THE PUBLICATION OF THE NEUROSCIENCES INSTITUTE

BrainMatters

Fall/Winter 2010

John Iversen: Keeping the Beat

The Biology of Consciousness

The accomplishments of scientific research have led to technologies that have revolutionized a variety of fields including medicine, communication, and computation. Less obvious but equally important is the increase that science brings to all of us in the understanding of our place in nature.

Unlike physics, which is concerned with laws that apply everywhere, biological research is concerned with concepts based on Darwin's notion of evolution by natural selection on earth. From a population of variant individuals, those that are on the average fitter can survive and reproduce. While this biological principle follows the laws of physics, it adds an element of historical change. As biological researchers, one of our important tasks is to trace the history and the complex mechanisms in living species that are the result of evolution.

We are now at a turning point in our understanding of a key part of that history. Advances in neuroscience now make it possible to confront a major biological mystery, that of human consciousness. Success in this domain will transform our lives by shifting our understanding from philosophical debate to scientific description.

Let me use a parallel case as an example of such a shift. From the time of Aristotle on, philosophers have advanced all sorts of hypotheses on the difference between animate and inanimate entities, considering forces outside of those that can be studied by physics and chemistry. None of these speculations have survived the insights gained from evolutionary theory, genetics, and molecular biology. These insights have made it clear what life is about: any self-replicating species under evolutionary selection can be described as living. Our concerns now are not for a philosophical definition but rather are to understand DNA, cells, and how evolutionary history has resulted in the diversity of living species.

We are now in a similar position to attack an even more profound problem. Neuroscientific studies of brain function during behavior suggest that, as I have said, we will be able to resolve the apparent mystery of consciousness. Success in this scientific approach would allow us to remove notions such as dualism, the idea that there is a physical domain addressable by science and a nonphysical or mental domain not so addressable.

The consequences of scientific success in this arena are enormous. After all, if you think about it, without consciousness, you and I would not be here. Prompted by the significance of this issue, scientists at The Neurosciences Institute have committed themselves to attack the problem of consciousness. Success in this enterprise will transform our appreciation of our place in the universe, our comprehension of human behavior, and our understanding of health and disease.

Stay tuned.

Dr. Gerald M. Edelman

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EDITORIAL CREDITS:
Jeanna Adams
Jessica Colby
Einar Gall
Debbie Honeycutt
Rachel Jonte
Bob Ross

PHOTOGRAPHY:
Debbie Honeycutt
Bob Ross
Adam Scoffield

DESIGN:
Bernard Groefsema

PRINTING:
Master Print Communications

Keeping the Beat

EXPLORING HOW WE PERCEIVE RHYTHM AND MUSIC

From the drumbeats of our primordial ancestors to the emotional handclapping at a church revival; from the syncopation of a tap dancer to the simple tick-tock of a grandfather clock; from the scat singing of Ella Fitzgerald and the pounding of ocean waves to the very beating of our own hearts, our species has always been surrounded by—and immersed itself in—that most basic of human experiences: rhythm.

The neural systems through which our brains experience and process rhythm—whether we sense it through our auditory system, feel it in our bodies, experience it only in our minds or believe it inhabits our soul—has given John R. Iversen, Ph.D., Associate Fellow in Theoretical Neurobiology at The Neurosciences Institute, the source material for a remarkable journey of discovery over the past decade.

Iversen's broad task is to investigate how the brain creates a rich and detailed view of the world from sensory stimuli. Specifically, he is researching how the perception of rhythm and music can be used as a tool for explaining complex brain processes, including those that may underlie language and movement, and potentially, disorders that afflict the brain, like Parkinson's.

"The seemingly simple task of keeping the beat—whether it's tapping your toe, dancing to music, playing an instrument to a metronome or marching in a band—is so ingrained in us we sometimes take it for granted," Iversen says. "In fact, the mechanisms our brain uses to create that internal are not yet understood.

"What's exciting is that as we understand more about the mechanisms that allow our brains to pick out and organize rhythmic regularities in what we hear and use to guide our movements, we may be able to understand why and how this internal rhythm system breaks down in patients suffering from movement disorders following a stroke or Parkinson's. It has been shown that rhythmic music therapy can improve the walking ability of some Parkinson's patients, but the potential for making even more significant discoveries motivates us to delve as deeply as possible into this rhythmic world."

