instruments, and for the creation of original musical works, is part of a research area that has only recently taken on relevance in musical thought, resulting in several interesting inventions and various musical pieces, in many electronic music research and production centres [8, 9].

Specific studies on feedback have been carried out also by CRM - Centro Ricerche Musicali in Rome, since the 1990s. The research carried out by CRM is constantly guided by aesthetic principles and pursues the objective of creating works and technologies aimed at developing the musical language and creating an innovative artistic production, resulting from the constant interaction between scientific research and musical composition [10].

2. PREVIOUS RESEARCH AT CRM

The restitution of a "corporeality" to sound and its ability to offer a "tangible" presence in the listening space is achieved through experiments on the vibrational properties of matter and other acoustic phenomena studied by the CRM of Rome since 1994.

Many interactive and adaptive sound installations have been designed with waveguides, resonators, reflective screens, multiphonic systems, or with original technologies such as Holophones and Planophones®, both by Michelangelo Lupone.

Holophones (CRM, 1998), sound projectors, are the first prototype of a multiphonic sound diffusion system provided with very accurate controls, which permit creative modulations of the wavefront. Holophone consist of a parabolic surface with a limited band loudspeaker in its focal point with controllable radiation angle. Based on plane waves emission, the Holophone is designed to ensure an accurate control of the soundwave movement and profile by appropriate regulation of the phase, amplitude, and frequency of the musical signal [11, 12].

Planephones® (CRM, 1996) are vibrating plates that allow exploiting the vibrational features of natural and synthetic materials, such as metals, wood, paper, glass, and their derivatives, with musical and plastic form. They can be considered both planar sound radiators that allow diffusion of plane waves, and instruments for sound elaboration and spatial diffusion when integrated into art sound installations [13].

These projects, together with previous studies on the physical model of the string [5, 6], have contributed to the development of research on augmented instruments produced at CRM, as well as to the deepening of my personal compositional research.

2.1 Sculptures

Experiments on resonant cavities and vibrating panels of different shapes and materials led me to create musical installations in collaboration with the visual artist Debora Mondovì, as part of a research started in 2005 on the sounds that can be produced with terracotta. Terracotta is extremely ductile and can be moulded into a variety of shapes using different techniques. The terracotta sculptural works have been designed considering the relationship between the material, the acoustic phenomenon, and the electroacoustic system, to achieve a complete integration between sculptural and musical form [14].

Risonanze dalla Terra (2007), *Terra delle Risonanze* (2010) and *Voci di Terra* (2011) were designed to resonate at certain frequencies and consist of sculptural elements used as resonators, where amplification, or attenuation phenomena occur, according to the shape and the size of the cavities.

Foglie di Terra e di Suono (2009) and *Voci d'amore* (2914) are instead made with terracotta panels of different sizes, shapes, and thicknesses, subjected to different cooking techniques. The different characteristics of the material and the different application of piezoceramic, or electromagnetic actuators, according to the Planofoni® technique, allows the creation of diversified sound elaboration and spatial diffusion, coherently with structures in terracotta.

2.2 Instruments

Specific applications of the resonance phenomenon on traditional acoustic instruments, gave rise to the production of three performative works, created from 2005 to 2011. In these works, the design of the electroacoustic system involved in the processing and diffusion of sound was integrated into the traditional acoustic instrument, or a stylized version of it.

In the work *Il suono incausato*[4] the clarinet is deprived of the mouthpiece and has a loudspeaker inserted in a soundproof cone frustum, inserted at the barrel height. This device carries out the function of conveying sound and air, produced by the movement of the loudspeaker membrane inside the instrument. The sound to the loudspeaker is produced by a real time algorithm made with the software Max/MSP and controlled by the performer – the clarinetist – through a MIDI pedal. The

[4] Silvia Lanzalone, *Il suono incausato*, improvise-action for suspended clarinet, clarinetist, and electronics. Editions Suvini Zerboni. Clarinetist Massimo Munari, Ivrea, Italy, 2005.

clarinet, thus modified, is suspended on a support, to give the clarinetist the possibility to "explore" the system, performing a gestural score. The score also indicates the gestures to be performed for the use of corks and trunks of cardboard or aluminum cones of different sizes, to be inserted respectively into the holes and into the bell, and of shims to be placed under the key levers [14, 15].

