

Sound and Video Anthology: Program Notes

Biophysical Music: Marco Donnarumma, Curator

Curator's Note

It is with great delight that I introduce the reader to *Computer Music Journal's* 2015 Sound and Video Anthology. I have curated a series of diverse, yet interrelated, works on the theme of biophysical music. With this term, I refer to live music pieces based on a combination of physiological technology and markedly physical, gestural performance. In these works, the physical and physiological properties of the performers' bodies are interlaced with the material and computational qualities of the electronic instruments, with varying degrees of mutual influence. Musical expression thus arises from an intimate and, often, not fully predictable negotiation of human bodies, instruments, and programmatic musical ideas.

We begin with a rare audio recording of a solo improvisation by seminal composer Michel Waisvisz in which he creates rhythmic textures and frantic glitches of analog electronic sounds by altering, with the touch of his hands, the voltages of the Crackle Synthesizer circuits. The sonic aesthetic of Waisvisz's piece resonates with the work by Shiori Usui, who, drawing on a similarly granular sonic palette, presents an enthralling composition for double bass, trombone, and the XTH Sense biophysical instrument. Here, two performers interact not only through the sound of their traditional instruments, but also by listening to the amplified and processed sounds of their muscles. The idea of the body as a source of sonic material lies at the core of the performance by Pamela Z, where grains of breath sounds mutate into multiple virtual voices in a complex counterpoint, elegantly mixing

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her gestural manipulation of digital sound processing and matchless vocal skill.

But what happens when the bioacoustic sounds of multiple bodies are networked into a large-scale instrument? Heidi J. Boisvert and colleagues feed the sound and data from muscles and blood flow of five dancers to genetic algorithms that, in turn, produce organic, multilayered sonic and visual bodies. The result is a gracefully dark audio and video composition manifesting a creative and physical tension between human and algorithmic agents. Shifting from dance to body art, we see the concept of the performer's body as an instrument stretched to its limits. In the work by Marcel-lí Antúnez Roca and his colleagues, pioneers of interactive audio and video performance, audience members trigger physical contractions of the performer's body by activating pneumatic devices attached to the performer's muscles and limbs. Each trigger initiates a tense series of rhythms, timbre variations, and visual animations—and there is room for some fire, too.

Taking the cue from the dense sound forms and intense gestural performance of Antúnez Roca, we introduce the practice of gestural music performance with a piece by Miguel Ortiz. By blending the processed sounds of an electric viola with the bioelectrical signals from his arms as he performs, he constructs a complex and vivid musical composition that compellingly explores the auditory thresholds of human hearing. In my performance for XTH Sense and light, I share Ortiz's interest in exciting human auditory thresholds, but I do so by making the digital instrument accumulate the very low frequencies of muscle sounds and blood flow until an unstable mass of acoustic energy unfolds and explodes in my hands. It is an approach that emphasizes the expressive potential of the unbalance between control and emergence in bodily musical performance, some-

thing that resonates with Terminal Beach's audiovisual orchestral work. Their piece has no predetermined score, for this is composed in real time using the variations in the heart rate of twelve musicians throughout the performance.

Their work allows us to introduce another area of investigation: the intermix of traditional and physiologically informed performance techniques. To explore this hybrid practice further, we look at the work by the influential BioMuse Trio, where a violin player and a performer, the latter wearing the BioMuse bioelectrical instrument, interact closely with each other through sound and programmatic actions. The musical experience they create demonstrates a transporting power, which emerges from an unlikely meeting between human performers, traditional instruments, and physiological instruments. To bring this journey to an end, Atau Tanaka, a crucial figure in the field of physiologically informed physical performance, offers us an exclusive audiovisual recording of a recent solo performance for a custom bioelectrical musical instrument. As he performs gestures with varying degrees of muscular force, multiple channels of raw electrical signals from his muscles are digitally sonified into an increasingly dense sound composition; sound becomes a direct externalization of the inner body mechanisms underlying the player's physical effort.