Few scientists are better suited to explore this particular type of uncharted territory than Iversen. Growing up he not only had the requisite insatiable curiosity that virtually all outstanding scientists possess, he also developed a love of music, especially percussion.

"I really got a kick out of knowing how things worked, so I was always taking things apart, even if I couldn't put them back together again," recalls Iversen, who was born in New York City but raised in Swarthmore, Pennsylvania, where his father was a statistics professor.

John with participants of the Job Shadowing 2009 event

"Eventually, I learned how to put everything back together. And like any kid, I also liked banging on pots and pans. So after playing violin for a year I switched to drums, which was more appealing and more appropriate, since there were a number of drummers in my family."

As he pursued music in the school band and his own rock band, academically he became fascinated with physics, making that his major at Harvard. However, although he enjoyed the mathematical foundations of physics, he decided he "would much rather study a topic of direct impact on human's daily lives and understanding of themselves." He began taking biology courses, including several in neuroscience, which piqued his interest. After several wonderful years working on biomechanics with Tom McMahon at Harvard, he was introduced to the auditory system during the summer he spent at Harvard/MIT scientist Nelson Kiang's auditory physiology lab that was doing groundbreaking work on how the ear is connected to the brain and how the latter processes sound.

After graduation, Iversen wanted to broaden his horizons and landed a Knox Scholarship that paid for graduate school in the United Kingdom. He obtained a masters in the history and philosophy of science at Cambridge and then returned to MIT to get his Ph.D. in a new graduate program that focused on speech and hearing science. He studied the details of how brains adapt to hearing loss with Chris Brown of Harvard Medical School. Nine years later, a former classmate and The Neurosciences Institute's Esther J. Burnham Senior Fellow Aniruddh D. Patel, Ph.D., invited Iversen to join him in La Jolla in a relatively new program that focused on music and the brain.

Almost a decade later, Iversen couldn't be happier with his move west.

"I've always felt the Institute is among the most unique of scientific organizations in the world," Iversen says. "We have the freedom to pursue whatever research direction we think will increase our understanding of the brain. Many of our colleagues around the country are envious of our lives here. The Institute is small enough that we regularly interact with our peers in other research areas, which leads to an incredible cross-fertilization of ideas that really enhances and pushes our research forward in a way you would never see at a major university or large scientific organization.

"Ani and I are also fortunate that the Institute's founder and director (Gerald M. Edelman, M.D., Ph.D.) is an accomplished violinist who is passionate about music and equally curious about its role in brain function. Dr. Edelman has pretty much given us free rein to pursue the many questions that music and rhythm pose. They are really powerful subjects because they touch on so many brain-based processes, whether it's language, memory, emotion, or movement."

Iversen's primary work uses advanced methods of brain scanning to measure what goes on in the brain when listening to music with a strong beat. Surprisingly, he has shown that the motor system is strongly activated, even in the absence of movement, emphasizing the important interaction of sensory and motor systems in basic auditory perception. This work is aimed at understanding the detailed mechanisms behind our ability to move in synchrony with a beat, an understanding that will form a foundation for music therapy of movement disorders.

MEG (magnetoencephalography) makes looking at the brain possible

Among the other questions Iversen has tackled: do the sounds of our native languages affect how we hear music? The assumption was that all humans hear basic rhythms the same. But Iversen and fellow Japanese researchers discovered that listeners from Western and Eastern cultures (U.S. and Japan) perceived different rhythms in identical sequences of sound. Those differences appear to be closely related to the rhythms of each culture's predominant language, English and Japanese, and suggest that the mother tongue influences how we perceive non-linguistic sound at a very basic level.

Recently, Iversen and Patel showed that dancing, or synchronized rhythmic movement in time with a complex musical beat, is not just a uniquely human trait as had long been thought. Thanks to the talent of a sulphur-crested cockatoo named Snowball (whose high stepping went viral on YouTube), the scientists proved the bird could in fact synchronize his movements to musical beats. The research raises questions about the biological bases of music and suggests new ways to expand our knowledge of how the brain works.