In the work *Voce*[5] the electronic part is performed through a structure made up of fifteen resonators, consisting of glass cavities of different shapes and sizes with fifteen small speakers, grouped on five stands. Resonators are selected to achieve the resonances of vowel sounds, and the signal processing algorithm emphasizes the resonances and creates further transformations consistent with the vocal sounds. The installation, called "glass choir", dialogues with the vocal performer, giving to the voice timbre an original and coherent sound characterization [14].

Clavecin électrique[6] is a performative work produced following research into the acoustic and technical possibilities of the historical harpsichord, with the aim of enhancing its sound diffusion and increasing its range of timbres. The work involves the integration of eight resonant pipes of different sizes, tuned to the main formants of the instrument. The pipes are placed below the soundboard, with their radiating end close to the main radiation area of the instrument. The sound of the harpsichord emitted by the pipes after digital processing, is thus transmitted to the soundboard, causing the sympathetic vibration of some strings [16].

The performative character common to the three works is developed in each of them according to different levels of freedom. The need to dramatize the gesture is implicit in the performance score for the new instrument. The performer can interact with the augmented instrument in an extemporaneous way, relating to the microstructural variations of the sound within the formal units; the timing, that is the choice of the duration of each formal unit; the management and morphology of theatrical actions.

3. FEEDBACK INSTRUMENTS AT CRM

Several prototypes of augmented instruments, realised with electroacoustic and computer systems in which the feedback phenomenon is involved, have been produced at the CRM laboratories: Feed-Drum®, SkinAct and WindBack, by Michelangelo Lupone; ResoFlute, by Silvia Lanzalone [7, 10].

The Feed-Drum®, designed in 1999 by Michelangelo Lupone for his work *Gran Cassa* (1999-2002), in order to explore the timbre during the bass drum attack phase and isolate its vibration modes by means of the membrane's electronic conditioning system. The signal produced by an excited membrane is returned through a speaker which, taking advantage of the feedback principle can potentially generate everlasting sounds. The damping of membrane motion leads to sound decay. The input energy level can be dynamically adjusted, in order to isolate high vibration modes [7, 10, 17, 18].

The SkinAct is an augmented membrane instrument designed by Michelangelo Lupone for the work *Spazio curvo* (2012), which was included in the work *Coup au Vent*, for three SkinActs (2015). The instrument can produce long sounds by exciting the membrane of a bass drum in a vertical position. The skin puts a vibrational detector and different actuators in feedback condition [7, 10, 18].

The WindBack, designed in 2011 by Michelangelo Lupone for his work *In sordina* (2011), is a saxophone modified by applying a loudspeaker in front of the bell and a miniature microphone placed near the mouth. The loudspeaker sends the sound of the instrument picked up by the microphone inside the instrument itself, causing acoustic feedback. The internal resonances allow the feedback to be tuned, and to modify its timbre in relation to the position of the keys [7, 10, 19].

3.1 ResoFlute

The personal research on the augmentation of the traditional instruments continues, between 2014 and 2018, with the production of two more performative works, in which the focus shifts to the musical and expressive properties of acoustic feedback.

ResoFlute, augmented instrument designed by myself for the work *Èleghos*[7], is a classical transverse Western concert flute, modified through the application of six miniature microphones inside the body of the instrument, a sensor, some control pedals, and an aluminum pipe for sound diffusion and resonance [Fig 1]. A miniature microphone is applied internally to the instrument's headjoint, instead of the traditional cork, and five other electret miniature microphones are placed on the body, making holes in the pipe according to the position of certain keys[8]. The six microphones detect resonances and sound pressure variations that can be found in different parts of the flute opening and closing the different keys. The body of the instrument also features a piezo-film sensor, used for detecting the position of the right-hand thumb, which is normally used by the flautist just to hold the instrument. The piezo-film signal is used via threshold circuit to produce on-off commands that the performer generates moving the right-hand thumb according to the score. The flute player also uses MIDI foot controls featuring Control Change and Program Change messages to activate certain sound processing according to the score. The sound of the traditional instrument is 'augmented' not only using microphones, but also through a digital signal processing algorithm and by the aluminum pipe. The latter

[5] Silvia Lanzalone, *Voce*, for small choir of glass, female voice, and electronics. Editions Ars Publica. Voice Angelina Yershova, Rome, Italy, 2006; Silvia Schiavoni, Rome, Italy, 2006.