With this anthology, I intended to emphasize the broad range of strategies and techniques that, during the past 30 years, have established the practice of biophysical music as an expanding and heterogeneous field of musical and technological investigation; the collection therefore spans across music improvisation, algorithmic and traditional composition, sound-based body art performance, and interactive dance. At the same time, I have envisioned this anthology as a musical journey, rather than

a chronological history; the aim is to convey how idiosyncratic musical ideas have echoed through diverse decades, and thus how they have reinforced, altered, or disrupted different conceptions of the intimate relationships between sound frequencies, musical ideas, circuits, algorithms, and human bodies.

1. *CrackleBox Solo Live in Ottawa 1978*—Michel Waisvisz

The Crackle Synthesizer consisted of the components of three Crackleboxes. These could be linked by touching special conductive pads. Potentiometers were used to control the amount of controllability of this instrument. “Minimum control” meant that the Crackle Synthesizer would easily play on its own for hours. Nowadays, many people refer to the the Cracklebox as the archetype of “glitch” or “circuit bending.” At some point I started playing by placing my fingers on the print board of a damaged electronic organ. By patching the different parts of the circuit through my (conductive) fingers and hands I became the thinking [wet] part of a electronic circuit and I started seeing my skin as a patchable cable, potentiometer, and condensator. The great advantage was that by intuitively touching the electronics one could learn to play this new instrument without having to have schematic knowledge about the circuitry—very much like a traditional music instrument. It could be learned by playing by ear and developing experience and manual/mental skills instead of having to dive into a world of logic, functions, interaction schemes, electronic circuit theory, and mathematical synthesis methods. One could play an electronic instrument in direct relation

to the immediate musical pleasure of performed sound.

Michel Waisvisz was a composer/performer of live electronic music who developed new ways to achieve physical touch with electronic music instruments. Sometimes this was done by literally touching the electric circuits inside the instrument, thereby becoming a thinking component of the machine. He was among the first play with synthesizers on stage and very early on he developed and performed using gestural controllers. He also is the inventor of the Cracklebox, The Web, and other instruments based on touch interaction. Together with Frank Baldé he designed live performance software such as LiSa and JunXion. Starting in 1989 he directed the STEIM foundation in Amsterdam—where performance artists from music, theater, dance, and new media art, together with DJs and VJs, work to develop personal electronic instruments. He advocated that artists, in order to not have their work polluted by the generic typicality of applied tools, should appropriate their tools and instruments by modification, or even complete custom builds—a mindset summarized in his slogan, “If you don’t open it, you don’t own it.” This statement is at the root of the work philosophy at STEIM: Music makers are encouraged to play an important role in the design and construction of their authentic live electronic performance instruments.

2. *Into the Flesh*—Shiori Usui

The work was composed for the XTH Sense (a biophysical musical instrument), tenor trombone, and double bass. The piece consists of two short sections, each of which explores different aspects of the

musicians’ muscle movements and the bioacoustic sound captured by the XTH Sense from the performers’ bodies as they play their instruments.

Into the Flesh I

This first section explores some minute movements of muscles such as the light trembling of fingers and arms. The data captured by the XTH Sense triggers extremely high pitches that resonate at the beginning. The sound increasingly becomes distorted and there is the introduction of harsh inhaled vocals as the music progresses.

Into the Flesh II

In this section, the original sounds of the muscles captured by the XTH Sense are preserved as much as possible, creating heartbeat-like effects from the movements of the musicians’ arms, combined with a percussive sound created by the double bass. The piece ends by returning to the high resonant pitches heard at the beginning of section I.

Tenor trombone and XTH Sense: John Kenny

Double Bass and XTH Sense: Andres Kungla

This work was produced as a part of Inventor Composer Coaction (ICC) project, Edinburgh, Scotland.

Originally from Japan, **Shiori Usui** is described as a composer with “individual ears” (*The Times*). Her works have been performed in Japan, Europe, and the USA by a diverse range of soloists, ensembles, and orchestras, including the pianist Rolf Hind, the Duke Quartet, BCMG, members of Klangforum Wien, members of Scottish Chamber Orchestra, A Far Cry, Tokyo Philharmonic Orchestra, and BBC Scottish Symphony

