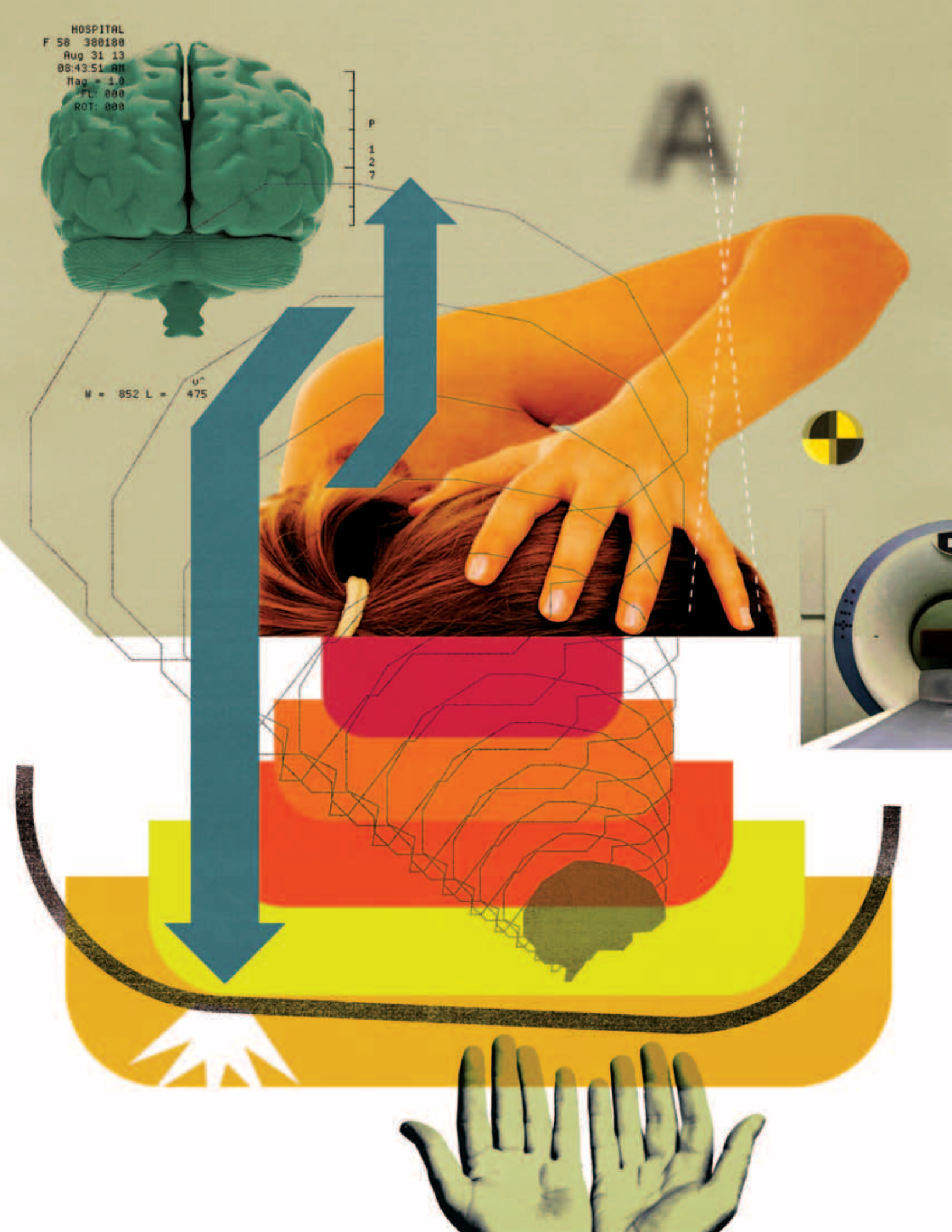
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NJIT IS BROADLY ENGAGED IN EFFORTS TO UNDERSTAND, TREAT AND PREVENT **TRAUMATIC BRAIN INJURY**

PROTECTING WHO WE ARE

Traumatic brain injury (TBI) is a threat to our well-being that's now widely publicized due to the wars in Afghanistan and Iraq, and the emerging link with sports, notably football. The Centers for Disease Control and Prevention (CDC) reports that there are at least 1.7 million TBIs recorded annually in the United States, which contribute to about a third of all injury-related deaths in the country.