[6] Silvia Lanzalone, *Clavecin électrique*, for harpsichord with resonant pipes and electronics. Editions Ars Publica. Harpsicord Giorgio Spolverini, Salerno, Italy, 2011; Rome, Italy, 2011.

[7] Silvia Lanzalone, *Èleghos*, for augmented flute, resonant pipe, and electronics (2014). First performance Festival ArteScienza 2014, Giardini dell'Accademia Filarmonica Romana, Rome, Italy, 06.07.2014. Flutist: Gianni Trovalusci. The previous version of the piece, entitled *Studio su Èleghos* was performed at the Auditorium of the University of Rome "Tor Vergata", Rome, Italy, 18.06.2014.

[8] The project on microphones was undertaken with the participation of Antonio Marra, audio technician and flute repair specialist.

not only diffuses the sound of the flute, but also filters it to enhance frequencies corresponding to its normal modes. The aluminum pipe mainly allows, thanks to its resonances and radiation directivity, to obtain controlled feedback and to tune the instrument without insufflation. The resonant aluminium pipe, 10 cm diameter and 180 cm length, is mounted inside a wooden case featuring the speaker and a second cabinet containing other electronic devices, including a power amplifier. The speaker is connected to the pipe through a conical joint, which enhances acoustic power effectiveness.

The algorithm, implemented with Max/MSP, consists of two banks of resonant filters 'tuned' on the pitches of the instrument. The microphone signal is analysed to extract amplitude and pitch envelopes, while the piezo film sensor signal is analysed to extract the amplitude peaks. Between the two filter banks are placed an FM synthesis process, a comb filter, and a modulation by means of a noise generator, all regulated by the analysis values. A compression algorithm is used to control acoustic feedback between the pipe and the microphones placed into the flute.

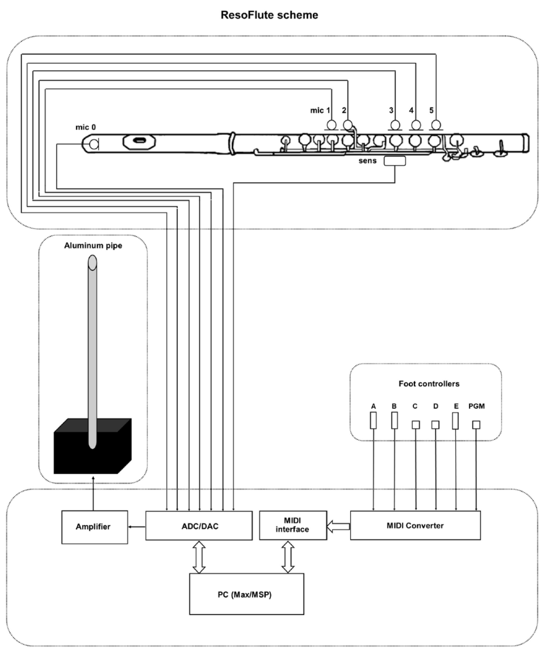

Figure 1. ResoFlute scheme.

Therefore, the entire system comprises an electroacoustic system for controlled feedback and digital algorithms for for generation and real-time processing of flute and feedback sounds. Feedback depends on resonant pipe features, responsible for sound diffusion, and on flutist position relative to the pipe. Feedback is produced and 'tuned' by specific gestures of the flutist, who modifies the sounds by moving the flute closer or further away from the pipe. The system has been designed to achieve maximum integration and balance between the natural sounds of the instrument and the electronic processing, both in terms of spectral and spatial diffusion [7, 10, 19].

The ResoFlute project is still under development for the construction of a new prototype, in collaboration with the architect and designer Emanuela Mentuccia[9]. The new prototype includes a system of wireless microphones and sensors inserted in a removable and easy-to-use structure, with a functional and non-invasive design, that can be applied to the traditional transverse flute without drilling holes or altering its structure.

Figure 2. Gianni Trovalusci plays ResoFlute. Roma, 2014.

4. FEEDBACK FOR TWO

Feedback for Two, composed between 2016 and 2018[10], experiments the possible relationships between two voices and two feedback systems, using two megaphones. The two megaphones are configured to process voice sounds and are placed at the center of two feedback processes, involving several transducers, internal and external to the same megaphones.

