

NEA ARTS

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A Kind of **Beauty** The Intersection of Art and Science



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About this Issue

Traditionally, art is held in the realm of imagination, emotion, and creativity. Science, on the other hand, is a matter of reason, accuracy, and meticulous, methodical process. But as artist Greg Mort, who has worked with the NASA art program, noted in an interview with the NEA, “There’s a scrutiny that science requires; there’s a scrutiny that art requires. Both have a passion for the notion of the question, also the idea of knowing.... I think, ultimately, science and art ask the same question. They both seek a kind of beauty.”

With the dawn of the 21st century, this shared spirit has manifested itself in countless new ways, and there has been explosive growth in interdisciplinary experimentation—even at the NEA. In 2010, the Arts Endowment and the National Science Foundation (NSF) hosted a workshop to re-think and promote the intersection between art and science. Recently, we entered into a partnership with NSF and the National Endowment for the Humanities in order to begin formally exploring how we might work together at the intersections of science, art, and the humanities. This year also marks the first time we have actively encouraged grant applicants to consider pursuing art/science projects.

In this issue of *NEA Arts*, we highlight some of the people and organizations that are blending the two fields. We delve into the neurobiology of music, learn what it means to be a visual strategist at NASA, and explore the science-based theater productions that have emerged from Catalyst Collaborative@MIT. We also look at how art can illuminate the impact of climate change, and the ways that science can reinterpret the very concept of dance. Be sure to check out arts.gov for additional online stories.

Stories

3 Finding Common Ground
Scientists and Theater Artists
are Kindred Spirits at MIT

BY PAULETTE BEETE

8 The Artistic Climate
Andrea Polli Transforms
Scientific Data into Art

BY WHITNEY DAIL YOERGER

12 Cosmic Creativity
An Artist’s View of Space

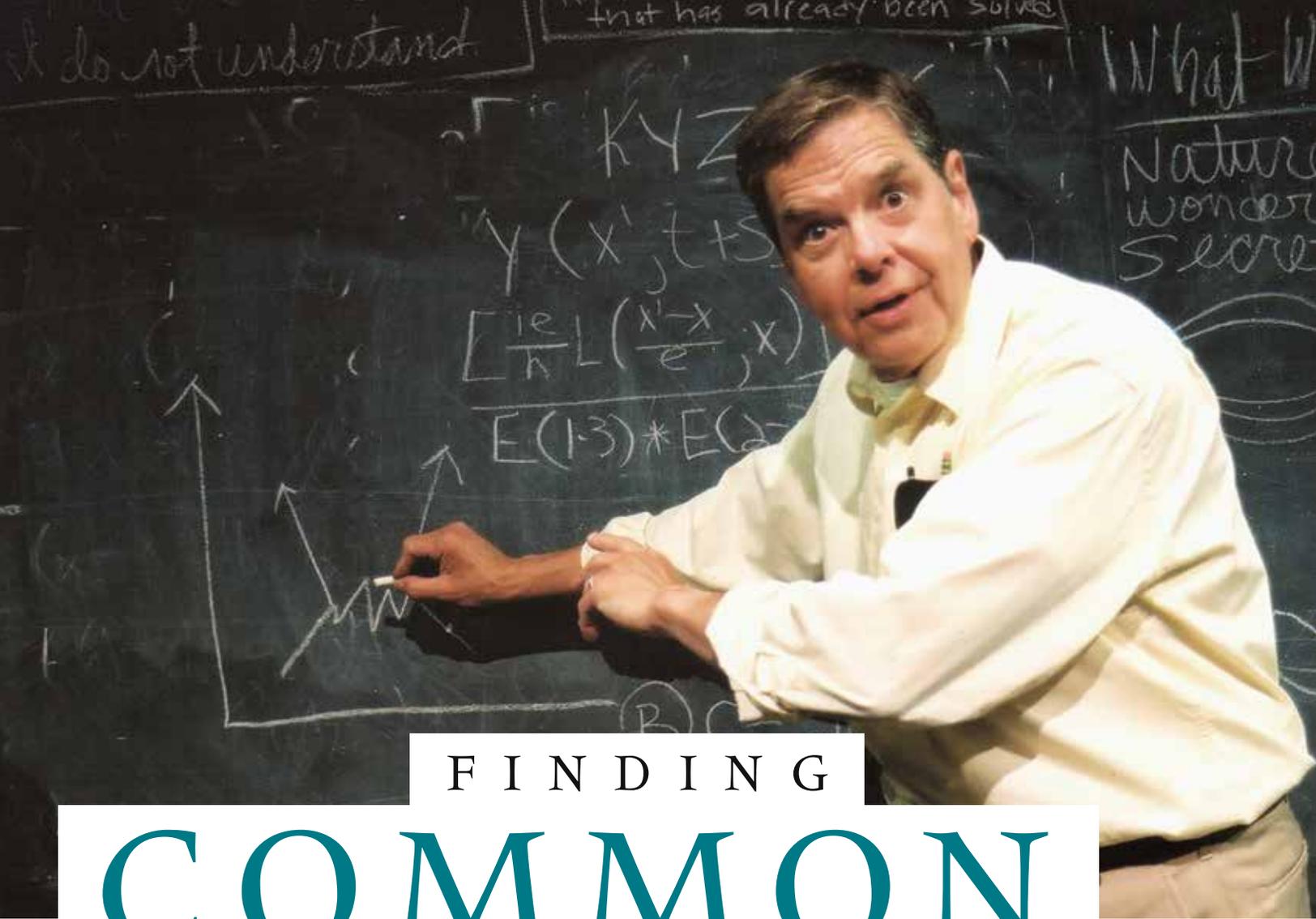
BY REBECCA GROSS

16 Decoding Music’s Resonance
A Look at Researcher and
Performer Parag Chordia

BY JESSICA GROSS

20 What the Body Is
Brain Waves and Choreography
with koosil-ja/danceKUMIKO

BY MICHAEL GALLANT



FINDING

COMMON GROUND

Scientists and Theater Artists are Kindred Spirits at MIT

BY PAULETTE BEETE

If you believe the popular conception of artists and scientists as polar opposites, you might expect that putting them into a room together would lead to brawls, brouhahas, and well, big bangs. But, in fact, as theoretical physicist and novelist Alan Lightman and playwright Alan Brody have found out, the only explosions in the room are creative ones. In

the early 2000s, the two men—both on faculty at the Massachusetts Institute of Technology (MIT)—decided to start a monthly salon for scientists and theater artists on MIT's campus. The members of the resulting Science on Stage salons discovered not only common ground but also how, in many ways, artists and scientists are kindred spirits.