Orchestra, with conductors such as Martyn Brabbins, Naoto Totsuka, and Matthias Pintscher. In 2012, her orchestral piece *Warai* [Laughter] received the Toru Takemitsu Composition Award in Tokyo, Japan; in the same year, the Civitella Ranieri Music Fellowship in conjunction with the UNESCO-Aschberg Bursaries for Artists Programme was awarded to her. July 2015 saw the première of Shiori's new work *Ophiocordyceps unilateralis s.l.* at the BBC Proms, performed by BCMG with conductor Franck Ollu at Cadogan Hall in London. Shiori has produced works in radical instrumental music and has worked with motion capturing sensors and biophysical technology. Many of her compositions are inspired by the sounds of the human body, the deep sea, and many other weirdly wonderful living organisms in the world. Shiori enjoys playing improvisation in the UK and abroad as a "noise" vocalist and pianist, and has performed with musicians such as Arve Henriksen, Ilan Volkov, Rie Nakajima, and Lee Patterson.

3. *Breathing*—Pamela Z

"Breathing" is the third movement of *Carbon Song Cycle*, a 2013 intermedia chamber work that I created in collaboration with visual artist Christina McPhee. Structurally, this solo piece plays upon the idea of the natural exchange of elements by passing sonic material between the various instruments—including my voice and live processing. In this particular movement, I sample my live voice and process it in real time to create digitally delayed layers and granulated flurries of my breath sounds and singing voice, which I then sculpt and control with hand and arm gestures. These live sounds are punctuated by the sparse tape part I

composed from fragments of sampled text that I took from a recording of my collaborator Christina McPhee discussing respiration. My controller (a component of the SensorPlay gesture control system I developed with Donald Swearingen) tracks my gestures via accelerometer and gyro, allowing me to manipulate sonic elements in real time.

Pamela Z is a composer/performer and media artist who works with voice, live electronic processing, sampled sound, and video. A pioneer of live looping techniques, she creates works combining extended vocal techniques, operatic bel canto, found objects, text, processing, and wireless MIDI controllers that allow her to manipulate sound with physical gestures. She has composed scores for dance, film, and new music chamber ensembles including the Kronos Quartet, the SF Contemporary Music Players, and the Ethel String Quartet. Her interdisciplinary performance works have been presented at numerous venues in San Francisco, the Kitchen in New York, and REDCAT in Los Angeles. Her installation works have been shown in exhibitions at the Whitney Museum (New York), the Diözesanmuseum (Cologne), and the Krannert Museum (Champaign, Illinois). Z has toured extensively throughout the USA, Europe, and Japan—performing at numerous festivals including Bang on a Can (New York), Interlink (Japan), Other Minds (San Francisco), La Biennale di Venezia (Italy), and Pina Bausch Tanztheater Festival (Germany). Her awards include a Doris Duke Artist Impact Award, a Guggenheim Fellowship, the Creative Capital Fund, the Herb Alpert Award in the Arts, the MAP Fund, the ASCAP Music Award, an Ars Electronica honorable mention, and the NEA and Japan/US Friendship Commission Fellowship.

She holds a music degree from the University of Colorado at Boulder.

4. *[radical] signs of life*—Heidi J. Boisvert

[radical] signs of life is a large-scale multimedia experience using biotechnology to integrate networked bodies and interactive dance. The work externalizes the mind's non-hierarchical distribution of thought through responsive, rule-based choreography and a database of phrases. The choreography is composed in real time by five dancers from a shared movement database in accordance with pre-determined rules. Music is generated from the dancers' muscles and blood flow via XTH Sense biophysical sensors that capture sound waves from the performers' bodies. This data triggers complex neurobiological algorithms to be projected onto multiple screens as 3-D imagery. As the audience interacts with the images produced, they enter into a dialogue with the dancers. Conceptually, the piece is an embodied examination of the increasing disparity between the encroachment of bio-data and the quiet discord of bio-memory.

Heidi J. Boisvert is a new media artist, creative technologist, experience designer, and writer. She founded and serves as the CEO and Creative Director of the futurePerfect Lab, a boutique creative agency that works with nonprofits to develop imaginative applications of integrated media and emerging technology. Boisvert was formerly the Media Director at Breakthrough where she designed, developed, and promoted a range of viral, new media, and pop culture campaigns that helped raise awareness and instigate policy change on pressing social issues. She created the first 3-D social change game, ICED – I

Can End Deportation, to shift the frame around unfair U.S. immigration policies. Boisvert also designed *America2049*, an alternative reality game on Facebook about pluralism, which was nominated for Games for Change and Katerva Awards. Most recently, with Marco Donnarumma, she co-founded XTH, an open-source creative biotechnology start-up, and was named a Harvestworks Creativity + Technology = Enterprise Fellow. She received her PhD in Electronic Arts at Rensselaer Polytechnic Institute.