The typical exponential shape of the megaphone is a characteristic of horn loudspeakers, whose feature to adapt the acoustic impedance between the transducer and the surrounding air makes it possible to achieve a high-power

[9] The first phase of the project was included in the "Make Your Idea 2017" programme, dedicated to the development of new projects in the Lazio Region's FabLab network.

[10] Silvia Lanzalone, *Feedback for Two*, for 2 voices, 2 megaphones and 2 feedback systems (2016-2018). First version: EmuFest 2016, Rome Conservatoire of Music 'S. Cecilia', 27.10.2016. Final version: Festival ArteScienza 2018, Auditorium "Parco della Musica" of Rome, 14.09.2018. Voices and megaphones, Eleonora Claps and Virginia Guidi. Scene and lighting design Emanuela Mentuccia.

output. The use of the exponential horn for voice amplification, already practiced in Greece in the sixth century BC, is found among the inventions of Athanasius Kircher, a German Jesuit and scientist of the 17th century. Horn shape has always been used for acoustic amplification and was integrated in many inventions for sound reproduction in the late 19th and early 20th century. The horn was inserted, for example, into various models of phonographs (Thomas Edison, 1877), of graphophones (Chichester Bell and Charles S. Tainter, 1885), and gramophones (Emile Berliner, 1887), to help amplification of the reproduced sound. In 1899, J.M. Augustus Stroh patented a violin amplified by a mechanical system consisting of an elastic membrane and a horn, like those of the first mechanical phonographs and gramophones of the time, with the aim of being able to record the sound with sufficient volume. The instrument does not need a sound box but is composed of all the other parts of the violin, with the vibrating membrane placed near the bridge. This invention was later applied to other stringed instruments, including the viola, mandolin, and guitar, but was destined to disappear from the 1930s onwards, when recording by electric amplification became widespread [7]. In the Futurist Manifesto *L'arte dei Rumori* (The Art of Noises) of 1013, Luigi Russolo describes the "intonarumori", the instruments he created, all characterised by the presence of acoustic horns, whose purpose is to amplify the sound[11] [20]. Stroh's violin and Luigi Russolo's "intonarumori" are among the first examples of the implementation of the acoustic horn for musical purposes, outside the traditional musical instruments. In July 1951 Shitetsu Kamimori registered the patent for the "electric megaphone", a prototype of an electroacoustic megaphone with shape and technical characteristics like the current one[12].

The electric megaphone is functional for remote voice amplification and is normally considered as a "closed" system, not to be used in a traditional musical context. In the 1960s, however, the megaphone began to be used in original musical works, mostly experimental, and especially together with other instruments, although with a marginal role. Ligeti's works *Aventures*, for three singers and seven instrumentalists (1962), involves the use of 3 megaphones for the amplification of a single long sound of the voices that mixes with the sound of the ensemble. Kagel's work *Acustica*, for experimental sound generators and loudspeakers, composed between 1968 and 1970, involves 2 to 5 performers and uses many objects, recycled or self-made, some traditional instruments, such as a trumpet, a trombone, a violin, and various technologies for recording, reproduction, and sound amplification, such as turntables, microphones, speakers, including megaphones.

The use of the megaphone for musical composition in more recent times is still quite rare. There are very few works that include the megaphone in the ensemble, however always together with traditional instruments and with a coloristic function. In the work *Dead City Radio. Audiodrome*, for orchestra (2003), Fausto Romitelli uses the megaphone to amplify the voice of the percussionists. A recent attempt to bring the essential, almost sinusoidal timbre of the feedback that can be produced with the megaphone, into dialogue with instrumental sound, was made by Simon Steen-Andersen in 2008, with the work *On And Off And To And Fro*, for vibraphone, saxophone/Eb clarinet, double bass/cello and three players with megaphones. The work includes an electric megaphone model with a mobile microphone[13] for the pitch of acoustic feedback. The score provides detailed instructions on the placement of megaphones to amplify the instruments, or to produce the desired feedback.