Automobile crashes, falls and other accidents cause many of these TBIs. But the sobering domestic numbers do not include the incidence among American troops injured in combat. About a fifth of those wounded in Afghanistan and Iraq have returned home with TBIs, particularly as a result of blasts from IEDs – improvised explosive devices. TBI has become the signature wound of these conflicts.

[CONTINUED]

ILLUSTRATION (OPPOSITE): STUART BRADFORD

While the National Football League has taken steps to prevent TBIs on the field, a substantial number of retired players are contending with early-onset dementia and comparable diseases most likely related to impacts endured during their playing careers. Suicides by former NFL stars have made headlines because of a probable TBI connection. Spouses of players witnessing heart-wrenching deterioration have also spoken out. "A slow, deteriorating, ugly, caregiver-killing, degenerative, brain-destroying tragic horror," is how Sylvia Mackey describes what has happened to her husband, former Baltimore Colt John Mackey.

The NFL Players Association is partnering with the Cleveland Clinic, the University of North Carolina and Tulane University in a program to help retired players afflicted by TBI. They can get physical and neurological evaluations, and a plan to deal with health issues that have resulted from head trauma.

And the soccer world is beginning to recognize the danger of TBI for unprotected amateur and professional players. The most popular sport in the world, soccer is played by an estimated 120-150 million people. Research indicates that the risk of TBI is the same for soccer players as it is for those playing American football.

Researchers at NJIT are responding to this health challenge with a comprehensive program to gain knowledge about TBI and to translate that knowledge into better therapies and protective measures. Professor Namas Chandra, who joined NJIT's Department of Biomedical Engineering in 2013 from the University of Nebraska, is director of the new Center for Injury Biomechanics, Materials and Medicine (CIBM3). "We can save lives by replacing the heart, lungs, kidneys and other organs from donors, but not the brain," Chandra says. "Protecting the brain from injury is protecting the essence of who we are as individuals."

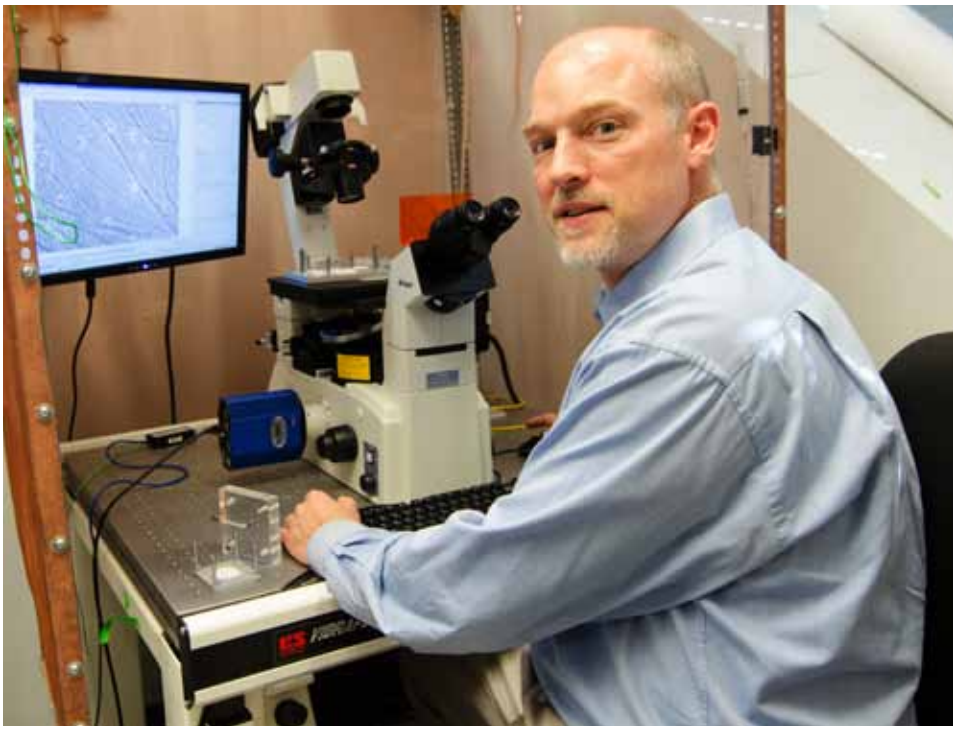


PHOTO: RICKY KHARAWALA

STARTING AT THE CELLULAR LEVEL

TBI occurs when the brain collides with the inside of the skull with significant force after a direct impact or when subjected to the shock wave from a blast. The injury can be severe, moderate or mild. The term concussion is often used synonymously with mild TBI. Severe TBI frequently results in death or serious incapacitation, while moderate to mild TBI