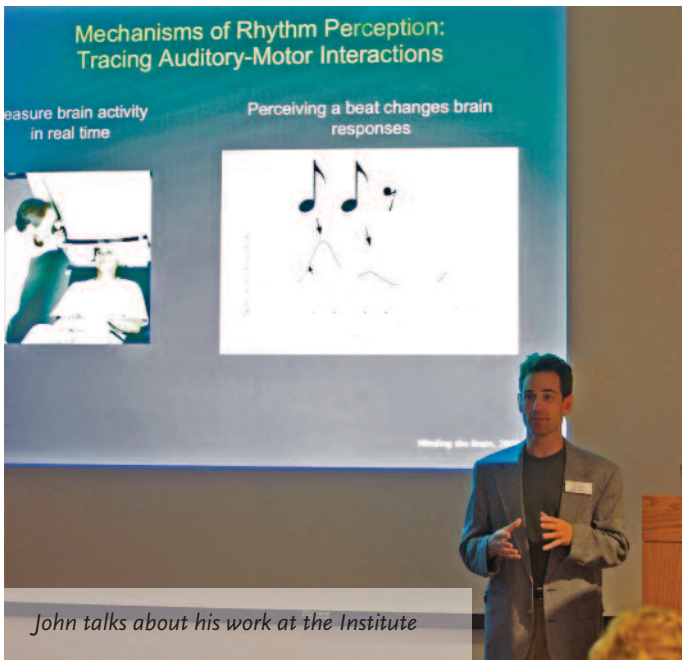
In the future, Iversen and his team will embark on a new project with strong potential for changing lives, especially those of the very young. Working with patients at Rady Children's Hospital in San Diego, Iversen, Patel, and colleagues will conduct a controlled study on the effect of playing lullaby music to infants in the Neonatal Intensive Care Unit (NICU).

"We know music can be soothing, that it reduces stress hormones like cortisol. We want to know its effect on a population of babies in an environment like the NICU which is anything but calm and soothing, where these infants are all sick and get stuck with needles and are hooked up to a lot of equipment.

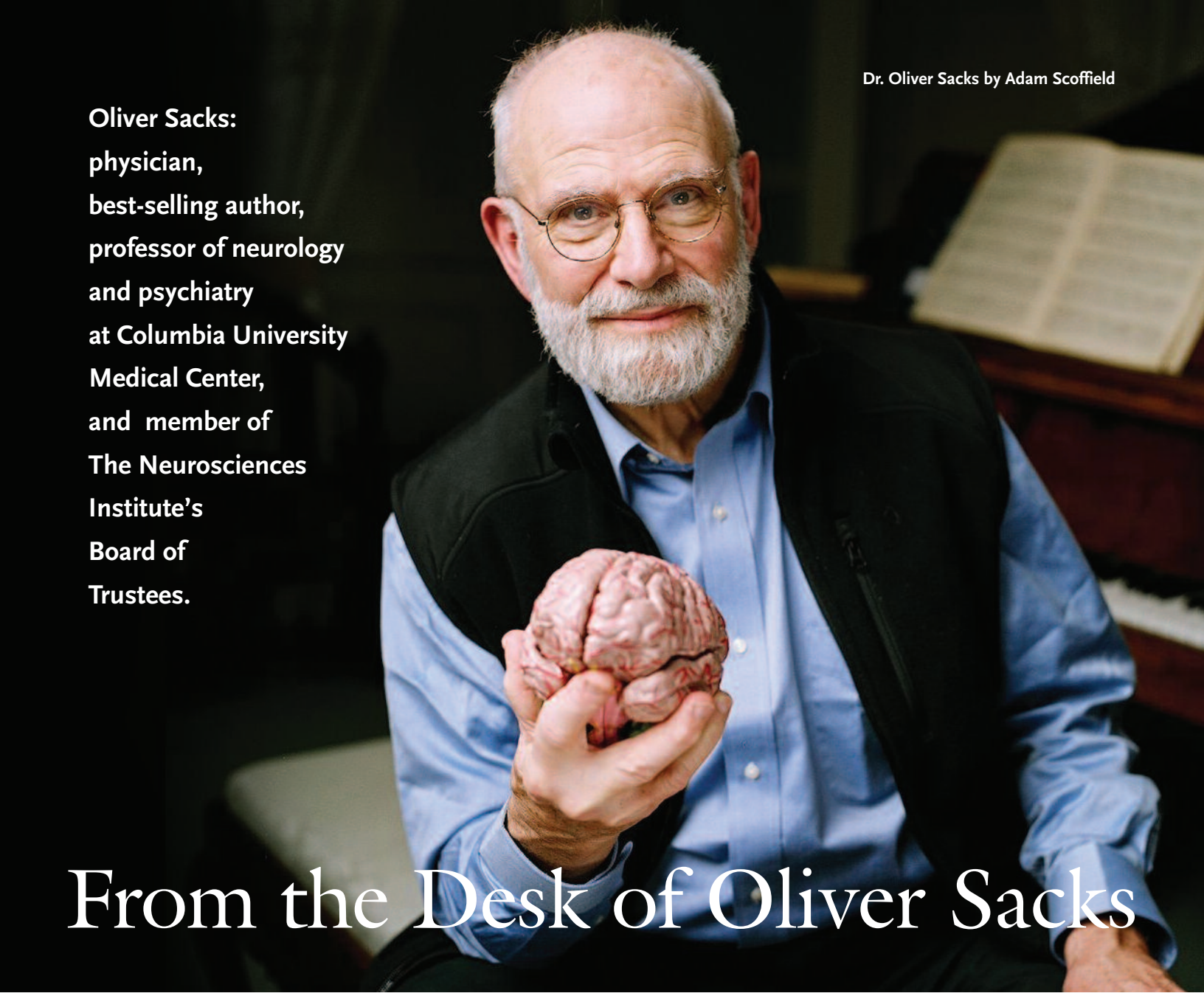
"This will be a fascinating study because we already know that stress can have a negative effect on brain development and inhibit the growth of neural connections, especially in the early most formative stages of life," Iversen says. "If we can show the music has a therapeutic, calming effect, thereby reducing stress, we may have discovered a simple and inexpensive way of enriching initial brain growth and increasing a young person's future potential."

