Neuroscience and the Arts Today

Michael Century, Siri Hustvedt, Denis Pelli, Jillian Scott, and Kyralesa Claire (KC) Wiley in conversation with Ellen K. Levy

PAJ explored the growing discourse on the concerns of body, mind, and consciousness that the arts share with neuroscience during a panel entitled "Neuroscience and the Arts Today: Shared Interfaces," which took place on December 11, 2012, at the SoHo gallery, Location One. Five individuals joined artist and moderator, Ellen Levy, to discuss this theme, including another artist, a dancer, a musician, an author, and a neuroscientist. This conversation is a transcription of the panel.[1] Where necessary, information appears in brackets in the text.

The featured artists and performers have built on recent neuroscientific knowledge, incorporating social, cognitive, or affective discoveries in their art. Some work collaboratively with neuroscientists while others work alone. All are engaged in communicating their insights about the body and mind to the general public, and many are educators. Today, knowledge gained in cognitive neuroscience by those working in the visual arts, performing arts, literature, and music has amplified productive approaches to creativity, emotion, and even the healing process. The reverse is also true: neuroscience sees art as an increasingly valuable resource, and its practitioners are finding ways to apply this knowledge. Novel therapies are in the process of developing by using knowledge of brain function and basic physiology to improve well-being, and artist/performers as well as scientists have undertaken a role in this process.

Michael Century is professor of new media and music in the arts department at Rensselaer Polytechnic Institute. He was program director for cultural research at the Montreal Centre d'innovation en technologies de l'information, and taught in the graduate program in communications at McGill University. Century initiated the Art and Virtual Environments project, Banff Canada (1991–94), and was panelist and co-author for the U.S. National Academy of Sciences 2003 report on information technologies and creative practices.

Siri Hustvedt is a novelist and essayist who lives in Brooklyn, New York. She received her PhD in English literature from Columbia University in 1986. She is the author of a book of poems, six novels, a book of essays on painting, and two additional

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collections of essays. She recently won the Gabarron International Award for Thought and Humanities.

Ellen K. Levy, PhD, a New York-based artist who has exhibited widely, is special advisor on the arts and sciences at the Institute for Doctoral Studies in the Visual Arts and was past president of the College Art Association (2004–6). Her honors include an arts commission from NASA, an AICA award, and a Distinguished Visiting Fellowship of Arts and Sciences at Skidmore College.

Denis Pelli is professor of psychology and neural science at New York University. He is co-inventor of the Pelli-Robson contrast sensitivity chart, which is widely used clinically. He works on object recognition, including how we recognize letters and how we read, and on crowding. Pelli is an editor (associate advisor) for *Journal of Vision* (2001–ongoing) and an editor for *PLoS ONE* (2008–ongoing).

Jillian Scott, a widely-exhibited media artist, has designed aids for blind actors and interactive sculptures. She is professor for research in art and science at the Institute for Cultural Studies in Art, Media, and Design at the Zurich University of the Arts (ZhdK) Switzerland, co-director of the Artists-in-Labs Program, and vice director of the Z-Node PhD program on art and science at the University of Plymouth, UK.

Kyralesa Claire (KC) Wiley is a dancer and choreographer who graduated with a BA from Sarah Lawrence College in 1992. Wiley has performed with many dance companies including the Chicago City Ballet, Carol Blanco, and the Son Mu Ga dance company. She began working with Parkinson's patients in 2009 and developed an ongoing dance and choreography workshop with Parkinzone, a theatre group for people with Parkinson's disease based in Rome, Italy. Wiley's choreography for the stage has been presented at Context Theatre in New York and the St. Stephen's Cultural Center in Rome. Her choreography for film can be seen in the films of Abel Ferrara and Cheryl Kaplan.

NEUROSCIENCE AND THE ARTS: AN INTRODUCTION

LEVY: The primary interface we are addressing in this panel is that between the arts and neurosciences. Both fields offer perspectives on how people perceive, think, and act, and the study of perception has long characterized their commonality. The reason we are here today is to explore what some have called "embodied perception." This term stresses the unity of bodily response made to varied signals from the environment. This is not new information; we have known for some time that visual perception is not solely visual but is influenced by affective, proprioceptive, and tactile dimensions as well as by the goals of the perceiver. What is new, however, are some of the shifts in practice occurring in both the arts and neuroscience in response to the recognition that perception is embodied, and this is the main focus of today's discussion.

I think embodied perception is well portrayed in the following passage from a book by one of our panelists, Siri Hustvedt, *The Summer Without Men*:

> But there is another aspect of long marriages that is rarely spoken about. What begins as ocular indulgence, the sight of the gleaming beloved, which incites the appetite for around the clock rumpty-rumpty, alters over time. The partners age and change and become so accustomed to the presence of the other that vision ceases to be the most important sense. I listened for Boris in the morning if I woke to see his half of the bed empty, listened for the flushing toilet or the sound of him filling the tea kettle with water. I would feel the hard bones of his shoulders as I placed my hands on them to greet him silently while he read the paper before going to the lab. I did not peer into his face or examine his body; I merely felt that he was there, just as I smelled him at night in the dark. The odor of his warm body had become part of the room.