Choreography: Pauline Jennings

Music composition: Doug Van Nort

XTH Sense biosensors interaction:
Marco Donnarumma

Wireless biosensing system: MJ
Caselden

Visual composition: Raven Kwok

Light design: Allen Hahn

Costumes: Amy Nelson

5. *Epizoo*—Marcel·lí Antúnez Roca, Sergi Jordà, and Rolan Olbeter

In the mid 1990s the performance *Epizoo* caused a commotion in the international art scene. For the first time, a performer's body movements could be controlled by the audience. By operating a videogame-like environment, spectators interacted with the bodybot worn by Antúnez Roca, moving his buttocks, pectoral muscles, mouth, nose, and ears. This performance stresses the ironical, and even cruel, paradox rising from the coexistence of virtual digital iniquity and the performer's physical vulnerability.

Epizoo's music did not use pre-rendered audio (hardly available in 1995), nor pre-programmed MIDI se-

quences. Making heavy use of 1995's "high-end" technology—namely, a Soundblaster AWE32 soundcard fitted with 8MB of RAM—the music, which favored timbral and rhythmic aspects over melodic ones, was instead computed and triggered note by note, control by control, according to the player inputs and the graphic animation's rhythms. By using different mappings and different sounds, each scene of the *Epizoo's* game environment behaves like a different musical piece or improvisational framework in which the user can improvise, controlling with the mouse not only the music, but also the development of the animations and the actions of the exoskeleton on the performer's body.

Idea and artwork: Marcel·lí Antúnez Roca

Music, interaction design, and computer programming: Sergi Jordà

Mechatronics: Rolan Olbeter

Infography: Marcel·lí Antúnez Roca and Paco Corachán

Light Design: Ramón Rey

Produced by Marcel·lí Antúnez Roca, Sergi Jordà, Loma Productions, and the Festival SIGMA 1995, Bordeaux (France)

Marcel·lí Antúnez Roca is well known in the international art scene for his mechatronic performances and robotic installations, which combine elements such as Bodybots (body-controlled robots), Systematugy (interactive narration with computers) and dresskeleton (the exoskeleton body interface). The themes explored in his work include the use of biological materials in robotics, as in *Joan l'home de carn* (1992); telematic control on the part of a spectator of an alien body in the performance *Epizoo* (1994); the expansion of body

movements with dresskeletons seen in the performances *Afasia* (1998) and *PoI* (2002); or microbiological transformations in the installations *Rinodigestio* (1987) and *Agar* (1999). He is currently working on the spatial and utopian artwork *Transpermia*. He was also founding member of La Fura dels Baus, working in that company as art coordinator, musician, and performer from 1979 to 1989. Antúnez Roca has received the following awards and distinctions: First Prize at the Festival Étrange, Paris 1994; Best New Media Nouveaux Cinéma Nouveaux Médias, Montreal 1999; Max New Theatre Award, Spain 2001; FAD Award, Barcelona 2001; Honorary Mention at Prix Ars Electronica 2003 and Premi Ciutat Barcelona 2004.

Sergi Jordà holds a BS in Fundamental Physics (1986) and a PhD in Computer Science and Digital Communication (2005). He is a senior researcher at the Music Technology Group of Universitat Pompeu Fabra in Barcelona, where he directs the Music and Multimodal Interaction Lab. During his undergraduate years in the 1980s, after discovering computer programming, he decided to fully devote himself to live computer music. Throughout the 1990s he conceived and developed award-winning interactive installations and multimedia performances, in collaboration with internationally renowned Catalan artists such as Marcel·lí Antúnez Roca and La Fura dels Baus. Back in academia since the late 1990s, his current main research interests are in the confluence of human-computer interaction and tangible, musical, and physiological interaction. He has received several international awards, including the Ciutat de Barcelona (1999 and 2007) and the prestigious Prix Ars Electronica Golden Nica (2008). He is one of the inventors of the Reactable,

a tabletop musical instrument that attained mass popularity after being adopted by Icelandic artist Björk in 2007. Since 2009 he is one of the founding partners of the company Reactable Systems.