Keith Jochim in Peter Parnell's *QED*, a play inspired by the writings of physicist Richard Feynman.
PHOTO COURTESY OF CENTRAL SQUARE THEATER



ABOVE | The cast of Alan Brody's play *Operation Epsilon*, based on the transcripts of German nuclear scientists while in captivity at the end of World War II, in a Catalyst Collaborative@MIT production. PHOTO BY A.R. SINCLAIR PHOTOGRAPHY

OPPOSITE | Kortney Adams and Wesley Savick in Melinda Lopez's *From Orchids to Octopi*, commissioned by the National Institutes of Health to celebrate the 150th anniversary of Darwin's *The Origin of Species*. PHOTO BY ELIZABETH STEWART/LIBBERDING PHOTOGRAPHY

While playwrights and physicists might have sounded like strange bedfellows, theater proved a natural way to illuminate the human dimensions behind theories and equations. “The theater can raise questions that no other medium can raise in quite the communal way a play does. There are issues about science that very often don’t get expressed and don’t get discussed.... [having] to do with the moral dimensions of our research,” explained Brody. “We’re trying to find out what the human conditions behind science are, and that’s, I think, one of the greatest values that we have in the theater.”

Debra Wise, artistic director of Underground Railway Theater, was one of the salon’s participating theater artists. “The enterprise of theater, of course, is to raise and explore questions. I used to think before attending these Science on Stage salons that this was in contrast to the essential enterprise of science, which was to provide reasonings behind certain truths that were first discovered and then articulated,” she said. “Now I understand, actually, that one thing that scientists and artists have completely in common is we both demand of ourselves to sit in the

middle of a question or a problem space for a very long time without running to one solution.... [I]t was a real epiphany for me as an artist, and I think to a certain degree to our colleagues who are scientists to see that the creative enterprise in both of our disciplines, in both of our domains, had that similarity.”

Brody said that he was particularly struck by the common passions that the group shared. “[I remember] a wonderful moment when Bob Jaffe, who’s a theoretical physicist, was talking about the nature of beauty in terms of equations, and it just blew my mind because he was talking about it in the same way we talk about it in the visual arts and we talk about it in the theater,” he said. “I thought, ‘They really do inhabit the same world we do with the same passions.’”

The group met monthly for more than a decade, engaging in spirited conversations around topics such as the intersection of religion and science. Each session began with discussion about recent theater productions and scientific developments. “And miraculously after about 15 minutes we would all settle on one of the topics that had been floating around... and the rest of the two hours

“There’s a lot that artists and scientists have to say to one another within the context of exploration, discovery, and experimentation.”

would be spent talking about that topic,” remembered Lightman. “This is the way it happened every time.... What made it work was that we never had an agenda. Nobody ever had homework.”

Brody agreed that the open-ended spirit of the discussions was key to their success. “We didn’t feel that we had to get things done. We just talked. And it was simply astonishing how with the kinds of minds that were around that table, the kind of lively interchange that happened with nothing at stake.”

While MIT has made its reputation at the forefront of science and engineering, it was actually an ideal home for the Science on Stage salon, according to Leila Kinney, executive director of arts initiatives and MIT’s Center for Art, Science, and Technology. The university has a long tradition of fostering collaboration across the arts and the sciences—for example, visual artist György Kepes founded the Center for Advanced Visual Studies in 1967, and

the university has a robust visiting artists program, recently hosting the likes of Trevor Paglen and Vik Muniz. MIT also had already dipped a toe into theater and science pairings with a symposium around a touring production of Michael Frayn’s *Copenhagen*, about a 1941 meeting between physicists Neils Bohr and Werner Heisenberg, and by partnering with Boston’s Museum of Science to produce staged readings of Peter Parnell’s *QED*, which imagines a day in the life of physicist Richard Feynman. According to Kinney, “There’s a lot that artists and scientists have to say to one another within the context of exploration, discovery, and experimentation.”

After a few years, some of the salon members began producing staged readings at venues on the MIT campus and around the community. One of its early productions was Brody’s *Small Infinities*, a play about Isaac Newton that was sparked during a salon discussion.

In 2005, Brody, Lightman, Wise, and the late





ABOVE & OPPOSITE | Debra Wise, Robert Najarian, and Steven Barkhimer in *Einstein's Dreams*, a stage adaptation of Alan Lightman's 1992 novel.
PHOTOS BY ELIZABETH STEWART/LIBBERDING PHOTOGRAPHY

playwright Jon Lipsky formally established Catalyst Collaborative@MIT to support theater productions about the culture of science. Around 2007, Wise's Underground Railway Theater and the Nora Theatre Company moved into a new home—the MIT-owned Central Square Theater. Catalyst Collaborative mounted a theatrical adaptation of Lightman's novel *Einstein's Dreams* as its first full production in its new home. (Catalyst Collaborative recently received NEA funding to support a theatrical adaptation of another of Lightman's novels, *Mr g*, scheduled to debut in early 2015.)

The project's overall goal was not only to produce plays, but also, according to Wise, "to follow these [productions] with conversations that put audiences in direct engagement with scientists who were doing cutting-edge work in the scientific areas that were being explored."

From the beginning, MIT participated in Catalyst Collaborative as much more than a landlord. "We have an advisory committee that's chaired by

Associate Provost Philip Khoury with responsibility for the arts. We actually review [the Catalyst Collaborative] season, the kinds of productions they're thinking of doing, how that relates to major topics in science and research at MIT," said Kinney. University scientists also sit on the project's board, and scientists from MIT and other regional schools participate in post-show audience talkbacks.

Mimi Huntington, artistic director of the Nora Theatre Company, which has recently become a Catalyst Collaborative partner, acknowledged the importance of the scientific community's participation to the project's success. "We have such resources [at MIT], and that makes the program really rich. People we can talk to for getting the science up to date, and people who are really supportive and want to be part of the process—whether it's talking to actors during rehearsal time in order to get them closer to whatever is being discussed in the play to having scientists and actors talking together at the talkbacks."

While each season at Central Square Theater is partially populated by existing theater works, such as Bertolt Brecht's *The Life of Galileo*, Catalyst Collaborative also commissions new work. For example, Melinda Lopez's *From Orchids to Octopi* was developed thanks to a commission from the National Institutes of Health. "They mandated us to create a piece that would be equally powerful for a high school audience as for a general adult audience," said Wise. "The takeaway from the play would be an understanding that evolution and natural selection were essential across disciplines of modern science."

As part of the development process, Lopez and the creative team interviewed approximately 30 scientists on the science itself, what they thought the science meant for society as a whole, and the importance of Darwin's seminal work *The Origin of Species*. The science community was also involved in readings of the play as it developed, in helping David Fichter design a mural that was a pivotal set piece, and in planning the content for symposia and audience talkbacks associated with the production.

All of the partners have been pleasantly surprised by enthusiastic reactions from both the scientific community and the general public. "I think the interesting thing about the Catalyst Collaborative is how receptive an audience they have found for these kinds of plays about furthering the public understanding of science, how willing and eager the scientists have been to participate in the dialogue, and that we just seem to be building an audience for this kind of thing," MIT's Kinney said. "I think it's a wonderful sort of contribution to what we used to call a public intellectual discourse."

Brody commented that the project's success is a case of the right project at the right time. "I think we are in the vanguard for the theater to talk about what the world is like in the 21st century. That in talking about science and theater, this is the 21st century's version of the 20th century's psychological drama."

Wise believes that, ultimately, the Science on Stage salons and Catalyst Collaborative are about more than using theater to encourage people to like scientists or understand scientific theories. "[It's about] looking at science as a way of understanding our place in the universe," she said. "Understanding that is a central part of our enterprise as a society." ▲





ABOVE | Andrea Polli setting up a station for the *Hello, Weather!* project.