All of us can identify with similar experiences. What then are the shifts in outlook and artistic practice that are actually occurring due to the recognition of embodied perception? I believe that they are demonstrated in awareness by practitioners in the arts who offer a potential for healing related to issues of attention and bodily movement. They are also shown in a critical awareness of technological interfaces and their potential for both good and harm. In turn, these shifts have inspired those in one profession to look around and see what others in altogether different arenas are doing. As philosopher Gilles Deleuze said, the "encounter between two disciplines doesn't take place where one begins to reflect on the other but when one discipline realizes that it has to resolve for itself and by its own means a problem similar to the one confronted by the other."[2]

In addition to Siri's turn to neuroscience, you will see this reflection among our other panelists. For example, KC Wiley is a dancer who realized that her practice had profound implications for those with movement disorders. And Jill Scott is a media artist who has exploited art's potential for expanding somatic vision and understanding. My own realization was that art, when engaged, can train attention. Part of Michael Century's interest in sound was its role as a transformative technology. All of us have found that neuroscience was addressing similar issues.

Denis Pelli, the neuroscientist with us today, looked at the work of Chuck Close to better articulate the relationship of size to scale. When members of the Optical Society of America awarded him a Leadership Award/New Focus Prize, in 2000, they stated that "Through leadership in visual science, Dr. Pelli has benefited artists, scholars and the visually impaired. His work has made significant contributions that have transcended both interdisciplinary and international boundaries." Denis, please describe some of your research.

PELLI: I am very keen on both neuroscience and art. I'm going to present a duality here of some work that I did trying to figure out perception as a scientist and then a parallel in something that an artist is doing. The first thing I will talk about is how size affects shape. Shape is supposed to be a property independent of size. Let me show you that it's not. [He then shows images from a PowerPoint presentation and

asks the audience to shout out the letter they see, over seven slides. Exactly the same image is shown each time, but successively smaller.][3]

This is a weird pattern that I created with a bunch of letters. First you will see letters that are somewhat strangely constructed in that what looks like an "F" or "E" from one distance (despite having some strange curves) will look like a "D" from a greater distance. People who are farther away will see different letters. [The audience responds to his request for information about what they see.] This shows that each time the thing is reduced in size, it's perceived differently. This parallels something in a Chuck Close work. [Pelli shows two differently sized images of Close's painting, *Maggie*, side-by-side in three successive close-ups.] This is a painting of his daughter, Maggie. The big image is a little bigger than the actual painting. Next to it, we have a smaller reproduction. What you observe, if you look at the smaller one, is an attractive young woman. In particular, she has a good nose. But in exactly the same image, just bigger, she has lost her nose; it is flat. You can walk back and forth and see this duality. Up close, her face is a flat plane made up of blocks. Far away, it becomes a continuous shape. When it's small your visual system successfully extracts the shape information from the shading. But this fails—shape from shading fails—when the image is big.[4]

Now I am going to talk about crowding. I will first show you one bit of science and then two artists who have done things that are related. First, let me explain what crowding is. This is something that happens in the periphery of vision. If you look at this image [an "A" in chaff] you will see a bunch of sticks. In the sticks you see an "A" among the sticks. Now move your eye to the red minus. Keep your eye there. Now you still see the sticks, but there is no "A." We think that what has happened is that your visual system is integrating too much and has put it all together ("A" and chaff) and tried, unsuccessfully, to make one object out of the whole mess. The bars represent features. If you look directly at the "A" or at the green plus, your visual system can isolate the relevant features of the "A" and identify it. If you fixate too far away, on the red minus, the brain combines features from the "A" and the chaff, and you get a jumble instead of a letter. This is crowding.[5]

Here is a wide panorama. While you are looking at it, it is mostly seen peripherally. Your peripheral visual field is subject to crowding. I think that's relevant to looking at Pablo Picasso's painting, *Nusch Éluard*, 1938. Keep your eye on the fixation cross, and look at her out of the corner of your eye. What do you see? She's blue. She has two eyes. She's pretty! Your peripheral visual system can't tell that things are in the wrong place. It's like the sticks I showed before if it's all bundled together. Your visual system can't see the problems in this girl, and she looks healthy. This happens in several of Picasso's cubist paintings. They are monstrous when viewed directly but seem normal when viewed out of the corner of your eye.