The first work in which the megaphone plays a "solo" role seems to be *Solo per megafono,* by Giuseppe Chiari, whose score reads, in perfect "fluxus" style, <<suonare liberamente>>[14], without any other indication. The performances of *Solo per megafono* which took place in '68 in Palermo and Florence, seem to have been of considerable influence[15] [21]. In 2009 Alessio Rossato produced a work for megaphone quartet and conductor, entitled *Omaggio a Giuseppe Chiari*[16]. In the quartet, the fluxus approach is taken up in a structured way through specific indications in the score with respect to "sound acts" (irregular rhythms with the power button, whispering, breathing noisily, provoking feedback with the mouth next to the microphone), "gestural acts" (frontal motionless, turning left and right, megaphone up, turning around oneself) and other directions for playing with megaphones[17].

In my work *Feedback for Two,* I have chosen to use the megaphone as an "instrument" for musical performance, to take advantage of its electroacoustic and ergonomic characteristics for the controlled management of feedback in the air. The high acoustic efficiency of the megaphone allows to achieve, with minimally invasive components, a significant amplification at medium-high frequencies, easily to control for the management of the feedback phenomenon. The remarkable directivity of the sound radiation allows a very detailed selection of the feedback triggering space. Furthermore, the megaphone is already ergonomically optimized, not only to be held with one

[11] <<Gli intonarumori hanno esternamente la forma di una scatola più o meno grande a base generalmente rettangolare. Dal lato anteriore esce una tromba che serve a raccogliere e rafforzare il suono-rumore.>> (Luigi Russolo, 1913) [20]. Translation: <<The "intonarumori" have externally the shape of a more or less large box with a generally rectangular base. From the front side comes out a horn that serves to collect and strengthen the sound-noise>>.

[12] Official Gazette of the United States Patent Office, Volume 687, October 26, 1954. Shitetsu Kamimori's patent is dated July 13, 1951, and has serial number 236,498.

[13] The score indicates that megaphones must be "Velleman M25 SFM" (ed. Edition·S – music¬sound¬art Copenhagen, DK).

[14] Translated: <<To play freely>>. The score *Solo per megafono* (1968) is published in G. Chiari, *Musica Madre*, Giampaolo Prearo Editore, Milan 1973-2000, together with *Solo per clarinetto* (1964). Another "solo" by G. Chiari is *Solo per tromba*, Florence 1998, self-published. See: Mario Chiari, Fabio Migliorati, *Giuseppe Chiari, una bibliografia,* http://www.giuseppechiari.eu/.

[15] The score of *Solo per megafono* was previously included in the collection of G. Chiari entitled *La strada*, per objects, instruments, 1965 [21].

[16] A. Rossato has performed / interpreted *Solo per megaphone* by G. Chiari on several occasions, starting from 2009.

[17] Another piece by A. Rossato in which the megaphone is included in a mixed ensemble is *Ancient dark scarecrow*, for piano with carillon, 4 puppets, soprano with gong, speaking voice with megaphone and resonator, live electronics and 8 digitised tapes (2007).

hand and moved according to the acoustic space, but also to be manually activated and adjusted via a switch and a potentiometer. These features were very useful for controlling feedback in the air during the performative action required in the piece.

The megaphone model used in *Feedback for Two* has a power output of 10 Watts RMS, a receive range of about 500 meters and a weight light enough to play without excessive wrist fatigue[18]. The technical adjustments to the megaphones were the exclusion of the original microphone, which is band-limited and placed in a fixed cabinet behind the horn, to avoid feedback. The application, in place of the original microphone, of a professional miniature microphone with omnidirectional characteristics inserted directly into the horn, required a slight acoustic correction. Sound-absorbing material was in fact placed at the points of maximum acoustic efficiency, where the reflections on the horn walls emphasize the feedback, making it unstable. Each megaphone system has two feedback chains: the first between microphone and megaphone and the second between megaphone and loudspeaker.