Roland Olbeter is a scenographer and rob artist, living and working in Barcelona since 1986. Formally trained as a concert violinist and naval constructor, he has worked extensively for the theatre, the opera, as well as for sound and movement installations. His work focuses on the creation of impossible artefacts and shows a technical sophistication most uncommon in the visual art and theatre. He has collaborated in multiple scenographies, from the Barcelona Olympic games in 1992, the thematic Pavillon OIKOS for EXPO 2008 in Zaragoza, to collaborations with Bigas Luna, Jaume Plensa, Alfred Arribas, Enric Miralles, Xavier Mariscal, La Fura dels Baus, and Marcel·lí Antúnez Roca, among others. He developed and directed the chamber opera *Orlando Furioso* for five music robots and soprano with music by Michael Gross, and the designed the scenography for Richard Wagner's opera cycle *The Ring of the Nibelung*, together with Carlos Padrisa and Franc Aleu. He is currently preparing an automatic puppet theatre with music by Kats Chernin.

6. *Carne*—Miguel Ortiz

Carne is written for amplified (or electric) violoncello and EMG sensors. The piece is loosely inspired by Terry Bison's 1991 short story "They're Made Out of Meat." In Bison's story, two apparently alien beings meet to discuss a shocking discovery about the beings on planet Earth, the fact that they are made out of meat. The idea of sentient, thinking, and singing

meat seems both unthinkable and unbearable for these characters. I took this idea of looking at the human body simply as "meat" and imagining all hand and finger movements as the simple grinding and sliding of meat pieces.

Miguel Ortiz is a Mexican composer and sound artist based in London. He has been involved in a vast range of activities related to modern music and sound art. He has worked professionally as a composer, sound engineer, lecturer, score editor, promoter, and sound designer. Sporadically, he takes part as a performer in ensembles such as BLISS, Control Group, and M&B, where he explores a vast array of performing media ranging from traditional acoustic instruments such as cello and trumpet, to laptop improvisation and performance with bio-instruments and hyperinstruments. Ortiz graduated from the Conservatorio de las Rosas in Morelia, México, before pursuing a Masters degree and PhD at the Sonic Arts Research Centre at Queen's University Belfast. He currently works as a research associate at Goldsmiths, University of London.

7. *Ominous*—Marco Donnarumma

Ominous is a sculpture of incarnated sound. The performance embodies, before the audience, the metaphor of an invisible and unknown object enclosed in my hands. This is made of malleable sonic matter. Similarly to a mime, the performer models the object in the empty space by means of whole-body gestures. By using the visceral, new musical instrument XTH Sense (created by the author), the bioacoustic sound produced by the contractions of the performer's muscle tissues is amplified, digitally

processed, and played back by eight subwoofer and loudspeakers. The natural sound of muscles and its virtual counterpart blend together into an unstable sonic object. This oscillates between a state of high density and one of violent release. As the listeners imagine the object's shape by following my gesture, the sonic stimuli induce a perceptual coupling. The listeners see through sound the sculpture which their sight cannot perceive.

Where performance art and sound art converge through technology, here lies the work of performer, artist, musician, and writer **Marco Donnarumma**. He uses biomedical and sound technologies, software algorithms, actuators, and body sensors to create intensely physical live works. His performances, concerts, and installations are renowned for combining a seemingly simple and minimalistic aesthetic, rigorous science, technical sophistication, and strong critical concepts. He has performed and spoken in over 50 countries across North and South America, Asia, Australia, and Europe. His works have been presented at leading art and music events; digital art, sound art, and performance art festivals; research institutions; historical music venues; and national museums. Among them are *Sónar+D*, *ISEA*, Venice Biennale, BBC Music, CTM, transmediale, ISCM World Music Days, FILE, Panorama, NYEAF, Sound Art China, CYPNETART, Pikel, EMPAC, Stanford CCRMA, NYU, STEIM, IRCAM, FACT, Experimental Intermedia, Spectrum NYC, Café Oto, Mumuth Concert Hall, Hoerbar, Museo Reina Sofia, CCCB Barcelona. He is a co-founder with Heidi J. Boisvert of XTH, an open-source creative biotechnology start-up, and is about to receive a PhD in Arts and Computational

Technology at Goldsmiths, University of London.