Another thing inspired by crowding is seen in the work of choreographer Julia Gleich. [In April, 2012, Gleich's new ballet in Brooklyn included five minutes based on Pelli's research on peripheral vision and can be seen at http://denispelli.com.] You are

looking at thirty seconds of a ballet. Watch the guy on the left. She has the dancers crowded together. Your visual system will interpret them as one person and not as three people. You need to keep your eyes on the guy to the left. When seen out of the corner of your eye, the group of dancers on the right is perceived as one object.

LEVY: One of the reasons I invited Siri is because she is resisting academia and is incorporating information about neurobiological concepts very subtly and poetically into her work.

HUSTVEDT: Thank you. Just to give you a little background, I was one of those girls who read novels and more novels and ended up with a PhD in English literature. I was not a science geek, but as a child I had migraines and auras including Alice in Wonderland syndrome, which I still experience. When I got older I began to try to make sense of these experiences. I am not alone. I have met many psychiatrists, neurologists, and psychoanalysts who entered their fields because they themselves or someone close to them had a neurological or psychiatric condition. In college I became interested in the neurology of mysticism. There was already quite a lot written about this in the early seventies. While I was working on my PhD, I found myself interested in the aphasias, various kinds of speech problems some people with brain injury develop. I applied that research to my dissertation on Charles Dickens in connection to his complex use of pronouns and how they serve to illustrate questions of identity in the novels.

I published my first novel in 1992. In one section of the book, the heroine is in a neurology ward with debilitating migraine. This reflected my own experience in Mount Sinai in 1983. I had a headache for a year. I have always read deeply in psychiatry, psychoanalysis, medical history, and philosophy, but it wasn't until about fifteen years ago that I began to study neuroscience. I was invited to join a discussion group that met every month at Cornell-Weill, which continued for three years until it disbanded. I also volunteered as a writing teacher for psychiatric in-patients at Payne Whitney, a job that lasted three and a half years and was one of the richest experiences of my life. Then I developed a seizure symptom and wrote a book about it: *The Shaking Woman or A History of My Nerves*. The condition remains undiagnosed, but the book has created a second life for me, because since its publication I have been repeatedly asked to give lectures on neuroscience and neurology from an interdisciplinary perspective.

I want to say something very important. There are genuine epistemological problems involved in having interdisciplinary conversations. Nevertheless, we can give one another a lot if actual dialogue takes place and we remain open. Neuroscience has entered my fiction. In my most recently published novel the narrator makes a number of jokes about and critiques of neuroscience. The more you know the more critical you become. It's also helpful to remember that, despite advances, there is no conceptual model for the brain-mind. We have no theory of consciousness, and there is a lot left to learn.

CENTURY: I am the odd person out. Because I don't actually work in the field of neuroscience, I was asked to be part of this for more speculative comments from the musician's point of view and that's what I'm doing. You know there's been some fifty years of ways of thinking of music and the interface of music and the brain. It goes back to brain wave music of the sixties and seventies and ongoing works in the performing arts, including what goes on in my Center where synchronization between brain waves and performance is a practical aspect of the work.[6] This is a burgeoning field. I'm very interested in the kinds of plasticity that come out of that. We musicians are taken as models of a plastic brain, especially where the output has to do with gaining skills and crossovers into other areas. I'm not really going to make a direct kind of connection with that body of research. But my recent interest in this area comes out of reading a book on the divided brain. It raises the idea of different types of attentional strategies. Years ago we spoke of differences between the right and left hemispheres in terms of what each hemisphere does. By contrast Ian McGilchrist's book, *The Master and His Emissary: The Divided Brain and the Making of the Western World*, leads me to think about different attentional strategies and music theory.

SCOTT: I'm sure we are going to end up in a very fascinating discussion here, and it is just the kind of discourse that we need to encourage. I'm going to talk about "Neuromedia," a term I coined ten years ago to describe the relation between media and neuroscience. My own historical background is body politics, and I have traced a trajectory from feminism to media philosophy to human biology and genetics. This interest has grown into areas of cognition and cross-modal interaction. In an early work called *Taped* from 1975, I am literally "taped to the wall" and talking to the public through a microphone. To me it was an important statement; it was about breaking out of isolation and away from my own art history. In a second project, called *Digital Body Automata*, from 1995, I showed how our concept of the body was being changed by bio-technological developments. I looked at human biology and genetics—that was a very important year for genetic cloning. By 2002, I had become very fascinated with cognition and cross-modal interaction. It was then I coined the term Neuromedia. I made collaborative attempts to apply perception to various media and interactive technologies. What's important to me is to bring together self-reflection (art) and objectivity (science) within the artwork and combine them with the sensory perception of the viewer. I aim to utilize how our sensory perceptions work so that the actual artworks can become visceral and embodied experiences.