The first of the two feedback in each of the two systems used by the two vocal performers, takes place between the omnidirectional miniature microphone[19] and the loudspeaker of the megaphone. The second feedback involves a second directional miniature headset microphone[20], placed in front of each performer's mouth. A third feedback occurs between one of the two microphones - the megaphone microphone, or the performer's microphone - and one or more loudspeakers, in a different way during the piece, according to the score. The speakers used have high directivity[21] and were placed in the middle of the stage, at eye level and behind the stage action, to allow the performers to approach and trigger the controlled feedback required by the score. The speakers contribute to the activation of the feedback and have the function of spreading the sound in the hall, so the work is self-sufficient in terms of its diffusion in the listening space[22]. Megaphones are also a very efficient acoustic source, if suitably pointed towards the audience by the two performers, as happens in some points of the work. Each described feedback is subjected to different signal processing within the feedback loop, with a latency of about 12 milliseconds. The live electronics algorithm, implemented with Max/MSP and controlled by the performer at computer, is composed of different processing stages, including compressors, delay with feedback, resonant filters, pitch detectors and pitch shift. Digital processing of the feedback signal is fundamental, not only for its dynamic control, but also to be able to obtain as many timbre variations as possible, such as harmonic tuned spectra, colored noise, short granular sounds, long glissando sounds, clusters with internal beats, and various other sounds. The performer at computer controls the feedback via software, but the complete sound processing take place in the space of the stage, in relation to the distances and positions of megaphones, microphones, loudspeakers and performers.

The composition is based on the relationships between the two performers and the sound produced through the actions with the feedback systems, performed extemporaneously, but following the indications included in the score. The two performers must shape the sound of the feedback generated by the megaphone systems through their gestures on stage, in terms of amplitude, intonation, length of the feedback, but also in terms of musical expression and theatrical action.

The composition is made according to musical structures created by theatrical actions aimed at representing different roles: a game, a challenge, a plot, a duel. The piece experiments with some possible relationships between voices and feedback systems. The two voices, sometimes in counterpoint, sometimes as soloists, intertwine, merge and blend, or resurface as solos from the electronic texture they have created.

Figure 3. Eleonora Claps (left) and Virginia Guidi (right) perform *Feedback for Two*, by Silvia Lanzalone. Auditorium Parco della Musica, Rome, 2018.

5. CONCLUSIONS

The phenomenon of acoustic feedback is of particular interest for musical composition, as it is directly related to the physical, mechanical, and electrical characteristics of the electroacoustic components involved. The feedback phenomenon is particularly sensitive to micro-variations in its generation system, which can be modified by the interpreter, if integrated with the musical instrument. The unpredictability of the phenomenon given by the feedback must be properly controlled by the insertion of a signal processing algorithm appropriately calibrated on the basis of the characteristics of the specific instrument.

The insertion of a feedback system within the electromechanical system of a musical instrument can give a strong originality to the sound. The timbral "vitality" of

[18] The megaphone model was RCF MG 80

[19] DPA 4060 - Omnidirectional Miniature Microphone

[20] DPA 4088 - Directional Headset Microphone

[21] To preserve the stability of the feedback system I used specific loudspeakers with the following technical specifications: dispersion angle of about 60 degrees, efficiency of about 94 dB 1W / 1m, power of about 130W RMS.

[22] Depending on the size of the hall, the work may have two to four speakers of the same technical characteristics placed at a distance of at least 1.5 meters from each other.

the feedback depends on the variations that can be made on the system by the performer. In fact, the feedback system reacts with great adaptability to external stimuli, matching to significant sound changes as a result of small executive gestures.

In this paper I tried to highlight how, in my work, the phenomenon of acoustic feedback, to be used in the compositional field as an autonomous system, requires an electroacoustic system to generate the positive feedback necessary to self-power the circuit. The implicit instability of the system, distinguished by an exponential and infinitely increasing sound result, requires the adaptive management of a complex set of parameters, some of which are entrusted to musical performance.

Furthermore, the digital signal processing within the feedback loop, allows the use of a very varied but extremely sensitive timbre palette, because it depends on many variables, not only internal, but also external to the system. The performer is no longer a simple player of the instrument but is responsible for the correct sound production and transformation within a complex system. The complex feedback system opposes its action to continuously tend elsewhere, theoretically towards infinity, practically towards its own saturation point. This feature reinforces the performative gesture, renewing its expressiveness.

6. REFERENCES

[1] I. Xenakis, Musique. Architecture, Casterman, Tournai, Belgium, 1976.

[2] G. M. Koenig, Genesi e forma. Origine e sviluppo dell'estetica musicale elettronica, Semar, Rome, Italy, 1995.

[3] P. Inverardi, P Pelliccione, M. Lupone, A. Gabriele, "Ad-Opera: Music-inspired Self-adaptive System", in Computation for Humanity: Information Technology to Advance Society, edited by Justyna Zander, Pieter J Mosterman, CRC Press, 2012, pp. 361-379.