As absorbed as he is in his research, Iversen is able to balance the intensity of scientific inquiry with a rich personal life with family, his wife Chikako and 11-year-old daughter, Chisato. And drumming continues to be an important part of his life. Iversen is an accomplished taiko drummer and co-founder of San Diego Taiko, made up of a dozen people from all walks of life who enjoy performing the dynamic rhythms and movements of Japanese taiko drumming. Iversen recently had his debut in the Institute's auditorium, playing to a sell-out crowd.

"It is not really surprising that a lifelong drummer somehow takes a career path that leads to studying the science of rhythm," Iversen says. "I've truly enjoyed being able to combine my avocation with my vocation, and experiencing how both disciplines have enhanced and enriched the other."



John talks about his work at the Institute



Dr. Oliver Sacks by Adam Scoffield

Oliver Sacks: physician, best-selling author, professor of neurology and psychiatry at Columbia University Medical Center, and member of The Neurosciences Institute's Board of Trustees.

From the Desk of Oliver Sacks

Music plays a vital role in every human culture, and (like speech) it has done so for many millennia; archaeologists have recently unearthed bone flutes 40,000 years old. Children respond spontaneously to music, especially its beat, in a way not seen in any other primate species. Music also has remarkable therapeutic powers: making normal movement possible for people with Parkinson's disease, allowing aphasic people to sing, and in patients with dementia or amnesia who may be stimulated, calmed and organized by familiar music.

The severely Parkinsonian patients I described in *Awakenings*, some of whom had been frozen like human statues for decades, would sometimes spring to life if the right music were played. Music, and often only music, could animate them and restore them to themselves and others. And I have frequently walked into a room full of people with advanced Alzheimer's, who are disoriented and frightened, or vacant and isolated, only to see a remarkable transformation when old songs are played to them. Familiar music seems to reach them at a profound emotional level, even when they are otherwise so disabled, enabling them to recall and connect with others.

All this suggests that music has a very special and unique representation in the human brain, but we know rather little about how and why it does. Scientists like John Iversen and Ani Patel are doing pioneering research at The Neurosciences Institute on the differences and similarities in the way the brain processes language and music, and on the basic mechanisms of processing rhythm and pitch. This work, as well as their planned work on the effects of soothing music on neonates under intensive care, promises to expand our knowledge and appreciation of this most marvelous human gift, multiplying the therapeutic uses of music in all sorts of contexts.

A Decade of Pioneering Research on the Neurobiology of Music

For the past decade, scientists at The Neurosciences Institute have been pioneers at the forefront of this emerging field dedicated to exploring the linkages between music and cognitive functions like learning, memory, and movement.

There may be no other medium that has as profound an effect on the human condition as music. Given music's ancient roots and its prominent role in modern life, it is remarkable that the field of the neurobiology of music is still in its relative infancy.