8. *Heart Chamber Orchestra—TERMINALBEACH* (PURE [Peter Votava] and Erich Berger)

The *Heart Chamber Orchestra—HCO*—is an audiovisual performance. The orchestra consists of 12 classical musicians and the artist duo TERMINALBEACH. Using their heartbeats to generate the musical score in real time, the musicians control a computer composition and visualization environment. They read and play this score from a computer screen placed in front of them. *HCO* forms a structure where music literally “comes from the heart.” The musicians are equipped with electrocardiogram sensors. A computer monitors and analyzes the state of these 12 hearts in real time. The acquired information is used to compose a musical score with the aid of computer software. It is a living score dependent on the state of the hearts. While the musicians are playing, their heartbeats influence and change the composition and vice versa. The musicians and the electronic composition are linked via the hearts in a circular motion—a feedback structure. The emerging music thus evolves during the performance.

The resulting music is the expression of this process and of an organism forming itself from the circular interplay of the individual musicians and the machine.

PURE (Peter Votava) has been making uncompromising electronic music since 1992. On stage he sculpts abstract sonic stories from evolving textures, pulsating repetitions, and dynamic breaks using both hardware and software that equally affect the

listener’s brains and bodies. He has over 30 physical and digital releases on labels such as Editions Mego as BOLDER (with Martin Maischein), PURE, and ILSA GOLD; on Hinterzimmer with his electronic percussion duo PRSZR (with Rafal Iwanski); on Crónica, Praxis, Staalplaat, Drop Bass Network, and many more. His early 1990s Rave prank-duo ILSA GOLD (together with Christopher Just) was the first internationally acknowledged Austrian techno act and is still occasionally active. His current Berlin-related activities include “Slowlands” (a monthly whisky-only bar night) and the world’s first Whisky & Doom Metal tasting series, “Taste The Doom” (with Lars Lundehave Hansen). He holds a Master degree in Computer Music from the University of Plymouth (UK).

Erich Berger is a visual artist and curator trained in philosophy and engineering. His interests lie in information processes and feedback structures, which he investigates through installations, situations, performances, and interfaces; these have been shown internationally since the mid 1990s. His current explorations of deep time and hybrid ecology led him to work with geological processes, radiogenic phenomena, and their sociopolitical implications in the here and now. Berger is Director of the Bioartsociety in Helsinki/Finland and is a Lecturer at the Fine Art Academy Vienna/Austria.

9. *Trio for Violin, Biosensors, and Computer*—Eric Lyon, Gascia Ouzonian, and Ben Knapp

The BioMuse Trio is an extension of my computer chamber music compositions, a series of works intended to promote an integration of the com-

puter into classical chamber music practice. Aspects of this practice that particularly interest me are precise coordination between the musicians in close quarters, and an emphasis on expressive musical interpretation and performance intimacy. Previous works in this series have used the laptop as the de facto interface for the computer, accepting its many limitations as a performance instrument. The introduction of the BioMuse allows for far more idiomatic musical gestures than are possible on the laptop. Equally important, the BioMuse presents the human body as musical instrument. A performance with the BioMuse involves two sets of prosthetics: the hardware, which extends and projects the gestural expressivity of the body, and the audio DSP software, which gives these gestures “voice.” The violinist performs in a traditional manner, demanding close musical interaction with the biomusician. The laptop performer manages asynchronous aspects of the sound processing; the direct generation and processing of the sound is under the complete control of the biomusician. As in my previous computer chamber music, all computer-generated sounds are derived from samples of the acoustic instrumentalist, captured live in performance. The BioMuse Trio is dedicated to Ben Knapp and Gascia Ouzonian, with whom it was composed.

