need for global co-operation in order to overcome this historic injustice.

Patricia was an impressive figure; her presence was felt wherever she went. Her diplomatic skills, her vision, her dedication, her high standards, her attention to detail, her empathy and friendship, and her sheer hard work brought her (and with her, the aspirations of so many creative women) to the attention of cultural gatekeepers at the highest levels. A tall, elegant woman with flowing auburn locks, stylishly dressed, she could not be ignored. Her energy seemed to be limitless, and her imagination for multinational projects was prodigious. Working right up to the last moment, "Time" eventually ran out on June 12, 2018. Her death was a shock to all of the members of Women in Music UK, and they have expressed their tributes to her.

To conclude, I am quoting from Patricia's email to me on May 16, just a month before she died. It is about her most recent project: a Global Call for New Music for Human Rights to be performed and recorded at the 70th Anniversary of the Campaign for the Universal Declaration of Human Rights. The concert is scheduled to be performed in the Teatro Argentina, Rome, on November 5, 2018. "Women's music is an essential part of world heritage**.** The fundamental role of women in the creation and transmission of tangible and intangible cultural heritage, and the creation and practice of music belongs, not only to a people or a culture, but to all of humanity."

By Tsippi Fleischer:

I met Patricia Adkins-Chiti in Alaska, in August 1993, at the wonderful Women Composers and Performers Festival organized by Suzanne Sommerville. Patricia and I were the only "outsiders," since we both lived on the shores of the Mediterranean. We immediately connected. After hearing my *Ballad of Expected Death in Cairo*, sung in Arabic by the American-Jewish mezzo-soprano Isabelle Ganz, Patricia approached me and insisted on performing my music. She invited me to Rome, in spring 1996, to work with her on my song-cycle *Girl-Butterfly-Girl*, with lyrics by Lebanese and Syrian poets, and she insisted on singing it in Arabic. Patricia had a beautiful mezzo-soprano voice, and her training was in the traditional European bel canto style.

The performance at the Vatican on Radio Vaticana is like in a dream in my memory. Of course, Patricia would not miss that occasion for an extensive broadcast interview with me; she served as the interviewer. She was so kind and treated me almost like a mother, encouraging me to pursue my career as a woman composer, despite the difficulties of living in Israel with the constant threat of terrorism and war. As she got to know me better, she initiated and produced a film featuring my work using many of my documentary videos. Those were the early days of the Donne in Musica project, which she discussed extensively with me.

Her players were enthusiastic about performing a purely instrumental version of *Girl-Butterfly-Girl* in addition to the original vocal work. Once such an idea was raised, Patricia would push it wholeheartedly. You may listen to and download these two separate versions on my website: (1) I recommend listening to Patricia singing the entire song cycle (click on "Discography" and CD tract list: "Israel at 50: A Celebration with Music of Tsippi Fleischer.") (2) For the instrumental arrangement (flute, bass-flute, piano), see "Girl-Butterfly-Girl ─ A World Journey," song No. 3 from the cycle.

New Interfaces, New Sounds: On Electronic Musical Instruments and Controllers

SARAH REID

> *I dream of instruments obedient to my thought and which with their contribution of a whole new world of unsuspected sounds, will lend themselves to the exigencies of my internal rhythm.*[1]

This famous quote from Edgard Varèse illuminates a familiar desire for many performers and composers: to extend one's personal practice beyond available tools and common standards, and to venture toward unfamiliar and idiosyncratic sound worlds. For some, this may mean pushing the limits of pre-existing instruments and exploring new sonic territory by adopting experimental performance or compositional techniques. For others, this desire may extend well beyond extant tools and practice into an imaginary world of entirely new musical instruments, interactions, and sounds.

This article presents an introduction to the world of designing and building new musical instruments, interfaces, and controllers for electronic and hybrid electronic/acoustic music. We will look at a few examples of such projects and their inventors in order to gain a glimpse into this fascinating field. This article is the third and final installment in a series discussing the integration of electronic and acoustic instruments in composition and performance. Previous installments explored the development of a performance practice with electronic instruments, integrating electronic and acoustic instruments in ensembles through improvisation, as well as some approaches to notation for primarily sound-based electronic/acoustic music.[2] [3]

Initial Thoughts: Instrument and Controller

To some, the terms "instrument" and "controller" may be deeply interwoven, and, indeed, as with many terms and concepts used to describe creative tools and practice, there is no absolute definition that will cover all use cases and approaches. That being said, it is perhaps worthwhile to spend some time considering these words and their function in order to provide some context and framing for our discussion.