Music is an ideal medium for studying the brain because it uses so many different brain areas and cognitive skills simultaneously. It activates memory, hearing, vocabulary, rhythm, motor skills, and emotion. It is also a unique form of human expression that isn't seen in a comparable way anywhere else in the animal kingdom, making it a fascinating platform for exploring the special qualities of our human brain that set us apart from other species.

These studies are also yielding many practical benefits, including insights in the areas of language learning, language remediation after brain damage, and the use of music as therapy for those with movement disorders, just to name a few.

The Institute is proud of the decade of work our scientists have contributed to the field of Music and the Brain. The following timeline shows some of the milestones in this emerging field and the Institute's contributions to it.

MILESTONES IN THIS EMERGING FIELD:

The New York Academy of Sciences hosts the first Biological Foundations of Music conference, bringing together leading scientists working in the emerging field who are using a wide range of different methodologies from the cognitive sciences and the neurosciences.

Institute scientists led by Dr. Aniruddh Patel show that the firing sequences of neurons in the human brain's auditory cortex reflect the patterns of pitch in musical melodies and speech intonation.

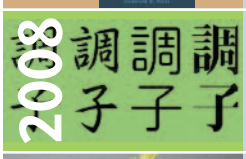
Institute scientists identify a strong link between rhythm and the hearing center of the brain, showing that complex rhythm is easily perceived through auditory stimulation but is not easily perceived by looking at patterns of flashing images.

Dr. Patel becomes the Esther J. Burnham Senior Fellow after a generous commitment to annual sponsorship of his research.

Dr. Patel discovers that the native language spoken by composers is mirrored in the stress and intonation of their music. In other words, a selected composer's work (i.e., Debussy/French and Elgar/English) is the musical mirror of their primary spoken language.

The use of magnetoencephalography (MEG) scanners explodes as improved computing power and hardware allows researchers to see what is happening almost in real time as the brain is processing musical and rhythmic stimuli.

Dr. Patel releases the book *Music, Language, and the Brain* – the first comprehensive study of the relationship between music and language from the standpoint of cognitive neuroscience, which challenges the widespread belief that music and language are processed independently.



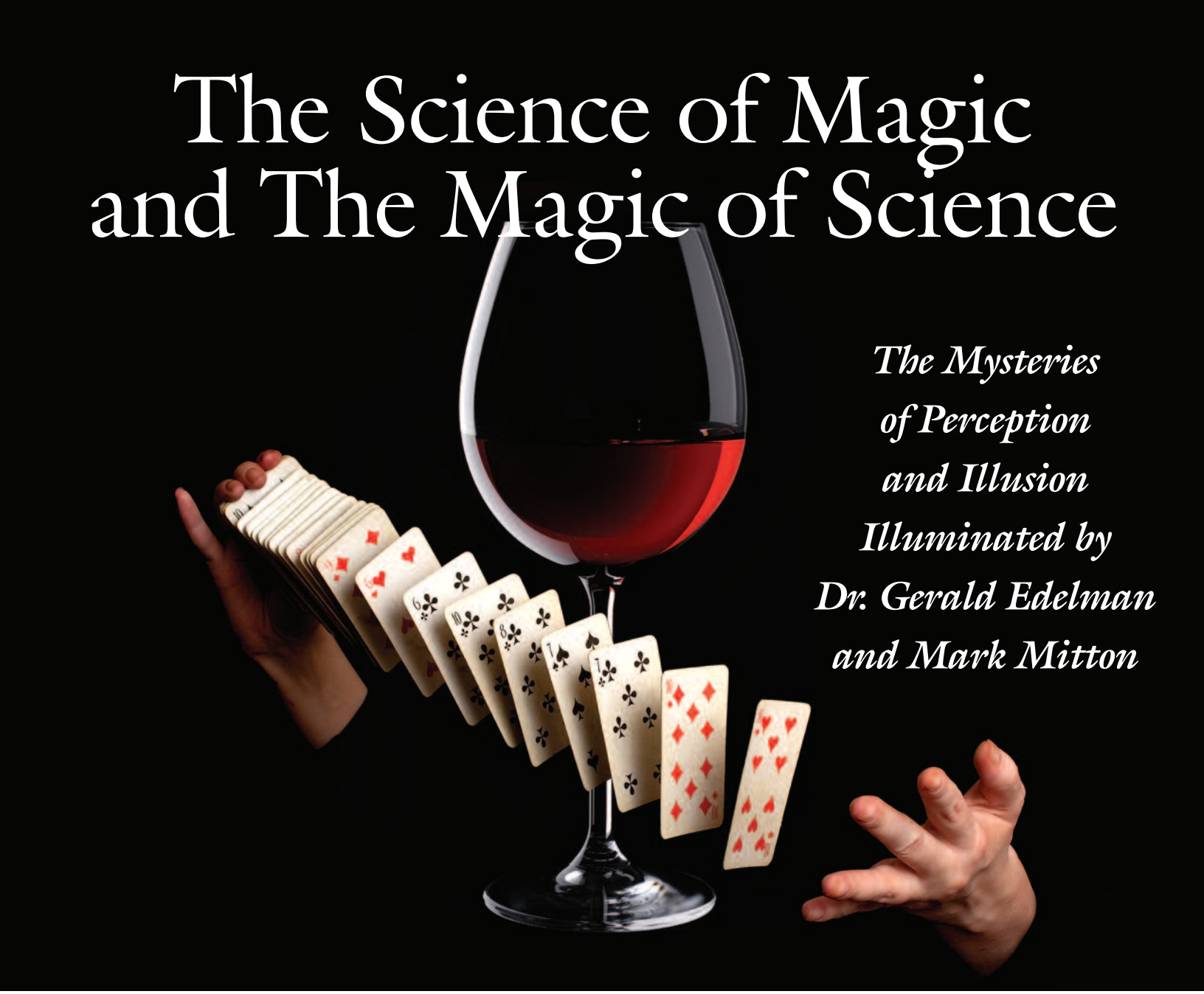
Dr. John Iversen, by examining Japanese and English speakers, proves that individuals can hear the same rhythms differently based on the rhythmic groupings common within their native language.