OPPOSITE | *Particle Falls* is a large-scale projection that allows viewers to see current levels of fine particles in the air by cascading data down the façade of the AT&T building in San Jose, California.

The Artistic Climate

ANDREA POLLI TRANSFORMS SCIENTIFIC DATA INTO ART

BY WHITNEY DAIL YOERGER

ALL PHOTOS COURTESY OF ANDREA POLLI

Call them eco-artists, call them environmental artists, call them crusaders. As concern over climate change has grown, many artists have employed their work to explore the human toll on the natural world. Take Andrea Polli, an award-winning digital media artist based in Albuquerque who teaches art and ecology at the University of New Mexico (UNM). Polli calls attention to the way our climate is evolving by transforming scientific data into soundscapes, sonifications, and participatory public artworks. For instance, imagine being aurally immersed in Antarctica's sub-zero environment or observing what looks to be a hyperventilating, "suffocating" car. Her projects vary in form, often utilizing interac-

tive websites, digital broadcasting, mobile applications, and performances in order to reach as wide an audience as possible. "I wouldn't say that I'm really explaining anything as much as I'm promoting a kind of emotional reaction," she said.

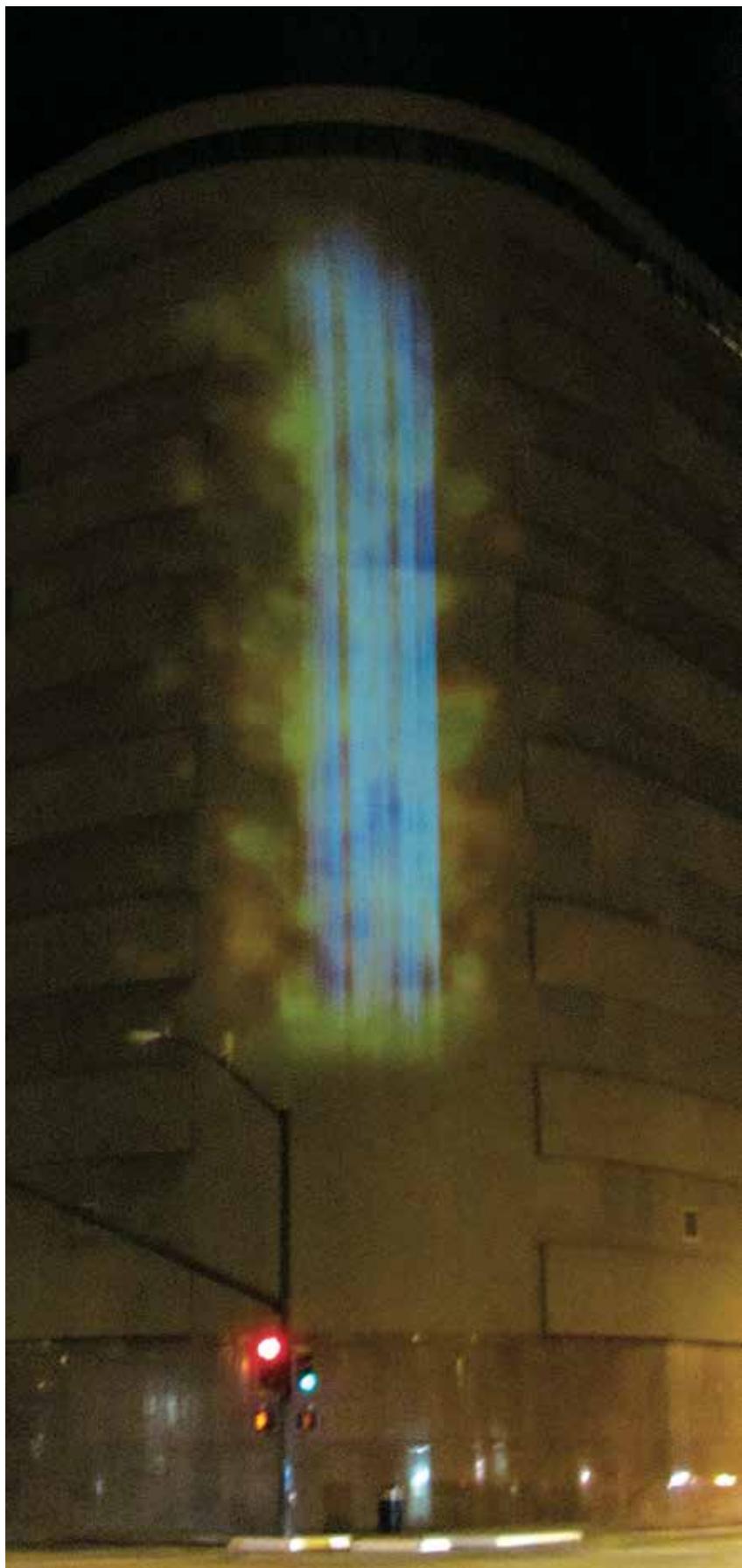
In her work *Particle Falls*, Polli drew attention to particulate pollution, or the tiny, menacing particles in the air such as car exhaust, tobacco smoke, mold spores, pollen, and silica dust. Using a nephelometer, which monitors air particulates, *Particle Falls* projects a cascading stream of current air quality data, enabling passersby to visualize the effect of their presence on the atmosphere in bright orange bursts. Polli suggested, "If you can see that in real-time, you have

a different kind of emotional reaction to it.” Through December 1, the Chemical Heritage Foundation in Philadelphia will project *Particle Falls* onto the Wilma Theater as part of the foundation’s *Sensing Change* exhibition. It will be the second presentation of *Particle Falls* since its development for the 2010 ZERO1 Biennial in San Jose, California. “I like to think of these projects as living things that are evolving,” she said. “I’ll show them more than once, and with each iteration it may change.”

Polli’s earliest artistic interest within the world of science began with chaos theory, a mathematical field studying the underlying orders and unpredictable behaviors of dynamical systems. “There was an article that came out in *Scientific American* about fractals and chaos and it gauged programming code,” she recalled. “I got curious about what that might sound like.” So during completion of a master’s degree in time arts at the School of the Art Institute of Chicago, Polli wrote a program to turn fractals into musical improvisations based on the Lorenz attractor, a set of chaotic solutions based on a mathematical formula first developed during studies of atmospheric convection.

It wasn’t until several years later that Polli started exploring ecology. Attending an art-science conference in Los Angeles, she met her first scientist-collaborator, meteorologist Glenn Van Knowe of Troy, New York. “I told him about [my] work with the Lorenz attractor, and we talked about how that was the simplified model for air movement through the atmosphere and how much those models had progressed,” she said. “That’s when we started talking about doing the *Atmospherics/Weather Works* project.”