An acoustic piano produces sound when a series of strings are struck (and thereby vibrated) by small hammers. The body of the piano acts as the resonator for the sound. The most common means of interacting with the piano is by playing the keyboard—pressing a key activates the corresponding hammer, which vibrates the string, and so on. With this image in mind, one could say that the keyboard portion of the piano is the "controller" while the hammers, strings, and resonating body are the "instrument." On the other hand, one might argue that a "piano" is necessarily the sum of all of these various components, and to remove or alter one aspect would result in a different instrument altogether.

When a performer strikes, plucks, or bows an acoustic instrument, it produces a sound that comes from the instrument itself. The range of sounds produced by a given instrument is also relatively limited—an acoustic piano will always sound more or less like a piano, a trumpet like a trumpet, and so on. There are, of course,

exceptional acoustic instrumentalists who have a very wide range of command and expression on their instruments. This statement is not intended to devalue their virtuosity, but simply to bring attention to the *relative* range of sounds that can be produced by acoustic instruments in comparison to most electronic instruments (many of which have virtually unlimited sonic palettes). The black and white keyboard is a control interface that is used for a large variety of electric keyboard and audio synthesizer instruments. But in many of these electronic instruments, striking the middle C key may not produce a middle C at all—the keys are removed from their original functionality of activating hammers and instead become neutral sources of control data. This data can, in turn, be mapped to virtually any result.

So then, what makes an instrument, an instrument? Is it the way it sounds, the way sound is produced, the way it's interacted with?

The goal of this section is not to answer these questions in any official capacity, but rather to simply consider them. When approaching the world of electronic and hybrid electronic/acoustic musical instruments, these considerations become all the more relevant. In the first article in this series, we discussed some fundamental differences between acoustic and electronic instruments. One of these differences is the instrument's means of control (input) and sound production (output). As briefly illuminated above, many electronic instruments have completely independent means by which to control and produce sound. This means that the same key or button can be used to trigger or control any number of sounds, or that the same type of sound can be produced using a large number of methods and tools. In a 1983 interview with *Polyphony* magazine, pioneering electronic musical instrument designer Don Buchla refers to this independence when he says: "I like to regard the instrument as consisting of three major parts: an input structure that we contact physically, an output structure that generates the sound, and a connection between the two. The electronic family of instruments offers us the limitation, if we approach it traditionally, and the freedom if we approach it in a new way, of total independence between input and output."[4]

Laptop musicians may consider each individual program they run on their computer its own digital instrument, or they might consider the computer itself to be the instrument and the programs to be compositions. Their controller of choice may be the keyboard that comes attached to the computer, or they may opt to interact with the computer using an external MIDI controller with sliders and knobs. Similarly, an ensemble of musicians all playing modular synthesizers may consider themselves to be playing the same instrument while having completely different modules and controllers in each of their setups.

This freedom that Buchla speaks of is something that many have explored in performance, composition, and the design of new interfaces and controllers. Oftentimes, the result of these explorations is something very personal to the artist who creates it—a tool or solution to interacting with sound that feels right, and helps the artist achieve her own creative goals. Electronic instruments that offer relative independence between input and output afford the opportunity to use any input structure or control source. So long as data can be transmitted from the control source to the sound source, *anything* can become the controller: a cell phone, a custom array of buttons and knobs, the performer's body, a coffee cup.… In fact, some electronic instruments may require little to no human input whatsoever, instead, relying on self-perpetuating or automated processes.

In the next section, we will look at a few examples of how different artists have chosen to design and build their own custom instruments and interfaces as a means by which to interact with sound in entirely unique ways.[5]

Daphne Oram

"Imagine yourself a 'painter in sound'. Your blank 'canvas' is a piece of magnetic recording tape….The whole evolves just like an oil painting….You can use any colour of sound that you can imagine, for any duration, with any rhythm, and at any pitch."[6]

Daphne Oram was a British composer, electronic music pioneer, and instrument inventor, born in 1925. From a very young age, Oram was fascinated by the possibility of being able to draw sound—to create markings on a piece of paper and have them translated into audible frequencies. To Oram, this interest was not centered upon being able to graphically represent a sound in an abstract form, but being able to construct and "manipulate every subtle nuance of sound"[7] through the precise drawing of waveforms and other fundamental building blocks.[8]