One of the very influential people that I met in 2002 was the neuroscientist Paul Bach-y-Rita. He spent a long time exploring the sensory modalities of human skin—vibration, pressure, and temperature—and in the end designed a project called Brain Port. This project consists of a camera mounted on the head of a blind person. Basically this camera records an image and converts this image into black, grey, and white levels, feeding this image to a microarray device with pins. The movement of the pins corresponds to these camera levels, and the device is placed on the tongue. Thus this device bypassed the optic nerve and the blind person is able to "see though

their tongue."[7] [Bach-y-Rita transduced the optical images picked up by a television camera into vibratory or direct electro-tactile stimulation that was mediated by tongue receptors.] With that evidence of cross-modal interaction I found myself on a mission to create electronic skin—or e-skin—based on tactile perception.

Here you see *eskin* on display at Kulturama, a show I currently have on at the science museum in Zurich.[8] In this version, you can manipulate an object that resembles a nipple on a breast. You have electronic sensors built into the object based on pressure, temperature, vibration, and proprioception. I also worked with congenitally blind people in workshops in order to test Bach-y-Rita's ideas of tactile information and Braille pattern reactions, and organized teams of people to explore translation problems between embodiment, the environment, and stimulation on the skin. I learned that new codes could easily be learned and that we could build customized potentials into wearable interfaces for congenitally blind people. Together we also designed a stage for people who are blind. Through interfaces they could have feedback onto their skin, but also actuate images on the stage as in a cultural event. For example, visually impaired people could create visually oriented cultural events for a sighted audience rather than the reverse.

Later, this interest led me to create a lot of sculptures, which were based on my residencies in neuroscience labs at the University of Zurich. In *Somabook*, for example, the viewer can actually interact with the spine like an open book, the pages of which are two touch screens. Here various chapters represent maps of the somatic cortex and their correlations, and a dancer can be manipulated to interpret the movements of bodies with various problems. She also demonstrates how to exercise the peripheral nerves because she has been trained in Body-Mind Centering techniques. In neuroscience they often investigate the problems of physical impairment, and my aim was to use tactile perceptions to show these problems, like the loss of balance or of tactile contact. For example, by touching the images of this dancer with spina bifida you can discover the relationship between these kinds of problems and molecular guidance. The viewer can also put his or her hand directly into the neural tube, and by stroking strip sensors, control the growth of axons across the screen. In *Somabook*, the viewer is "learning by doing."

In conclusion, what do we get out of collaboration? Artists can be enabled to explore sensory perception, can play with different sorts of impairments and work with disabilities—this is an important new area for artists to move into—and they can utilize scale on genetic and cellular levels. What do scientists get out of it? They get different approaches about their research and how to bring research to the public. They see their research from another perspective. They think about how to bring this research to the public. They see and can think about how to build their experiments differently. This is a very responsible way that artists can help scientists. It's a two-way street; perception is at the heart of both disciplines. Because it is at the heart, the opening up of a dialogue between the disciplines can take place.

WILEY: I will give you my history. Dr. Nicolo Modugno started a theatre group for people with Parkinson's disease. It was based on research in Italy at the time that captured data when scientists were scanning the brain while actors were memorizing lines. Modugno founded this group along with some professional actors. I felt that dance teaches us about the body. As you know, Parkinson's disease deals with movement disorders. I met with the group once a week for three hours. The first hour and a half was the dance class I developed with the Dance for Parkinson's Disease program at the Mark Morris Dance Center, along with some of his dancers, and the second part—the creative part—was original material we would develop together and have them perform. When I would talk about my work people would say I'm a dance therapist. I would say, no, I am developing material as I always would as a choreographer. But it was being developed under a neurologist. A lot of physical therapists became very interested in the work I was doing, and I began to work with a team of therapists incorporating dancing technique into the physical therapy. So what I found as an artist was that the problems it presented to me were to identify the physical capabilities people could have and what was involved. I opened the group to their families and caregivers. One reason is that I wanted this to be an activity that they could participate in with other family members, and I wanted the families to see what was involved. Very often members of the family would say, "I had no idea that my sister, my brother, my mother was capable of doing this."

What I loved most about it was that it challenged my preconceived notions of what a dancer is. My ideas were that dancers were very particular kinds of people—young and physically capable of anything. I was working with people who were not young and had Parkinson's disease, and they were really limited but doing phenomenal things. It opened a whole new world for me. By looking at physical therapy, it allowed me to really search my knowledge of dance and work with people that I normally never thought I would be working with—physical therapists, neurologists, and so on. Hospitals are now doing this and incorporating programs similar to what I am doing.