Using the latest technology in atmospheric modeling, their partnership resulted in a multi-channel sonification of two historic storms that struck the Mid-Atlantic: the Presidents’ Day Snowstorm (1979) and Hurricane Bob (1991). *Atmospherics/Weather Works* debuted in 2003 as a 16-speaker sound installation at a firehouse-turned-gallery in Lower Manhattan’s Tribeca neighborhood. These cacophonous musical pieces interpreted “the more unpredictable complex rhythms and melodies of nature.” With sound, Polli provided a soundtrack of storm activity that mapped the sudden weather changes that occurred over a 24-hour period.





Polli's *Cloud Car* at the New York Hall of Science in conjunction with the Ear to the Earth Festival in October 2008. *Cloud Car* was developed in residence at Eyebeam Art + Technology Center and supported by the New York Hall of Science, International Symposium for Electronic Art, Belfast, and Parco Arte Vivente (PAV), Torino.

In some ways, there is also a sensational quality to Polli's art. One such example is *Breather*, a bubble-encased car suffocating on its own exhaust fumes, that draws attention to Delhi, India's mounting health crisis due to air pollution. Similarly, the mist-cloaked *Cloud Car* makes visible the effect that automobiles have on air quality. “[*Breather*] and the *Cloud Car* piece are very much a spectacle,” she replied when asked how people have responded. “One thing I thought was effective about [both pieces] was that people would come up to the car and we would hand them a fact sheet that would say, ‘If you have to drive, here are some things you can do that will reduce your emissions.’” The point of these projects is ultimately to raise awareness and understanding of the issue. “If we just tried to hand people that information without having some kind of fun spectacle to perk their interest, they might reject it or feel insulted by it or just not want to look at it or read it.”

She hopes that an emotional response will prove powerful enough to prompt changes in human behavior. “I think that art [and] digital media can help maintain people's interest by creating all kinds of different ways to raise awareness and raise people's energy and interest in doing things that are positive,” she said. “I've talked to the meteorologists

I've collaborated with, even as far back as 1999 to the 2000s, and they told me that they could not do their work without visualization. So it's become essential to the scientific work as well... I think [data visualization] is going to become really integrated in people's everyday lives.”

The creative process for Polli's pieces is multifaceted, and often includes collaborative, interdisciplinary teams as well as extensive fieldwork. “I'm very interested in the people, specifically the scientific researchers and the site—what they're doing and what their knowledge is,” she said. For *Sonic Antarctica*, Polli flew to the remote continent of Antarctica and spent seven weeks at a residency with the National Science Foundation's (NSF) Antarctic Artists and Writers Program. There she worked alongside scientists studying the global effects of climate change while conducting her own artistic inquiries. The result was a performance piece and a sound and visual installation based on her research.

When asked about her greatest environmental concern of the moment, she said, “Waste. I think it's a really huge issue.” Polli added, “Right now, what I'm thinking about is how important it is to have a cycle of production that's circular rather than a linear cycle so that we can be more effective

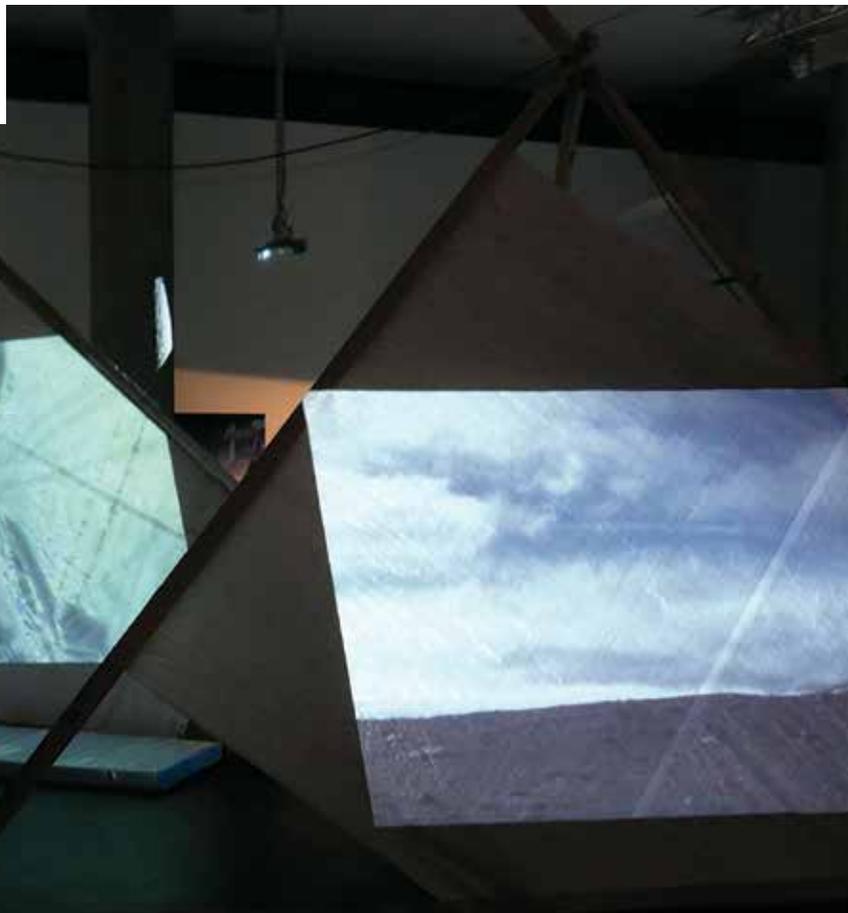
at reusing our resources.” Polli will explore this issue over the next five years with the Social Media Workgroup, a lab that she directs at UNM’s Center for Advanced Research Computing. The Social Media Workgroup is comprised of faculty, undergraduate and graduate students in engineering and the arts, and industry professionals who work together on “projects related to media technology, environment, and social change.”

The group’s latest project, which received an NSF grant, will explore new approaches to energy harvesting and raise awareness of global behaviors to energy consumption. “My research team is working on the outreach and raising public awareness about this kind of work,” Polli said. The plan is to create a large LED grid for a high-rise in downtown Albuquerque visualizing the city’s energy consumption and energy potential.

With her dedication to this type of large-scale public work, Polli has managed to successfully break out of the studio and enter, well, the environment, making even the most stubborn people stop and think about our responsibilities as human beings on our shared planet. ▲



Whitney Dail Yoerger is a writer and cultural worker living in Maryland. She reports on activities and projects at the intersection of art, science, and technology.



COSMIC CREATIVITY

AN ARTIST'S VIEW OF SPACE

BY REBECCA GROSS

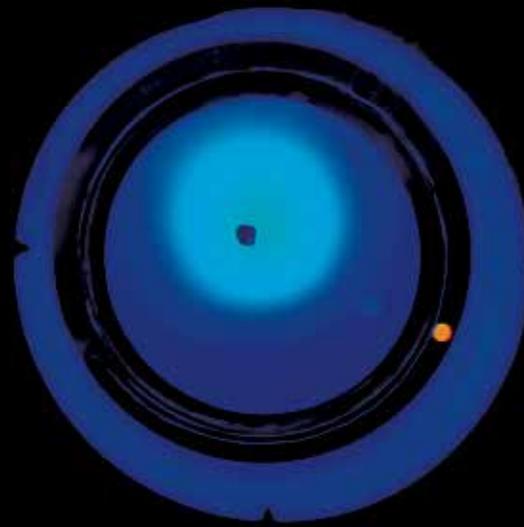
When Dan Goods was studying graphic design, he figured he'd probably end up at an ad agency or some sort of commercial corporation. But these days, his artistic concerns are bigger than choosing the appropriate typeface, layout, and color. Much bigger. Like Jupiter-sized big.