In the early 1960s, Oram designed and built a machine called the Oramics, which allowed her to accomplish just this. The Oramics is a large analog audio synthesizer that produces sound by reading markings on transparent strips of 35mm film. The instrument contains ten tape loops that are passed over photocells (sensors that detect light). The drawings on the film cause the light received by the photocells to be modulated, producing voltages which in turn control oscillators and various aspect of the sound.[9] The strips of film that are fed to the Oramics machine are in essence the musical score, containing information about pitch, note duration, timbre, and vibrato. However, instead of a five-line staff and traditional Western symbols, Oram's notation looked more like squiggly lines, irregular shapes, and dots. For those familiar with digital audio workstations, there is a striking similarity between Oram's notation and MIDI automation lanes and piano roll editors—but of course, the Oramics pre-dates these techniques by several decades.

Laetitia Sonami

Laetitia Sonami built the first prototype of the Lady's Glove in 1991, as a means of "finding a more fluid way to perform with the computer."[10] (See Figure 1.) The Lady's Glove went through numerous iterations and designs, eventually evolving into a nuanced and flexible gestural instrument with which Sonami performed for many years. Embedded in the glove are numerous sensors to detect subtle finger bends and wrist movements, as well as the overall speed and movement of the performer's hand in space.[11] Instead of being restricted to performing from behind a computer, the Lady's Glove enabled Sonami to explore a freer, more physically engaging means of interacting with her instrument and audience.[12]

Fig. 1. Laetitia Sonami with the Lady's Glove

More recently, Sonami developed a new instrument called the Spring Spyre. (See Figure 2.) The Spring Spyre incorporates a series of intersecting springs attached to a circular metal frame. In performance, the springs are plucked, rubbed, and tapped to generate control information for real-time audio synthesis. Sonami uses a machine learning software called Wekinator, developed by Rebecca Fiebrink, to teach the computer physical gestures and how they should be mapped to musical output.[13]

Fig. 2. Laetitia Sonami performing on the Spring Spyre

Kristina Warren

Composer, improviser, and researcher Kristina Warren created a full body, wearable instrument called Exo-Rosie.[14] (See Figure 3.) The instrument is a "wearable exoskeleton"—a jumpsuit covered in resistors and other electrical components, connected with wire and conductive thread. When the performer connects different parts of her body together (e.g., touching the right wrist to various points along the left arm), different circuits are closed, resulting in the activation of various analog oscillators and the output of digital control information. In describing the project, Warren mentions that Exo-Rosie is not just an instrument, but also a persona (Rosie the Riveter), and expresses that the "limb-to-limb choreography" required in performance "conveys strength and subjectivity."[15]

Fig. 3. Kristina Warren presenting Exo-Rosie
(photo by Gregory Taylor)

Akiko Hatakeyama

Myaku is an instrument developed by Akiko Hatakeyama that uses candlelight as its main input source. A series of ten light sensors are placed on a table surrounding small candles, which are lit and repositioned during performance. The light from the candles is used to control loudness of various audio samples, creating an undulating and flickering texture. Candle flames emit strong light compared to electric lights, and the dancing motion of the flames is visual as well as audible in this piece. Hatakeyama says that she makes "compositional decisions by considering the light intensities and movements of different candles to place them to create a desired yet autonomous sound environment."[16] Compared to some electronic instruments, Myaku is relatively simple in terms of technical design, but the application of this instrument in performance yields a truly compelling, mesmerizing audiovisual experience.

Sarah Reid and Ryan Gaston

The work of the individuals mentioned above has greatly inspired my practice as a performer-composer. In fact, the world of instrument-building and new musical interfaces was what initially piqued my interest in music technology altogether, compelling me to learn the basics of electrical engineering and computer science in addition to my musical studies. Coming from a classical background as a trumpet player, I became very interested in the possibility of integrating new, custom electronics with my acoustic trumpet.

One of the projects that emerged from this work is a wireless interface for trumpet called MIGSI (Minimally Invasive Gesture Sensing Interface).[17] I developed MIGSI in collaboration with Ryan Gaston. It features a number of sensors embedded on the trumpet to capture gestural information during performance. The sensors detect valve displacement, instrument tilt, as well as hand tension and pressure while holding the instrument. (See Figure 4.)