LEVY: As a participant in addition to chairing this panel, I will provide some information now about my own collaborative art work, *Stealing Attention*, which explored the subject of attention. What you are looking at on the screen is a urinal. The art people here will say Duchamp's urinal. An ingenious economist who worked for the International Airport in Amsterdam noticed that the lack of precise aim at airport urinals was resulting in the defacement of public property. What you see to the left of the drain holes of this urinal is not a smudge. The economist's idea was to have an image of a black house fly etched onto the bowls of the airport's urinals. Legal scholar Cass Sunstein and economist Richard Thaler commented that if you give men a target, they can't help but aim at it. The outcome was that spillage declined eighty percent. What this shows is that seemingly small changes in the environment can influence behavior by manipulating people's attention.

My interest is in making visible what is generally unnoticed. Let me present some information about my collaboration with Michael E. Goldberg, Director of the Mahoney Center for Brain and Behavior at Columbia University. We devised an

animation about the subject of inattention blindness.[9] This is the inability to see something directly in front of you, if distracted. A randomized animation set the theme for an installation of panel paintings and works on paper that examined the critical issue of where we cast our attention and the consequences of that decision. To highlight the fact that visual selection always comes with a cost, I referenced the con game three-card monte, and one negative consequence of the war in Iraq, the looting of relics from national museums. In our animation, in over roughly three minutes ten looted objects disappear from the shelves in the background of this animation. A task was given at the onset of the video, to count the number of times the Queen of Hearts appears. Less than half of the viewers saw the disappearing relics. My question was to see if an art installation throughout a gallery could redirect attention to what was unseen. In other words, I asked whether art can change behavior. The answer was definitely yes. An artist could help retrain attention. When people saw the animation a second time after walking around the installation, more than sixty percent could then see what they had missed the first time. This installation was shown at several venues in New York, Michael Steinberg Fine Arts, and as part of a group exhibition at Ronald Feldman Fine Arts.

Our animation was modeled on a well-known experiment called "Gorillas in our Midst," by Simons and Chabris, who found a striking way to show how much people missed seeing in their daily environment. They made a videotape of teams consisting of white shirts and black shirts dribbling and passing a basketball. Experimental subjects received a task to keep silent mental counts of the total number of passes made by one or the other of the teams. During the game, a figure in a full gorilla suit appeared, beat its breast, and walked away. More than one half of the experimental subjects failed to notice the Gorilla.

I will conclude with an image of an exhibition that I had at Wesleyan University in which choreographer Liz Lerman instructed her students to interact with my art work by choreographing movements appropriate to the content of the installation, which included the adverse effects of industry upon an Arctic environment. Today it is increasingly commonplace to see these kinds of collaborations with dancers, musicians, and neuroscientists. Artworks stress social, emotional, and metaphorical dimensions that are of increasing interest to scientists. By manipulating these dimensions, art can work with the constraints of vision and shift the viewer's focus.

GENERAL DISCUSSION

LEVY: We have now set the stage for a general discussion. Let me start by assuring the skeptics among us that this panel is not about neuro-imaging. Its overuse with regard to explaining essential functions and human activities has been characterized, in some cases, as brain porn. We aim to avoid this. My first question is directed to Denis: Do you perceive a greater interest among your colleagues in art. Does neuroscience see art as an increasingly valuable resource? If so, could you elaborate on this?

PELLI: I would say that, to scientists, art is obviously very important, but it's not clear how to think about art scientifically. In the last ten years, a number of neuroscientists

have tried to connect what they know about vision science to art. I like Margaret Livingstone's book, *Vision and Art: The Biology of Seeing*.

LEVY: The other panelists should feel free to ask questions.

HUSTVEDT: I don't know how many of you know that V. S. Ramachandran, another neuroscientist, got into a lot of trouble with members of the art community. He's a very clever neuroscientist, but he has a theory of art that is quite reductive, that the simple cartoon is inevitably more powerful than, say, a highly elaborated, baroque image. He related this to the fact that newborn chicks prefer exaggerated appearances of a maternal beak to natural ones and will readily respond to the exaggerated ones. This is known as the "peak shift effect." He used the phrase peak shift to summarize visual aesthetic experience. Well, people who have been studying the philosophy of aesthetics for a long time did not really buy this. Ramachandran's extremely reductive formulation demonstrates the dangers involved in interdisciplinary conversations. Because I look at and write about visual art and care about science and philosophy I am sympathetic to both sides.

PELLI: Can I step in? I haven't read that work but I just feel that the danger you are describing is the scientific method, the reductionist approach, applied to aesthetics. As a scientist, you take some over-simplified idea and you see how far you can go with it. You learn a lot in the process. And so, the fact that this particular example seems incomplete is something one learns from. This is the good thing about the scientific method.