TOP: *Bryan Pfister, associate professor of Biomedical Engineering, studies traumatic brain injury at the cellular level, where injury begins with damaging distortion of neuronal cells.*
ABOVE: *An image of neurons undergoing an injury response known as chromatolysis.*

"WE CAN SAVE LIVES BY REPLACING THE HEART, LUNGS, KIDNEYS AND OTHER ORGANS FROM DONORS, BUT NOT THE BRAIN. PROTECTING THE BRAIN FROM INJURY IS PROTECTING THE ESSENCE OF WHO WE ARE AS INDIVIDUALS." *– Professor Namas Chandra*

can cause a multitude of ill effects in daily life. These include impairing sight, hearing and speech, as well as the ability to walk and to control emotions.

The CDC estimates that 75 percent of the TBIs that occur each year in the US are the mild type. Diagnosing and treating mild TBI can be especially problematic, as much needs to be learned about the relatively subtle changes in the brain related to specific symptoms. Someone who has sustained mild TBI may appear to be well at first, but then manifest physical or psychological changes. For example, there is growing evidence of a strong connection between mild TBI and post-traumatic stress disorder.

Severe TBI has received extensive scrutiny for several decades, largely because it occurred in so many automobile accidents. Despite its relative frequency, this has not been the case with mild TBI. But that's changing, as evidenced by the focus on mild TBI at NJIT.

All TBIs start with mechanical changes in the brain, explains Bryan Pfister, associate professor of biomedical engineering. The sudden trauma of an impact or blast can stretch neurons to nearly twice their normal size. It is this stretching that Pfister believes to be the ultimate cause of most symptoms seen at the systems level – such as dysfunction in vision, speech and motor control.

In his laboratory, Pfister studies the effects of stretching on cultured neuronal cells, work funded by the New Jersey Commission on Brain Injury Research. "If you want to see the evolution of a TBI, you have to begin at the cellular level, where the trauma creates a mechanical shape change," Pfister says. The deformation he investigates can occur in milliseconds upon direct impact, and be so fast in the vicinity of a blast as to be impossible to time.

Pfister is collaborating with Assistant Professor Viji Santhakumar, Department of Neurology and Neurosciences at Rutgers New Jersey Medical School, and Professor Kevin Pang, who is affiliated with the same department at Rutgers as well the Veterans Affairs New Jersey Health Care System. Their goal is to develop a more comprehensive understanding of how TBI evolves from the cellular to the systems level, understanding that Pfister anticipates will be enhanced by data from Namas Chandra's new NJIT research center.

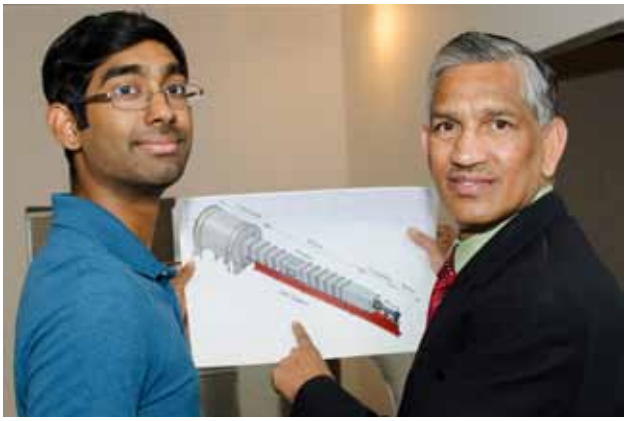


PHOTO: JED MEDINA

Professor Namas Chandra (right) and PhD student Matthew Kuriakose at the campus site of the new Center for Injury Biomechanics, Materials and Medicine, which will be under Chandra's direction. When operational, the center will have three shock tubes, such as the one in their diagram, that will subject biological samples and dummy heads to shock waves traveling at speeds as great as 900 miles per hour.