One of the goals behind MIGSI was to extract data from gestures that are inherent in playing the instrument (such as pushing valves and holding the trumpet) instead of adding new buttons, switches, and knobs. The unique challenge of this design is one of parsing and mapping the data in compelling ways, such that the integrity and playability of the original acoustic instrument is maintained while new sonic control is added. Since the completion of the initial prototype in 2015, a large number of compositions have been created for MIGSI, including a recent piece in which data from the trumpet controls an ensemble of mechatronic drums and percussion instruments.

Final Thoughts and Next Steps

Electronic instruments are unique in their ability to provide independence between input control and output. As we have seen above, working with these types of instruments affords a wealth of possibilities for designing customized means of controlling and interacting with sound. With these new tools, performers can define the nature of interaction with their instrument: they can create a controller that outputs precise data for highly repeatable performances and traditional development of virtuosity; they may create a controller that uses their input to initiate processes that yield unpredictable results; they may even devise a system that enables input control to directly alter the relationship between input and output, in effect creating an instrument that changes behavior depending on how it is played.

The work shared in this article may seem advanced—indeed, each project outlined above is the result of many years of research and iteration—but that should not discourage you from exploring this field if you have interest. My hope in presenting this work is to spark interest and curiosity, and perhaps even to compel a few readers to venture into new territory with their personal creative practice.

Perhaps the most important concluding remark to make is this: Every project begins with an idea and a simple prototype. In Sonami's case, the prototype was fabri-

Fig. 4. Sarah Belle Reid playing MIGSI

cated from a pair of yellow rubber kitchen gloves.[18] Almost all of the technical projects I have created start with brown cardboard and tape. This is important to realize because often it can be challenging for someone—especially someone new to this field—to see the steps involved in progressing from initial idea to completed musical instrument. However, getting started and taking those initial steps is actually simpler than one might realize. The availability of open source microcontrollers, electrical components, sensors, and project kits makes it easier than ever for individuals to begin learning the necessary skills to prototype new ideas. Many of these tools are accompanied by informative tutorials, thorough step-by-step guides and code examples. For those curious about how to start or where to go next, a brief annotated resource list is included at the end of this article.

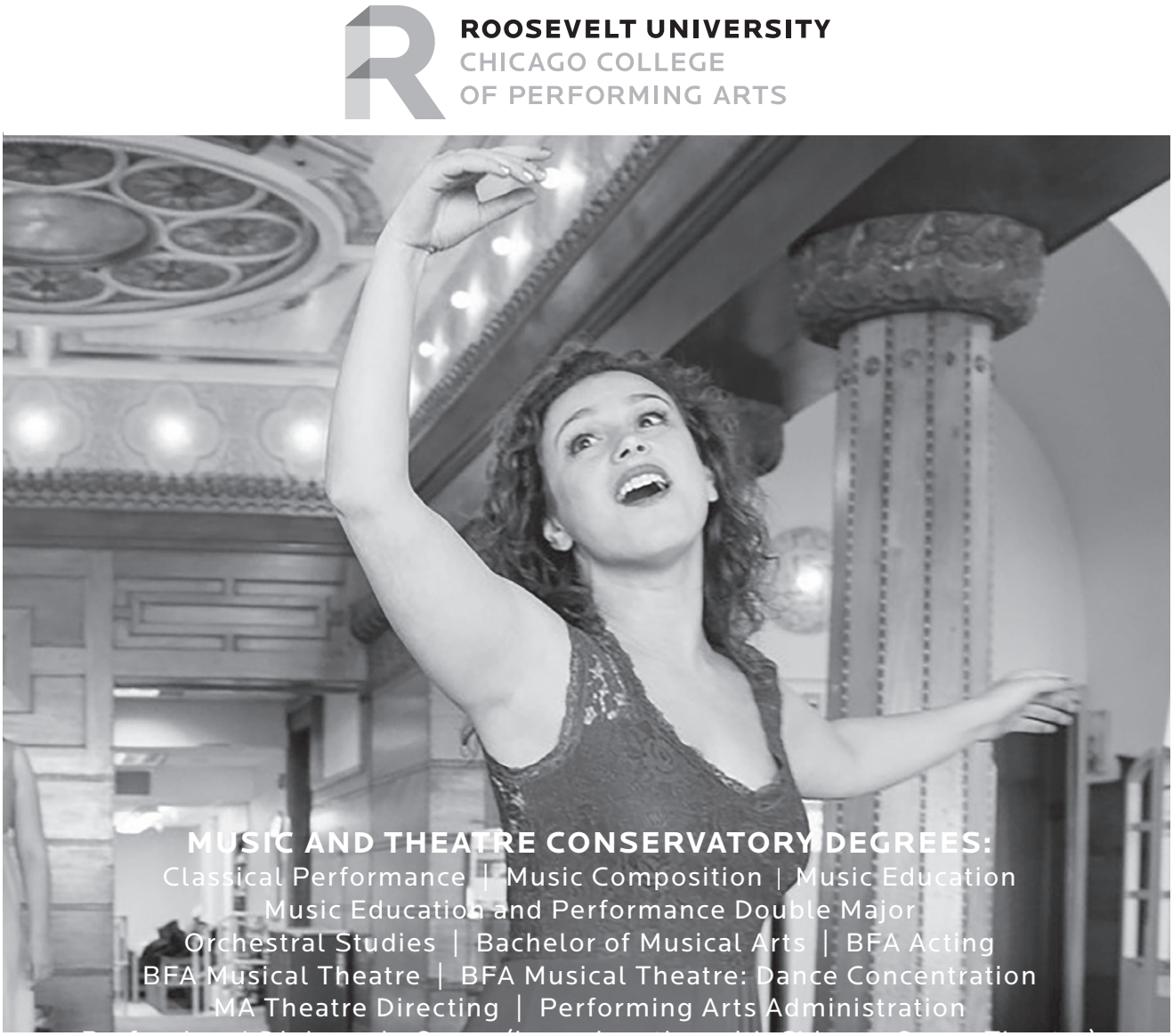
When Varèse dreamed of new, strange instruments, he did not have access to affordable, pocket-sized computers and online retailers specializing in parts needed for DIY technology projects. But the creative dreamer of today does. This opens a world of possibilities for sonic exploration and new modes of interaction that are rich with potential—a merging of established practices with new curiosities, traditional instruments with those not yet invented, acoustic and electronic, bizarre and beautiful.