For the past ten years, Goods has worked as a visual strategist at the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory (JPL) in Pasadena, California. His job is to translate the technical, data-driven language of JPL's missions into engaging, public-friendly works of art. When negotiating his position, the original idea was that Goods would create visualizations communicating JPL's work. But Goods pushed back: he didn't want people simply to see the universe; he wanted them to feel it.



“What is great about being here is that I get to work with content that is, in its essence, mind-blowing. But you still have to express it in a way that’s mind-blowing as well,” said Goods, who was named “one of the most interesting people in Los Angeles” by *LA Weekly* in 2012. “I want to be able to give people a moment of awe about the universe that we live in.”

Take his piece *Beneath the Surface*, inspired by the Juno spacecraft’s mission to Jupiter. Launched in 2011, Juno will penetrate Jupiter’s thick cloud cover for the first time, allowing scientists to study the planet’s evolution and properties, including the depth of its powerful lightning storms. Intrigued by the idea of these massive storms, Goods used vaporized tap water, ultrasonic misters, infrared lights, and audio of thunder to simulate what it might be like when Juno descends upon the gas giant.



To demonstrate the relatively tiny number of planets discovered in the Milky Way, Goods drilled a hole in a grain of sand as part of his installation *The Big Playground*. The grain of sand was viewed through a microscope. PHOTO COURTESY OF NASA/JPL-CALTECH

He filled a darkened room with a vast, amorphous cloud, backlit by an eerie reddish glow. In a nod to the instruments needed to see below Jupiter's clouds, the installation's "lightning" was created using infrared lights, which are invisible to the naked eye but can be seen with a cell phone camera. As thunder crashed all around, people were able to use their phones to embark on their own exploratory mission of the lightning storm.

"That experience of going into this room, seeing this crazy cloud, touching it, using their cell phone—it's all an experience I like to hope people take with them for a long time," Goods said.

Although Goods said he has always been fascinated by space, he didn't consider pursuing science professionally until he arrived at the Art Center College of Design, also in Pasadena. When nearby California Institute of Technology opened its summer research program to Art Center students for the first time, Goods became one of the first three artists accepted. He found himself working alongside conceptual artist David Kremers to help create the "Mouse Atlas," a digital tool that visually mapped the development of mice. While a far cry from astrophysics, it left a profound impression on Goods.

"The experience of hanging out with scientists was fascinating for me," he said. "I loved the big ideas that science works with, and I felt like I was doing something meaningful."

The experience was so positive that after graduation, Goods focused his job search within the world of science. After a number of false starts, he was invited

on a tour of JPL with the president of Art Center and the director of the NASA facility. "I had about two seconds to sell myself," Goods remembered. Eventually, he was able to show JPL's top brass the Mouse Atlas and a traveling pipe organ he had invented by rigging soda bottles to a car. The projects were innovative enough to convince JPL staff that he had more to offer than the animations they had in mind.

"Most of the time, if someone says, 'Do you want to do animations?' You say, 'Yes,' when you need a job. You don't usually say, 'Hey look at this bottle project,' to a person from NASA, expecting them to be enticed by it. But I took the risk, and it paid off," said Goods. He was told he'd get six months and then they'd re-evaluate. That was ten years ago.

It didn't take long for Goods to make his mark. One of his earliest projects, *The Hidden Light*, illustrated the difficulty of locating planets, which are often obscured by the blazing light of much larger, brighter nearby stars. "They have an analogy [that] if there is a firefly in front of a spotlight in New York, you're trying to see it from Los Angeles," he said. "That gives you a sense of the difficulty and challenge." Goods' own challenge was how to turn this idea into a compelling experience for the public. The result was brilliant in its simplicity. He trained two light sources onto a blank, outdoor wall: a movie projector and a 20,000-watt spotlight. Because the spotlight was so much brighter than the projector, the projected film could only be seen when people stood in front of the spotlight, blocking its luminosity. As people experimented with the different

ways their shadows could reveal the image on the wall, the installation became a throng of walking, dancing, playing, and perhaps inevitably, shadow puppeting.

His other projects for JPL have all shared Goods' signature originality and sense of wonder. For *The Big Playground*, Goods drilled a hole in a grain of sand and displayed it under a magnifying glass in order to depict the relatively tiny number of planets discovered in the Milky Way. Six rooms were then filled with sand to represent the galaxies still awaiting human discovery. Another installation, *For Those Who Dream, Far Away Does Not Exist*, was inspired by the cosmic aspirations of NASA employees. Set within a darkened room, the piece projected shifting colored lights onto blocks of aerogel, a nearly weightless material used on twin Mars rovers Spirit and Opportunity. The stunning interaction between this space-age substance and light resulted in an ethereal installation that was a dreamscape all its own.

Despite the endless inspiration space may provide, Goods has come to serve as something of a muse himself. In recent years, he and his team—which now includes people from the worlds of architecture, advertising, film, special effects, and product design—have expanded their role, and are beginning to help design actual missions. While a mission's technical details are still left to the ex-

perts, Goods and his crew are there to spur the out-of-the-box thinking so necessary for the study of space.

“When scientists and engineers come to our studio, they're in a mindset that they want to be in a creative space,” said Goods. “They feel permission to be more creative because we're around.” When it comes to mission design especially, “We're trying to figure out how our role can enhance the thinking and creative process they have.”

In turn, his own creative process has come to resemble something akin to the scientific method. After meeting with scientists and engineers to determine “what is meaningful and powerful and interesting about a topic or a person,” he asks questions, conducts research, experiments, fails, then experiments again. “Hopefully,” he said, “you succeed at some point.”

And succeed he has. Throughout his career of melding art and science, he has managed to continuously capitalize on a central component the two fields share: their ability to make people step back, open their eyes, and see the world (or in this case, the universe) in ways they never have before. Goods however had a different way of putting it: “I'm hoping I can create things that make people go, ‘Wow.’” ▲



For the installation *The Hidden Light*, Goods used a projector and a spotlight to illustrate the difficulty of locating other planets. PHOTO COURTESY OF NASA/JPL-CALTECH



DECODING MUSIC'S RESONANCE

By Jessica Gross

A Look at Researcher and Performer Parag Chordia

Parag Chordia has spent much of his life thinking about music, first as a performer and researcher, and now, as an app developer. This combination has led him to pursue questions that most listeners—and even most performers—simply take for granted. “Most of us are musicians or deeply touched by music,” said Chordia of the researchers

in his field. “And we also have this kind of engineering or scientific drive to understand why.”

Music became a central part of Chordia’s life during high school in South Salem, New York, when he attended his first Indian classical music concert with his father. He was so moved that by college, he’d decided to pursue Indian classical music performance,

and took a year off from school to live in India and study the *sarod*, a fretless, stringed instrument. (He eventually returned to school, receiving a BS in mathematics from Yale and a PhD in artificial intelligence and music from Stanford University.)