SCOTT: I have quite a few comments on this subject. One is about the new field of neuroscience called "neuroaesthetics," which is really quite controversial. Here scientists are attempting to determine aesthetic preferences over a range of people. Why do they like the color blue more than red? This quest becomes quite problematic and hardly objective. The other comment is from what we found in our artists-in-lab projects where artists have been involved in scientific research, and this leads to very different approaches. We've been putting artist into labs for about ten years now, and we really can't generalize about how scientists or artists will react in different situations. Some questions that often come up are: can art really be a catalyst to promote their research to the public, and do artists want that role at all? This is one of the biggest dilemmas because, on one hand, certainly art can somehow bring science to the public, but we have to actually question whether that is really our role.

LEVY to PELLI: Denis, you yourself are finding that artworks are catalysts for your own experiments.

PELLI: Sure. I spent a long time with Chuck Close's paintings, particularly when he had his retrospective at the Met. He had spent a long time asking the same questions that I was. He was doing it as an artist while I was doing it as a scientist. Artists publish their experiments, and we scientists do not. We throw the equipment away and publish an article instead. The artist's curiosity to understand was similar to mine. But he exhibited his paintings and I published an article.

HUSTVEDT: Am I wrong? Doesn't Close suffer from the condition, the word for which I can never remember—propagnosia—a difficulty recognizing faces. What one thinks of as a handicap has become for Close a strength in his art. Close's story is part of the narrative.

LEVY: I am going to change the direction slightly. We have seen some extraordinary new concepts emerging from the neurosciences. First, many of us were moved by research being done by Sperry and then by Gazzaniga on the divided brain. Then we have read about experiments on neuroplasticity. In addition, there was speculation that is not yet proven about mirror neurons. I had a discussion with Michael that touched on some of this but especially about the divided brain. Both of us had been very moved by a speculative work of fiction by Julian Jaynes. Maybe Michael could talk a bit about this.

LEVY to CENTURY: When we spoke you said how relevant ideas of the divided brain were to you. How would you apply these ideas to sound and music?

CENTURY: That's a complicated question. Jaynes's book is the *Origins of Consciousness and the Breakdown of the Bicameral Mind.* I was comparing this to a more recent book that covered that divided brain material in terms of attention rather than hemispheric divisions, a book by Iain McGilchrist that deals with the attentive level rather than rational versus emotional breakdowns. The way I think about this is from a procession of time point of view. There are a couple of ways in which we take in music. You can think of music coming in as an ordered pulse and the pulsation is something you might be trained in. Or music can come in as a non-pulsation, a sort of open versus measured idea. I think that the process of passing between these two kinds of time perceptions is one of the most interesting things that we can explore speculatively about music-making and perception.

LEVY: How are you or other musicians today incorporating some of these ideas?

CENTURY: In contemporary music-making and, I guess, I would say also interfacing with technology, I am interested in the oscillation, as I call it, between the processing of music as a pulsating or non-pulsating phenomenon.

LEVY to SCOTT: Jill, you are working with musicians in artists-in-labs, I believe.

SCOTT: Yes, Luca Forcucci is a musician, a composer. He basically worked at Olaf Blanke's lab, at EPFL in Lausanne, Switzerland, where they're conducting experiments with peripersonal space [the space surrounding our bodies]. In a context of sound art and acoustic pieces, he explored the relationship between interior body sounds and the environment itself. This "in-between" space has cultural implications. Like Alvin Lucier, who made work using the patterns of brain waves to compose music and tried actually to control his brain on stage, Luca also explored EEG potentials. To make a long story short, he actually took a set of interior body sounds and made an installation where you could stand inside a circle of speakers and listen to all of these, then step outside and the sound would change into environmental sounds.

When viewers moved through the installation they changed the sound. In this lab they are also using virtual reality to explore neuropsychology. It's an appealing lab for media artists who are experimenting with projects in neuropsychology and cognitive science.

LEVY to CENTURY: Recently I saw a concert at the Experimental Media and Performing Arts Center (EMPAC) at Rensselaer Polytechnic Institute by Kurt Hentschlager. Many ideas of the body and about whether perception comes from within or without are exploded in this piece.

CENTURY: The work you are referring to is a different sort of direction where there is a certain kind of oscillation that goes on with Kurt. To get inside your head, by the way, with a very intense rhythmicity—meaning here the way in which it interacts with brain cells—is really tremendously powerful. That's a great example of working with a kind of micro-temporal programming, which makes a point about the difference between traditional music and music that is either played back or controlled by micro-timing technology. Polyphony or polytemporal composition with traditional aspects can be very intense and the sonic experience tremendously powerful. Now with computers there is much more work happening at the level of micro-programming.

LEVY to WILEY: This leads directly to my next question. Your comments segue into a question about using video as a way of giving dancers with Parkinson's disease feedback about their performance, about how to give information back to them about their bodies and whether that makes a difference in their ability to control their body. After all, neurofeedback is being used to control ADHD in certain instances.

WILEY: Your question is about filming the actual process. I don't like this because film flattens. It makes it two-dimensional and develops a superficial awareness. It is not successful when working with dance. I think that's not to say you can't do it.