[4] M. Lupone, L. Bianchini, S. Lanzalone, A. Gabriele, M. De Luca, "Struttura, creazione, interazione, evoluzione: la ricerca al CRM per la realizzazione di Forme Immateriali di Michelangelo Lupone", in Proceedings of XXI CIM-Colloquio di Informatica musicale, Cagliari, Italy, 2016, pp.77-84.

[5] M. Palumbi, L. Seno, "Physical modelling by directly solving wave PDE", in Proceedings of ICMC-International Computer Music Conference. Beijing, Republic of China, 1999, pp.325-328.

[6] L. Seno "Modelli fisici e Strumenti musicali", in Acustica Musicale e architettonica, edited by S. Cingolani, R. Spagnolo, UTET, Torino, Italy, 2005, pp 455-494.

[7] S. Lanzalone, "Strumenti aumentati", in Acustica. Fondamenti e applicazioni, a cura di R. Spagnolo, UTET, Torino, Italy, 2015, p.877-888.

[8] E. F. Callery, E. K. Canfield-Dafilou, "Methods for Performing with Feedback in Virtual Acoustics", in Proceedings of the 17th SMC-Sound and Music Computing Conference, Torino, Italy, 2020, pp.138-144.

[9] D. Sanfilippo, A. Valle, "Feedback Systems: An Analytical Framework", Computer Music Journal, The MIT Press, Volume 37, Number 2, Summer 2013, pp.12-27.

[10] M. Lupone, L. Bianchini, S. Lanzalone, A. Gabriele, "Augmented Instruments at CRM - Centro Ricerche Musicali of Rome: Feed-Drum, SkinAct, WindBack and ResoFlute", in Proceedings of ICMC-International Computer Music Conference, New York, USA, 2019.

[11] L. Maiorenzi, L. Seno, "A mathematical model for the holophone, a high directivity acoustical radiator", in atti del XIV CIM-Colloquium on Musical Informatics, Firenze, Italy, 2003, pp.173-176.

[12] M. Lupone, "Musica Elettronica" in Acustica Musicale e architettonica, a cura di S. Cingolani, R. Spagnolo, UTET, Torino, Italy, 2005, pp.526-586.

[13] L. Seno, "Nuova liuteria: caratterizzazione acusto-vibrazionale dei Planofoni®", in Proceedings of Annual Meeting of the Acoustical Engineering Society. Como, Italy, 2005.

[14] S. Lanzalone, "Suoni Scolpiti e Sculture Sonore: alcuni esempi di installazioni d'arte elettroacustica", in Proceedings of XVII CIM-Colloquio di Informatica Musicale, Venezia, Italy, 2008, pp.149-156.

[15] S. Lanzalone, "The 'suspended clarinet' with the 'uncaused sound'. Description of a renewed musical instrument", in Proceedings of 8th International Conference on NIME-New Interfaces for Musical Expression, Casa Paganini-InfoMus Lab, Genova, Italy, 2008, pp.273-276.

[16] S. Lanzalone, "Clavecin électrique. Studio e realizzazione dell'opera", in Proceedings of XIX CIM-Colloquio di Informatica Musicale. Trieste, Italy, 2012, pp. 104-111.

[17] M. Lupone, L. Seno: "Gran Cassa and the adaptive instrument Feed-Drum". Proceedings of Rencontre Musicale Pluridisciplinaires. Lyon, France, 2006, pp 27-36.

[18] W. Cianciusi, L. Seno: "Feed-Drum e SkinAct: l'ultima frontiera dello strumento aumentato". Proceedings of XIX CIM - Colloquio di Informatica Musicale. Trieste, Italy, 2012, pp.72-78.

[19] M. Lupone, S. Lanzalone, L. Seno: "New advancement of the research on the augmented wind instruments: WindBack and ResoFlute". Proceedings of EAW - Electroacoustic Winds 2015. Aveiro, Portugal, 2015, pp.156-163.

[20] L. Russolo, L'Arte dei Rumori, Milano, Italy, 1916.

[21] G. De Simone, Accessi all'opera di Giuseppe Chiari, in "Konsequenz", XIII, n. 13-14 new series, Liguori Editions, Naples, Italy, 2006, pp. 98-108.