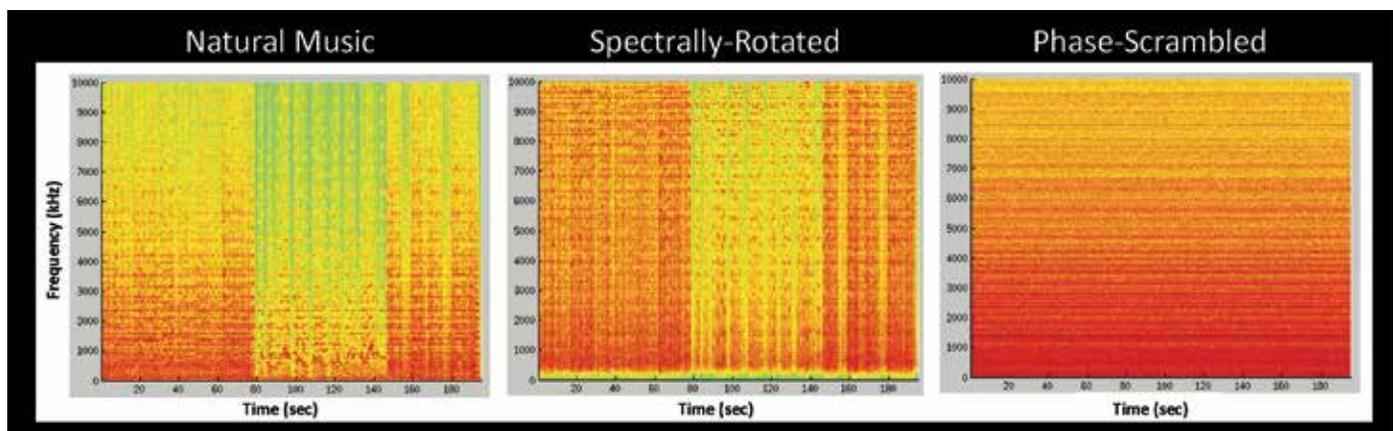
Years later—and after a decade of studying with renowned sarod teacher Pandit Buddhadev Das Gupta—Chordia has become an experienced performer. What’s more, his intense connection to music has blossomed into a career off-stage as well. Prior to taking on his current role as chief scientist of the music app developer Smule last spring, Chordia founded and directed the Music Intelligence Group at the Georgia Institute of Technology. His work, partly funded by the National Science Foundation, has focused on a number of questions: “How is sound produced, how can it be manipulated—and, also, how is it perceived?” Chordia said. “How does the brain organize sound, and why does it elicit the types of responses and emotions that it does?”

At Georgia Tech, Chordia and his colleagues wanted to better understand the connection between music and the voice. “We said, okay, when a person is happy, their speech sounds different than when they’re sad,” he explained. A sad person speaks softly, slowly, often mumbles, and has a darker tone; a happy person speaks more quickly and brightly. “We started to wonder, is music bootstrapping off of the same processes? In other words, are those fundamental acoustic cues being used to signify happiness and sadness in music?”

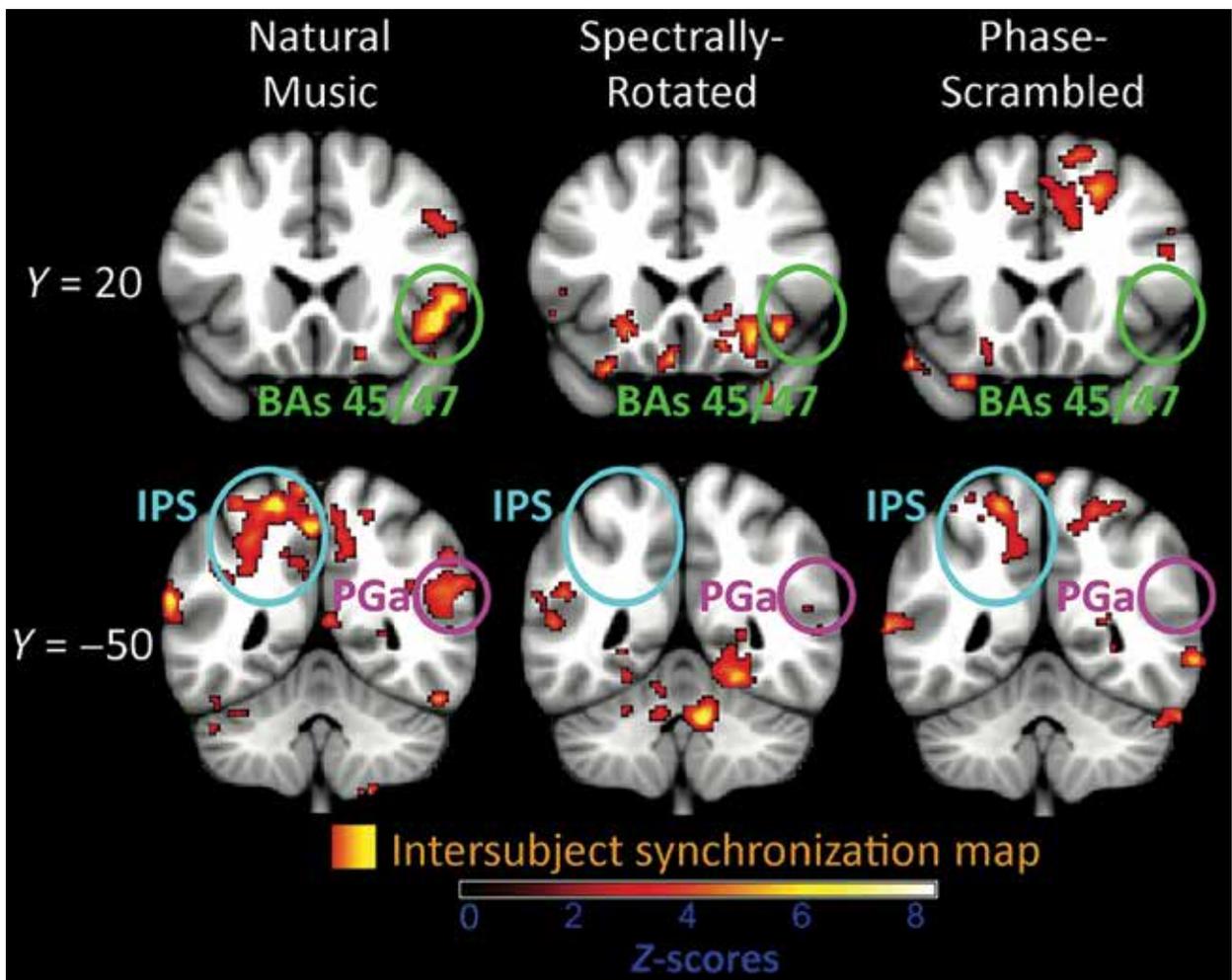
Chordia’s team created an artificial melody, then shifted it to sound either slightly higher or slightly

lower. One group of participants heard the higher melody, followed by the original; the second group heard the lower melody, followed by the original—so the second melody both groups heard was exactly the same. The surprising results: the participants experienced that identical melody differently. Those in the first group described the original melody as sad, because it was lower than the first sample they heard, while those in the second group described it as happy, because it was higher than the first sample they heard. The upshot was that pitch does confer emotion in music in a way that mimics our response to vocal expression. This is, Chordia explained, why a tremolo in music registers as intense: it reminds us of the way an angry, adrenaline-spurred voice shakes. Indian classical music’s overlap with human vocal properties is also part of what makes it “so emotive and expressive,” Chordia said.