PELLI to WILEY: You made a strong point, when you were presenting your work, that you are not a therapist. Can you elaborate?

WILEY: I don't have the medical background. And none of us does in this group. The only person with a medical background was Dr. Modugli. There was research going on but the development of the work wasn't dictated by science. I could develop my program according to my needs as an artist.

PELLI: It's been said that when art becomes therapy it ceases to be art.

WILEY: This wasn't replacement for physical therapy. It was another option. It was a way to allow people to create something, to develop confidence as movers. Because those with Parkinson's disease are limited as to what they can do, it was a way for them to do something new and to mark their progress. It was a way for them to explore a new territory.

HUSTVEDT: There was a parallel phenomenon with the psychiatric patients I taught in my classes. I never thought of writing as therapy, but when you put words on a page they are fixed, immovable. For people who have severe integration problems due to their illnesses, the texts we wrote and read aloud in the class became a static object of focus. It turned out that this did have a therapeutic effect, but that was not the point of the class. In fact, I always felt that it was great for people to walk in and, for at least an hour, not have to think about their diagnoses.

SCOTT: When we were working with the congenitally blind we actually realized that they rarely had the opportunity to design their own spaces or interfaces. Most people design for them. In *eskin* we tried to think about what could be designed from their perspective! This was not a therapeutic approach; it was more about them being creative. They said afterwards that they rarely had that experience. Even though our visually impaired people had undertaken confidence classes, contact improvisation therapy was a new thing. In other words, they had not experienced "touch" with a lot of other people.

LEVY: One of the issues that I want to raise about technological interfaces is that it is sometimes said that it diminishes rather than extends our knowledge of the body—that there is a kind of leveling of one medium into the other. How do people respond to the critique that digital information seems to level the senses so they become interchangeable? Friedrich Kittler raises this point when he talks about the interchangeability of the senses. The idea is that the general digitization of information erases the differences among individual media. The theoretical rejoinder is, I believe, from Mark Hansen who argues for the use of the living body in conjunction with digital technology.

LEVY to SCOTT: What interfaces do you use in your work?

SCOTT: The thing is one uses the technologies around us; they exist with this gadgetry already, such as robots with sensors. We need to step back from this visually dominant world and think about other ways to interface with the world that are based on other senses. That seems to be left out from digital technology.

LEVY to PELLI: Do you feel you use different technologies than the artists you come in contact with?

PELLI: I do my work at a computer keyboard.

LEVY: It is clear that for all of us here aesthetics is key for both the artists and scientists and has dictated the kind of styles with which people are approaching their work. I think there has been a change from issues of formalism, which are ocular-oriented, to multimedia and an interest in multi-modal perception. Would anyone like to elaborate on this?

SCOTT: I just want to say that that this collaboration between artists and scientists is also about the level of access that artists can have to scientific tools. Scanning

electron microscopes, atomic force microscopes, fMRIs to EEGs, and all kinds of mapping tools like GIS—these are really important tools for our visual culture. That's what our artists-in-labs also find fascinating—access to use the tools that they have not encountered before.

LEVY: On the subject of tools, I think that one of the most important has been the development of tools that can quantify emotion and affect. This has brought emotion within range of science and encouraged more scientific exploration than has previously taken place in that area.

HUSTVEDT: I think we can say the big breakthrough exposes a deep-seated prejudice against emotion. A friend of mine, Antonio Damasio, a leading researcher in affective neuroscience, told me that when he decided to study emotion and the brain, his colleagues told him his career would be ruined. Another friend, Jaak Panksepp—who works mostly with animals and wrote a terrific book, *Affective Neuroscience: The Foundations of Human and Animal Emotions*—has been fighting for a place for emotion in brain science even longer than Antonio has. There was a strong sense that emotions were "squishy"—a soft and feminine phenomenon that could never be quantified or measured. Scanning technology and growing research has changed this by revealing brain regions implicated in emotion, but it has been a big fight. This is significant because a computational model of mind has dominated cognitive science for years, but emotion has not been easily fit into this schema. Computers don't feel anything, after all. When other people began suggesting an embodied model of the brain-mind, they were attacking the computer metaphor as inadequate and borrowing ideas from phenomenology, Maurice Merleau-Ponty, in particular. Artists jump on the embodied, emotional band wagon because it makes intuitive sense to us, but there are many in neuroscience who want nothing to do with it.

SCOTT: Yes, neuropsychologists are often talking behind the scenes about this. Phenomenological variations were once considered to be one of those "esoteric problems" but now are thought of differently. These older esoteric concepts like synesthesia are now considered to have conceptual and creative potentials. One of my students is learning a lot about it by placing herself, as a subject, into those neuropsychological tests.

LEVY: At this point we have covered a range of issues. I would like the audience to be able to ask some questions.