Resource List

Adafruit: an online resource for open source hardware, electronic parts, and DIY project kits. They have a number of excellent, free learning resources including a community blog, tutorials, guides, and demos for all of their products. https://www.adafruit.com

Instructables: a very wide range of community-submitted DIY project guides and instructions, often including useful snippets of code to help jumpstart your project. https://www.instructables.com/

Kadenze: for those looking to dive into some serious studies, Kadenze is an online course provider that offers classes in topics ranging from introductory audio



Learn more: roosevelt.edu/ccpa-performs

synthesis to advanced machine learning and audio/visual programming. https://www.kadenze.com/

Make Magazine: an online magazine with extensive DIY projects ranging from e-textiles to 3D-printing to robotics. https://makezine.com/

NIME: an annual conference on New Interfaces for Musical Expression, where artists and scholars come together to share new developments in the field of instrument and interface design. The entire proceedings archive for this conference is available free and is a wonderful resource and source of inspiration. http://www.nime.org/

NOTES

[1] E. Varese, "The Liberation of Sound," ed. Chou Wen-chung, *Perspectives of New Music* 5, No. 1 (1966): 11–19.

[2] S. Reid, "Approaching Electronic/Acoustic Performance Practice Through Improvisation," *Journal of the International Alliance for Women in Music* 23, No.1 (2017): 2–7.

[3] S. Reid, "Notation Strategies for Sound-Based Electronic/Acoustic Music," Journal of the International Alliance for Women in Music 23, No.2 (2017): 10–16.

[4] J. K. Diliberto, "An Interview with Donald Buchla," *Polyphony* 8.5 (1983): 14–17.

[5] This article will introduce just a few artists and their work. A more thorough (yet still far from comprehensive) list of works in this field can be found in S. Reid, S. Sithi-Amnuai, A. Kapur, "Women Who Build Things: Gestural Controllers, Augmented Instruments, and Musical Mechatronics," *Proceedings of the International Conference on New Interfaces for Musical Expression* (Virginia, 2018).

[6] D. Oram, "Electronic music, the present and the potential," *Musical Events* XV (December 1960): 20.

[7] "End or Beginning," BBC Radio 3, September 26, 1972. Presented by Thea Musgrave, with Tristram Cary and Daphne Oram. National Sound Archive.