Eric Lyon is a composer and computer music researcher. His work focuses on articulated noise, spatial orchestration, and computer chamber music. His software includes FFTease and LyonPotpourri, written for Max/MSP and Pd. He authored “Designing Audio Objects for Max/MSP and Pd”, which explicates the process of designing and implementing audio DSP externals. In 2011, Lyon was awarded a ZKM Giga-Hertz award, resulting

in the 43-channel computer music composition *Spirits*. His 124-channel composition *The Cascades* was premiered in the Virginia Tech Cube, and presented at BEAST FEaST 2015. Lyon has composed for such artists as The BioMuse Trio, Margaret Lancaster, The Noise Quartet, Ensemble mise-en, String Noise, The Crash Ensemble, Esther Lamneck, Kathleen Supové, and Marianne Gythfeldt. Lyon has taught computer music at Keio University, IAMAS, Dartmouth College, Manchester University, and Queen's University Belfast. He teaches in the School of Performing Arts and is an ICAT Fellow at Virginia Tech.

R. Benjamin Knapp is the Director of the Institute for Creativity, Arts, and Technology (ICAT) and Professor of Computer Science at Virginia Tech. ICAT seeks to promote research and education at the boundaries between art, design, engineering, and science. Knapp also leads the Music, Sensors, and Emotion research group, with researchers in the UK and the USA. For more than 20 years, Knapp has been working to create meaningful links between human-computer interaction, universal design, and various forms of creativity. His research on human-computer interaction has focused on the development and design of user interfaces and software that allow both composers and performers to augment the physical control of a musical instrument with direct sensory interaction. He holds twelve patents and is the co-inventor of the BioMuse system, which enables artists to use gesture, cognition, and emotional state to interact with audio and video media.

Gascia Ouzonian's work is focused on experimental traditions in music and sound art after 1950. Her writing has appeared in numerous peer-reviewed journals and edited volumes including *Music, Sound & Space* (edited by Georgina Born, Cambridge University Press). Particular areas of interest include sound installation art, site-specific sound, spatial sound, and the intersection of experimental music, visual art, and sound art. With architect Sarah Lappin, Gascia co-leads the research group *Recomposing the City: Sonic Art & Urban Architectures*. In 2013 she founded Optophono, a label for interactive music and sound art. As a violinist Gascia has performed internationally with ensembles that have included Yo-Yo Ma and the Silk Road Ensemble, Theatre of Eternal Music Strings Ensemble, Hutchins Consort, and Sinfonia Toronto. She is a founding member of Bird On A Wire, BioMuse Trio, Pale Gates of Sunrise, and Hard Rain Ensemble.

10. *Myogram*—Atau Tanaka

Myogram is an eight-channel sonification of muscular corporeal states. By placing a ring of four electrode channels on each forearm of the performer, we hear the neuron impulses of muscle exertion from the shoulder through the hand. The multiple electrodes on the forearm focus on specific muscle groups from flexor to extensor, the carpi ulnaris, brachioradialis, to palmaris longus. This reports on voluntary muscle activity causing wrist rotation and finger movement. These rings of sensors on each arm, left and right, are mapped to dual quadraphonic speaker spaces,

a ring on the left wall and a ring on the right wall. First, a direct audification of motor unit action potentials is heard as spikes. This stochastic pulse train reflects performer limb activity. The pure spikes then feed resonators and filters, resulting in a sonification by sound synthesis that responds to the musician's gestural language. This piece was created using custom biosignal hardware circuits by Martin Klang, wearable design by Irene Regueiro, and in musical collaboration with Miguel Ortiz. The research leading to this work has received funding from the European Research Council (ERC grant FP7-283771).

Atau Tanaka creates musical instruments using sensing technology to capture movements and gestures of musicians. Tanaka studied at CCRMA Stanford, and conducted research in Paris at IRCAM. His first inspirations came upon meeting John Cage during his Norton Lectures at Harvard and he would go to on recreate Cage's *Variations VII* with Matt Wand and :zoviet*france:. In the 1990s he formed Sensorband with Zbigniew Karkowski and Edwin van der Heide and worked in Japan, playing with Merzbow, Otomo, and KK Null. His work has been presented at the ICA, NTT/ICC, Palais de Tokyo, Ars Electronica, Transmediale, Eyebeam, and SFMOMA. He has been researcher at Sony Computer Science Laboratory Paris and Artistic Co-Director of STEIM Amsterdam. He conducts research in music and gesture in the Embodied Audio Visual Interaction (EAVI) research unit and is professor and Director of Research in Computing at Goldsmiths, University of London.