Drs. Iversen and Patel overturn the idea that humans are the only animal that can synchronize movement to a musical beat when they studied Snowball the cockatoo.

Institute researchers Iversen and Patel deliver 23 lectures and presentations about their work both nationally and internationally.

The work continues ...

The Science of Magic and The Magic of Science



The Mysteries of Perception and Illusion Illuminated by Dr. Gerald Edelman and Mark Mitton

Audience members having fun trying magic trick

Institute members and special guests were treated to a Taste of Magic on Friday, October 22, where they sampled fine wines and hors d'oeuvres before an enlightening and entertaining evening of science and magic.

WINE TASTING STATIONS WERE DONATED BY

ARTESA

FALKNER WINERY

Dubé Vineyards

Women with Wine

About Mark Mitton

Mark has trained with the greatest masters of magic and comedy and has entertained audiences around the world for over 25 years with his mind-bending magic performances. Mark's fascination with illusion and deception has compelled him to spend much of his time recently pursuing discussion with neuroscientists about the neural bases of perception.

Mark with audience member showing the three ball and cup trick

As Mark Mitton and Dr. Gerald Edelman proved on the evening of October 22nd, ***magic*** is a wonderful way to bring attention to the marvelous complexity of the human brain.

Opening with an entertaining and informative introduction about the fascinating science behind illusion and the brain's perception of magic, Dr. Edelman set the stage for the night. Audience members became more keenly aware of their own conscious attention and many were determined to try to figure out the magic and conquer the illusion.

Mark proved that challenge to be difficult with his mastery of sleight-of-hand and other baffling but entertaining magic tricks. He charmed the audience with his fun style and remarkable skill.

All those who attended left with an appreciation of the marvelous human brain and its vast capabilities while enjoying an evening of entertainment and fine food and wine.

All proceeds from the event support the Institute's ground-breaking research on how the brain works, providing a platform of knowledge that will benefit humankind in countless ways.

Guests enjoying the wine tasting

Much Merriment at Minding the Arts!

Two hundred people turned out for the 8th annual *Minding the Arts* fundraiser that was held on Sunday, September 12. This fun and unique event, presented by Audrey S. Geisel and The Dr. Seuss Foundation, raised over $116,000 for the Performing Arts Program at The Neurosciences Institute!