[8] D. Oram, *An Individual Note: Of Music, Sound and Electronics* (London: Galliard Paperbacks, 1972).

[9] J. Hutton, "Daphne Oram: innovator, writer and composer," *Organised Sound* 8.1 (Cambridge University Press, 2003), 49–56.

[10] http://sonami.net/ Accessed September 10, 2018.

[11] T. Rodgers, *Pink Noises: Women on Electronic Music and Sound* (Duke University Press, 2010).

[12] E. Karp, "Artist Interview: Laetitia Sonami." Available at: http://www.somarts.org/laetitiasonami/

[13] R. Fiebrink, "Machine Learning as Meta-Instrument: Human-Machine Partnerships Shaping Expressive Instrumental Creation," T. Bovermann, et al. (eds), *Musical Instruments in the 21st Century* (2016), 137-151.

[14] http://kmwarren.org/ Accessed September 10, 2018.

[15] http://kmwarren.org/exo-rosie.html. Accessed September 10, 2018.

[16] http://akikohatakeyama.com/v_chi.html. Accessed September 14, 2018.

[17] S. Reid, R. Gaston, C. Honigman, and A. Kapur, "Minimally Invasive Gesture Sensing Interface (MIGSI) for Trumpet," *Proceedings of the International Conference on New Interfaces for Musical Expression* (Brisbane 2016), 419–424.

[18] http://sonami.net/ladys-glove/ Accessed September 10, 2018.

Sarah Belle Reid has presented and performed with MIGSI at institutions and festivals around the world, and her compositions have been performed by renowned musicians. In 2017, Flux*, for amplified percussion quartet, won the Grammy-nominated Los Angeles Percussion Quartet's Next Wave Composer Initiative. She has premiered over 40 works for solo trumpet as well as multiple chamber and performance art pieces, and she is a founding member of the trumpet/modular synthesizer duo Burnt Dot. Reid has published technical and theoretical papers on the subjects of interdisciplinary process and collaboration, musical interface design, and alternate methods of musical notation.*

Oh, the Places You'll Goh

YEN-LIN GOH

Congratulations to Yen-Lin Goh! She was recently selected as a 2018 OneBeat Fellow by the U.S. Department of State's Bureau of Educational and Cultural Affairs from a pool of more than 1,500 applicants. OneBeat is an international music exchange that celebrates musical collaboration and social engagement through innovative people-to-people diplomacy. Musicians (ages 19-35) from around the world come together in the U.S. for five weeks to collaboratively write, produce, and perform original music, and develop ways that music can make a positive impact on our local and global communities. Yen-Lin's residency was for September/October 2018.

The IAWM is delighted to welcome Yen-Lin, our first member from Malaysia. I invited her to tell us about her unusual career and her experiences in three very different countries.

From Malaysia to the United States

As a pianist, composer, and teacher, I have traveled widely and lived in three different countries, starting and ending in Malaysia. Although I was born on Penang Island in Malaysia where my parents lived, we moved to the capital Kuala Lumpur because of better job opportunities. But were there opportunities for musicians? When I was young, I was told that my career options would be very limited if I chose the arts, so I majored in science, like most other "good" students, even though I was not especially interested in science.

I was anxious to travel and continue my education in America. Since Malaysia is a tropical country, where it is summer all year long, I wanted to go where I could experience the four seasons and snow, and I was accepted at the University of Wisconsin-Madison, majoring in communication arts/radio-TV-film and piano performance. That was a milestone in my musical journey and probably one of the most important decisions I have made. I enjoyed my music classes the most, and through my participation in an ensemble I re-discovered my love of improvisation, became fascinated with contemporary music, and realized that I had ability as a composer after creating a piece for the improvisation ensemble inspired by Malaysian culture. This was also a period of social adjustment for me. Living in a large country and attending a large school meant that I was no longer a prominent student, as I was in the small Yamaha music school in Malaysia. I also had to adjust to the American education system, which was quite different from the one I grew up with in Asia. In Malaysia's exam-oriented educational system, students focused on doing well in the final exams, whereas in my experience in American universities, coursework and performance throughout the semester took precedence. In other words, there was much more emphasis on the learning process.

For financial reasons, I had expected to return as quickly as possible to Malaysia, but my planned two-and-one-half years in the U. S. extended to ten years. I was fortunate to receive a full scholarship to Oklahoma City University for graduate study. It was a fruitful two years; I could focus on piano playing and music making at a small