The study’s other takeaway is that our experience of music is relative to what we’ve heard before—our perception of music isn’t static. Neither is music itself. Chordia explained that music strikes a remarkable balance between predictability and novelty. Humans are simultaneously attracted to both elements. On the one hand, evolutionarily speaking, there is a reward for accurately predicting what’s to come: if we can anticipate threats, we’re in better shape than if we can’t. On the other hand, the drive toward novelty is vital: if we never sought out new sources of food or new social connections, we’d be less successful. Correspondingly, our reward systems kick in—that is, we experience pleasure—in both instances.



ABOVE | Spectrograms reveal the synchronicity of neural activity in study participants as they listened to three variations of a symphony while undergoing fMRI scans. IMAGE COURTESY OF PARAG CHORDIA
OPPOSITE | Parag Chordia performing on the *sarod*. PHOTO BY PREERNA GUPTA



ABOVE | These fMRI images show areas of the fronto-parietal cortex that responded in similar ways across study participants as they listened to three variations of a symphony. Synchronization was strongest when participants listened to the original, unaltered symphony. IMAGE COURTESY OF PARAG CHORDIA

OPPOSITE | One of the subjects of a study that scanned brain activity of trained musicians while they played familiar songs and while they improvised. PHOTO BY PARAG CHORDIA

“I think what’s really interesting about music is that it plays off of both these things,” said Chordia, who has studied this phenomenon through computational and statistical modeling of music’s structure. “One of the ways that we describe music is ‘safe thrills.’ It’s like a roller coaster. On the one hand, you know nothing really bad is going to happen, but there are all these pleasant surprises along the way. A lot of music is like that: you set up a pattern and expectation, and then you play with it.” That might mean slightly varying the drumbeat, changing the chord pattern, or adding or removing instruments. “Those little surprises, it turns out, can be very pleasurable.” They result in what Chordia calls a “supercharged stimulus.”

The surprises aren’t reserved for the first time we hear a song, either. “If you play a segment of music

ten times,” Chordia said, “at points of high surprise, there’s a distinct pattern you can see in the brain, and what’s interesting is that that low-level surprise doesn’t disappear.” There’s some habituation, but a piece of music can give us that little jolt of surprised pleasure even if we know it very well.

As a performer, Chordia isn’t just interested in how we perceive music. His research also investigates what happens to us while we play it. In one study, Chordia and his colleagues hooked trained musicians up to an EEG machine, which measures electrical activity in the brain, while they played simple, familiar songs, and then improvised. Based on preliminary data, it appeared that when they improvised, certain areas of their brains actually muted. That is, rather than requiring more activity

across the brain, a highly creative state benefits from fewer active areas, so that more disparate regions can communicate with each other and create unexpected new insights. (This is perhaps one reason, Chordia suggested, that alcohol and music often go hand-in-hand.)

But making music doesn't just enable new kinds of communication within our brains; it also enables an incredible level of synchronicity between people. If you've ever sung in a chorus, been to a concert, or played in a band, you probably recall the camaraderie. Chordia and his colleagues wanted to figure out whether there was neurological basis for this sensation.

Using fMRI scans, which measure changes in neural blood flow, the study revealed that people who listened to the same piece of music had activity in similar areas of the brain at the same time. "If you think about it, this is pretty amazing," Chordia said, pointing out that an fMRI of two people talking or writing or gazing out the window together wouldn't yield this kind of coordinated brain activity. "I think our powerful intuition that it is a shared experience is true."



In recent years, Chordia's interest in the roles of performer and audience, and how the two overlap, has led to his latest endeavor: creating apps that allow listeners to become performers.

Chordia's main missions in his current role at Smule are encouraging people who don't think of themselves as musicians to sing and play anyhow, and enabling people to connect with each other through music. He aims to accomplish both using smartphones: "How can we create a 21st-century folk music through technology?" Yes, there's the irony of fighting isolation via the devices that enable it. But in another sense, this is a natural next step in musical evolution: every instrument is a kind of technology. Smartphones are simply a digital kind.

LaDiDa, one of Smule's apps that grew out of Chordia's academic research, creates background music for users' vocal samples, a sort of reverse karaoke. *Songify* turns speech into a song, while *AutoRap* turns speech into rapping. Creating each involved extensive research into the fundamentals of how music works (what is rap, exactly, and how can a computer create it?). The broad message is that everyone can sing—you included.

Other apps help advance the collaborative-music piece of Smule's mission. *Sing! Karaoke* allows users to perform karaoke with their friends, logged into smartphones far away. On *Guitar!*, users can create the background music for others' vocal samples.

Given Chordia's academic discoveries, as well as his history of playing Indian classical music, his passion for reviving shared music-making experiences isn't surprising. "Playing classical music is less about performing and more about immersing yourself in it," Chordia said.

But regardless of his musical study both onstage and in the lab, there are some aspects of this emotional resonance that may never be fully understood. "At the most fundamental level, my research really stems from this question: Why are we as humans so attracted to musical sounds? What is it about music that moves us? Why does this abstract pattern of sonic activity give rise to some of our most cherished human emotions? It's really weird, actually, if you think about it." ▲

Jessica Gross is a freelance writer in New York City. She has contributed to the New York Times Magazine, the Paris Review Daily, Kirkus, and other publications.



WHAT THE BODY IS

BRAIN WAVES AND CHOREOGRAPHY WITH KOOSIL-JA/DANCEKUMIKO BY MICHAEL GALLANT

Enter a koosil-ja/danceKUMIKO performance expecting to see ballet, tap, hip-hop—or any established genre of dance—and you will likely leave disappointed. Walk in expecting a multimedia event that stretches your conceptions of movement, dance, and the human body, and you may just experience something transcendent.

In fall of 2014, the innovative New York City dance company plans to debut a new project entitled *Ecology of Image of Body*, a creative collaboration between the company’s artistic director and choreographer Koosil-ja and composer and media artist Geoff Matters. Supported by an NEA Art Works grant, *Ecology* will continue the rich and gutsy experimental tradition established by its co-creators over the last decade, mixing the worlds of science and art to push boundaries for dancers and audiences alike.

Koosil-ja and Matters first crossed paths in the early 2000s as enthusiastic members of a cutting-edge and then-underground music scene in New York City. “I grew up in New York, studied at California Institute of Technology, and then returned in

2000 and began doing open media jam projects every week in the East Village,” described Matters, who also created GDAM, one of the world’s first DJ mixing and live music performance software programs. “People would come with all kinds of instruments—traditional and electronic, laptops, and other high-tech things—and we’d experiment and make music together.”