Minding the Arts

Mesmerizing tango performance by Tango Alma

Dr. Edelman, Institute Member Lawrence Schneiderman, and Master of Ceremonies Dr. Nicolas Reveles strike up a conversation

Dr. Edelman, Mary Coakley, Walter Munk, Audrey Geisel, Joani Nelson, Coop Cooprider

The Davidovitch Trio: Karen Davis, piano; Timothy Landauer, cello; Jisun Yang, violin

The Performing Arts Program exists to enhance the vibrancy of San Diego's arts community by offering premier performance space to local non-profit performing arts and educational organizations at no charge. Support is focused on events featuring instrumental, vocal, dance, and theatrical performances and lectures aimed at a broad audience. The program seeks to encourage organizations to provide high-quality events at lower ticket prices, increasing accessibility for more San Diegans.

Save The Date

2011 *Minding the Arts* event
September 18, 2011

Food & Beverages Donated By:

- Artesa Winery
- Authentic Flavors Custom Catering
- Betsy G. Catering
- Convivial Catering
- Estancia La Jolla Hotel & Spa
- Karl Strauss Brewery
- Pamplemousse
- Sammy's Woodfired Pizza
- St. Tropez Specialty Cakes & Desserts
- TK&A Custom Catering
- Waters Fine Catering

Musical Performances By:

- Camarada with Tango Alma
- The Davidovitch Trio
- San Diego Young Artists Symphony

Sponsors:

- Audrey S. Geisel/The San Diego Foundation, Dr. Seuss Fund
- Donald & Darlene Shiley's Shiley Foundation
- Indian Fine Arts Academy
- Patricia & Christopher Weil
- Dr. Steve & Lynne Wheeler
- Mandell Weiss Charitable Trust

Ambassadors

Thank You to Our Performing Arts Program Ambassadors

The Performing Arts Ambassadors is a group of enthusiasts who are committed to spreading the word about The Neurosciences Institute's Performing Arts Program and its only fundraiser, the annual *Minding the Arts* gala event, which occurs each fall.

The vital role of the Ambassadors is to:

- Serve as advocates by bringing attention to the program within their own spheres of influence
- Provide feedback that guides *Minding the Arts*
- Attend occasional meetings to remain up-to-date on the program

Ambassadors spend time socializing, attending performances, and generally having a good time while spreading the word about this important program. For more information, contact Rachel Jonte at jonte@nsi.edu

Performing Arts Program Ambassadors: Back Row (L-R): Jeane Erley, Reena Horowitz, Veryl Mortenson, Jeanette Stevens, Sherry Kline. Front Row (L-R): Linda Satz, Joani Nelson (Event Chair), Patti Cooprider, Jean-Marie Hamel, Toni Nickell

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Neurosciences Research Foundation, Inc.
10640 John Jay Hopkins Drive
San Diego, CA 92121

ADDRESS SERVICE REQUESTED

The Neurosciences Institute is a Very Special Place to Audrey Geisel

Audrey Geisel is one of San Diego's most generous philanthropists through her support of literally dozens of organizations. Among those many wonderful non-profits, the President and CEO of Dr. Seuss Enterprises, Dr. Seuss Fund, and Dr. Seuss Foundation has a handful of favorites, and she is delighted to let you know that The Neurosciences Institute is one of them.

There are two reasons for Geisel's affection for the Institute. Foremost is the Performing Arts Program in which the Institute's acclaimed auditorium is made available at no charge to local non-profit arts and educational organizations. The Institute incurs annual costs of more than $350,000 to provide this community service for nearly 100 events each year.

"I love The Neurosciences Institute because it's the only organization I know of that gives back to the community in such a unique way by making its auditorium—an amazing acoustical marvel—available completely gratis to the public. I still don't comprehend that kind of generosity. I just know I want to support it!"

And support it she does. Geisel has sponsored *Minding the Arts*, the Institute's annual fundraising event for the Performing Arts Program, every year since 2003. The elegant event begins with an outdoor cocktail reception with food stations, followed by a concert by select arts organizations that have benefited from the use of the auditorium.

"Supporting *Minding the Arts* is such a pleasure because it provides people with a lovely afternoon and evening in which they can watch a wonderful performance, see just how spectacular the auditorium is, and hear a little bit about the amazing research on the brain that the Institute is conducting," Geisel says.

That research is the other reason for Geisel's fondness for the Institute. Her own experience two decades ago with a non-malignant tumor that doctors discovered had been growing in her right frontal lobe for years has made her fascinated with the brain.

"The Institute is the only organization I know of that deals so exclusively above the neck," Geisel says. "The fact that the Institute can be so focused on cutting-edge research to reveal how the brain works and still have the wherewithal to be so generous with its own facility makes it truly one of the great organizations in San Diego."