QUESTION 1: Could you further elaborate on why, when art becomes therapy, it ceases being art?

WILEY: No, it doesn't necessarily have to cease being art, but therapy has an agenda to rehabilitate and art does not. My only criterion was to teach and create dance.

PELLI: You used the word creative as the distinguishing feature. Is therapy not creative?

WILEY: The therapy can be creative if you have a very good therapist. But dance therapy is not collaborative—they are not asking their patients to create.

HUSTVEDT: In my case I write books because I have to. If I couldn't do it, I feel my life would be wrecked. Making art is a need. Isn't that therapeutic for me in some way?

SCOTT: That's the value of freedom. You can choose if you wish to branch into the therapeutic side.

LEVY: We can take a few more questions.

QUESTION 2 for CENTURY: A project in the MFA program at your university involved a mind-controlled levitation experience. Could you elaborate on this?

CENTURY: *The Ascent* is by Yehuda Duenyas, a multimedia performance director. He created an interactive neuro-driven installation, which was deemed one of the largest bio-feedback machines in the world. He built a piece that tracked brain waves and that resulted in elevating participants in a harness in an arc. It was synchronized a bit like Barnum and Bailey and was a big success. It was show-biz that succeeded in making a lot of waves.

QUESTIONER: The art work used alpha and beta waves to make a spectacle, and cognition was the content.

CENTURY: Right. The piece worked as successful exploration of the interface; it involved the specifics of the waves.

LEVY: Coming back to the subject of therapy, such neurofeedback devices have been used in treating ADHD.

QUESTION 3: There is a point where research in art and science merge. Because many of you in both fields work with dysfunction, how might your concept of healing have changed from work you have done?

SCOTT: Working with people who might be sedated changes my work. It has helped me with respect to how I approach my own work.

QUESTION 4: The history of neuroscience collaborations has shown instances where the art has helped the scientists. For example Heddy Lamar in the 1930s created what became the basis of cell-phone technology. What other kinds of ways have artists helped scientists as well as the reverse?

HUSTVEDT: By learning fields that are difficult for me I have developed another mind. We become what we read. I tell students and young scholars and artists: read against yourself. If you don't like physics, read physics. If you are a scientist and dislike novels, force yourself to read fiction. It is vital that we do not isolate ourselves in what Habermas calls "expert" cultures. It is also vital that we examine our hierarchies. No

one laughs at an artist who reads science. Not a chuckle. But a hard scientist who reads, say, a novel written by a woman, might risk being grinned at. Specialization has its advantages but also its weaknesses. Without a dialogue between the arts and the sciences, both will be impoverished.

LEVY: This is a great note on which to end. Thanks to all.

NOTES

1. A video of the discussion in two parts is available at http://vimeo.com/58058438 and http://vimeo.com/58056879.

2. G. Deleuze, "The Brain Is the Screen," interview by Peter Canning, *The Brain Is the Screen: Deleuze and the Philosophy of Cinema*, ed. Gregory Flaxman (Minneapolis: University of Minnesota Press, 2000), 369–74.

3. This demo appears as the first image in this article: N. J. Majaj, D. G. Pelli, P. Kurshan, and M. Palomares, "The role of spatial frequency channels in letter identification," *Vision Research* 42 (2002): 1165–84. http://psych.nyu.edu/pelli/pubs/majaj2002channel.pdf

4. The image of Maggie and the analysis of Chuck Close's paintings appear in this article: D. G. Pelli, "Close encounters—an artist shows that size affects shape," *Science* 285 (1999): 844–46. http://psych.nyu.edu/pelli/pubs/pelli1999close.pdf

5. D. G. Pelli and K. A. Tillman, "The uncrowded window of object recognition," *Nat Neurosci* 11(10) (2008): 1129–35. http://psych.nyu.edu/pelli/pubs/pelli2008uncrowded-complete.pdf

6. In 1965, Alvin Lucier composed the first musical piece using the EEG; then David Rosenboom developed EEG-based musical interfaces.

7. P. Bach-Y-Rita, Y. Danilov, M. E. Tyler, and R. J. Grimm, "Late human brain plasticity: vestibular substitution with a tongue BrainPort human-machine interface," *Intellectica* 1 (40) (2005): 115–22.

8. J. Scott and E. Stoecki (eds.), *Neuromedia: Art and Neuroscience Research* (Berlin: Springer, 2012).

9. E. K. Levy, "An artistic exploration of inattention blindness," in *Frontiers Hum Neurosci* 5 (2012): 1662–5161. http://www.frontiersin.org/human_neuroscience/10.3389/fnhum.2011.00174/abstract

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For further information about the panelists, see the following:

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Siri Hustvedt: http://www.sirihustvedt.net/
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Denis Pelli: http://psych.nyu.edu/pelli/biography.html
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