Koosil-ja, who had come to New York in 1981 to study dance with Merce Cunningham, gravitated toward the creative vibe of such events. “Though I have a dance background, I was always interested in electronic music, technology, and the energy of the scene,” she said. She met Matters at one of his GDAM workshops. “I was already the director of a dance company, and I invited him to compose music,” continued Koosil-ja. “He has a very special brain and has a unique way of working with the threads of my ideas.”

Though their backgrounds and areas of expertise differ greatly, both Koosil-ja and Matters clearly cherish the creative bond that they share. “I always find myself challenging her work and playing devil’s advocate,” said Matters. “About 60 percent of

our collaboration is me going with what Koosil-ja wants, 20 is me pulling in the directions I want to go in, and another 20 is prodding her to help her figure out how she wants to pull the work itself.”

“It’s been great,” Koosil-ja added, laughing. Their first collaborative work came to life in 2003 in a grungy Brooklyn warehouse space. But more intriguing than the performance’s venue were the creative seeds that informed the piece. “I was trained in the Merce Cunningham technique, but I spent years trying to wash that style off of my body and to find my own vocabulary,” said Koosil-ja. “It occurred to me that, instead of solidifying a style in my own body, I shouldn’t have any style at all. I should copy everybody else’s way of movement. I also wanted to ask questions about being through questioning the body, what the body is and how it works, and to use images that could let us go deeper into those questions.”

As Koosil-ja and Matters began to further collaborate, such images often came in the form of video. “I use clips from movies, things uploaded to YouTube, anything that interests me from pop culture to hip-hop to

a plastic bag floating in the air,” said Koosil-ja. “Whatever suits a particular project.” Some of the company’s rehearsals and performances have included dancers watching three videos simultaneously with each dancer’s head interpreting one source, arms and torso following a second, and legs receiving creative guidance from a third. And when it comes to the duo’s wedding of dance and technology, that’s just the beginning.

Koosil-ja/danceKUMIKO’s 2007 production, *Dance Without Bodies*, combined pre-recorded footage with live cameras, incorporating real-time visual feedback as an active element of the performance.

“The choreography was taken from dancers following video clips, as if their bodies and movement were being inhabited by this external force,” said Matters. “We split the performance area in half with cameras filming each half and projecting to the other side, so as dancers moved back and forth, you’d sometimes see them live, sometimes only see a projected image, and sometimes see a live dancer interacting with a projected image of another live dancer.”

Through the cameras and projections, the team sought to create an unexpected alchemy: remove the



ABOVE & OPPOSITE | Choreographer Koosil-ja during a rehearsal of *Wind Blowing On Us*, featuring Geoff Matters on the screen, at DANY Studios in 2013. PHOTOS BY FREDERICK BERNAS



As part of Koosil-ja's piece *Blocks of Continuity/Body, Image and Algorithm*, an avatar named Hack is created by Peter Blanco with an environment created by Alex Kao during a 2010 performance. PHOTO BY ROBERT RAMIREZ

essence of the dance from the physical space, and the dancers' willful independence from their own bodies, and place both in the realm of technology. "What happens to the domain of the body when the dancer can fluidly move between the real space and a projected image?" Matters asked. "That's one of the questions we started to explore."

Subsequent pieces have delved into similar themes. "What if we track the body's movement and use it to manipulate objects in a 3D game space?" Matters continued. "What if we used dancers' brain waves to generate music and manipulate physical, mechanical objects in the space?"

These are more than rhetorical questions. One technique that Koosil-ja and Matters have begun to explore in the creation of *Ecology* involves live dancers, brain wave-detecting headsets, and a carefully planned redirection of the audience's focus from carbon- to silicon-based elements of the performance.

As Koosil-ja described it: "Imagine that the audience sees a dancer repeat the same phrase more than ten times—*turn, spin, step*—but each time, the dance movement becomes smaller and smaller as the dancer takes the movement into the internal place. Eventually they don't see the physical dancer move at all."

The dancer in question wears a brain wave-sensing headset that feeds information back into the performance via a system custom-designed by Matters.

"As the movement of the dancer becomes invisibly small, the dancer's brain is still actively dancing the dance," he said. "The interplay between watching the dance disappear in physical form, but continuing to see it represented in the mental form, via video projections triggered by the brain wave readings, is another interesting aspect that we're experimenting with."

Even though koosil-ja/danceKUMIKO will be working with cutting-edge, brain wave-scanning headpieces, translating the information collected from those sensors into something creatively useful can be both a challenge and an opportunity. "Brain waves are based in this physical organ, but they're electric impulses, fleeting and ethereal," said Matters. "You can't see them, but you can measure them. Data from the brain comes to us just as numbers, so we can use that information any way we want to."

The field of neuroscience continues to progress in leaps and bounds, he said, but truly accessing the contents of a human brain, for creative purposes or otherwise, may amount to an impossible task. "There are billions of connections between synapses and capturing the amount of information being processed in the human brain at any given moment is beyond what any computer can handle and model," said Matters. "The challenge is figuring out how to use some small portion of that information in a way that's meaningful to us, and is most appropriate for the piece we're working on."



The ultimate goal of such experimentation for *Ecology* is to make the audience unlearn preconceptions, expectations, and associations concerning the body, Koosil-ja said—a process she described as “erasing attributions through this work.” Using his collaborator as an example, Matters explained further: “When you look at a dancer like Koosil-ja, you see a certain age, shape, size,” he said. “She has many attributes like number of limbs and features that are typical of humans. But through her dances and our collaborations, she wants to remove those kinds of attributions and move away from the human form to more abstract representations.”

“How far can we go erasing clichés of the body?” he asked. “Can we take something like a sphere, or a collection of spheres, and—through video technology, brain wave scans, motion detection, or some other type of technology—still have it be a representation or abstraction of the dancer? We want to take that idea and push it as far as it can go.” ▲

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ABOVE | Koosil-ja (front) and Geoff Matters performing in *mech[ja]OUTPUT* 2007. PHOTO BY NANAKO NAKAJIMA

BELOW | Koosil-ja performing her work *deadmandancing EXCESS* at the Performing Garage in 2004. PHOTO BY PAULA COURT



COVER ART | *Nimbus Munnekeholm* by Berndnaut Smilde, 2012 (front cover), and *Flying Boy Over Truro's Pond* by Fran Forman, 2009 (back cover), are part of the Smithsonian Air and Space Museum's exhibit *High Art: A Decade of Collecting*, which features 50 works acquired by the institution from 2003–2013. The exhibit, showing through December 1, 2013, visually explores the human and scientific fascination with flight. IMAGES COURTESY OF SMITHSONIAN INSTITUTION



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The online content for this issue, which you can find by scanning the QR code or visiting arts.gov, includes a talk with Abbas Raza, founding editor of *3 Quarks Daily*, a curated website of articles, essays, and videos on the arts and sciences; a look at the *High Art: A Decade of Collecting* exhibit at the Smithsonian Air and Space Museum; a visit to the Kinetic Grand Championship, a three-day race of human-powered art sculptures known as the “triathlon of the art world”; and more.

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