ACCELERATING RESEARCH

According to Pfister, the relationship between mechanical input and biological change has yet to be clearly defined when it comes to mild TBI. Being able to see how impacts of varying intensity and orientation affect neuronal tissue with greater precision would be significant for gaining basic neurological knowledge, developing targeted therapies, and improving protective technologies.

The laboratory that Chandra is building at NJIT will be a major national research facility that promises progress in all of these areas. For more than 25 years, he worked with the US Army to improve protective systems, including body armor and helmets. In recent years, he began to study the relationship between blast injuries and TBI, research that has expanded to include impact TBI.

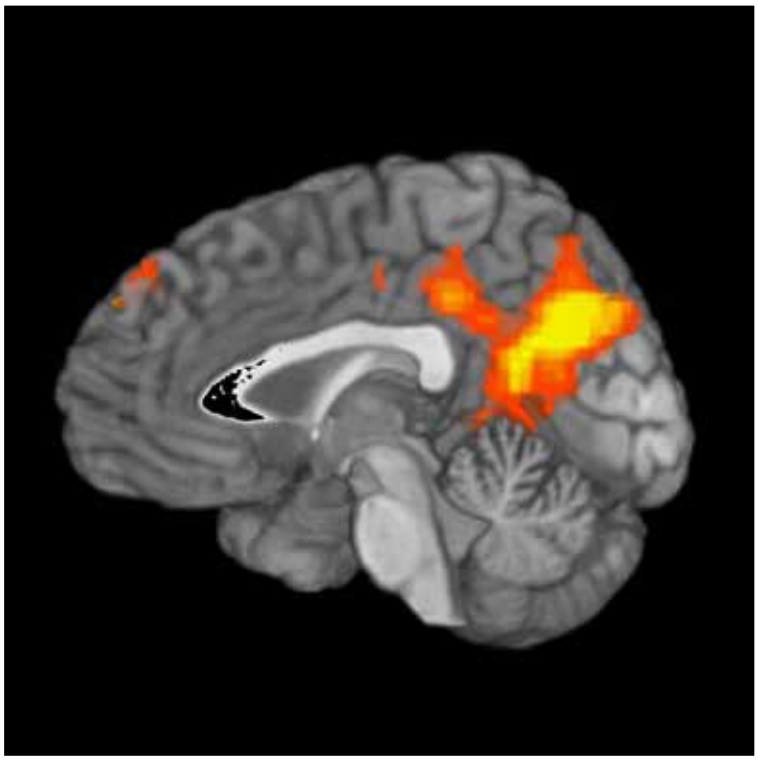
At NJIT, Chandra will be taking a broader look at key aspects of mild TBI. He sees defining the relationship between an injury-causing event and the medical outcomes as a major challenge. "We will recreate TBIs under various conditions to learn which part of the brain is injured, and what the consequences are," Chandra says. "We need this information to make better TBI diagnoses. Unfortunately, many cases of mild TBI go undiagnosed and untreated."

The equipment in Chandra's laboratory, which he expects will be fully operational by spring, is designed to subject biological samples and dummy heads to the trauma of impact and blast TBI in various ways. There will be a system to drop samples to replicate one type of impact TBI. Three shock tubes will make it possible to recreate far more forceful TBI scenarios.

Two of the shock tubes are 28 inches by 28 inches in cross section and approximately 20 feet in length. A third tube is 9 inches by 9 inches and some 30 feet long. Shock waves generated with helium and nitrogen gas at one end of the tubes will travel at speeds as great as 900 miles per hour and hit experimental targets in the test section in the middle of the tubes.

In addition to biomedical engineering, Chandra plans to draw on the expertise of colleagues in many disciplines, such as biochemistry, physics and materials engineering. He will also be assisted by NJIT students like Matthew Kuriakose, for whom hands-on involvement with research is a key part of the NJIT experience at all levels.

A biomedical engineering major and Albert Dorman scholar, Kuriakose '13 initially considered entering the workplace after graduation and studying for a master's part-time. But he started to change course during his senior capstone project, a team effort to research how a system to detect concussions might be built into a football helmet. And with additional



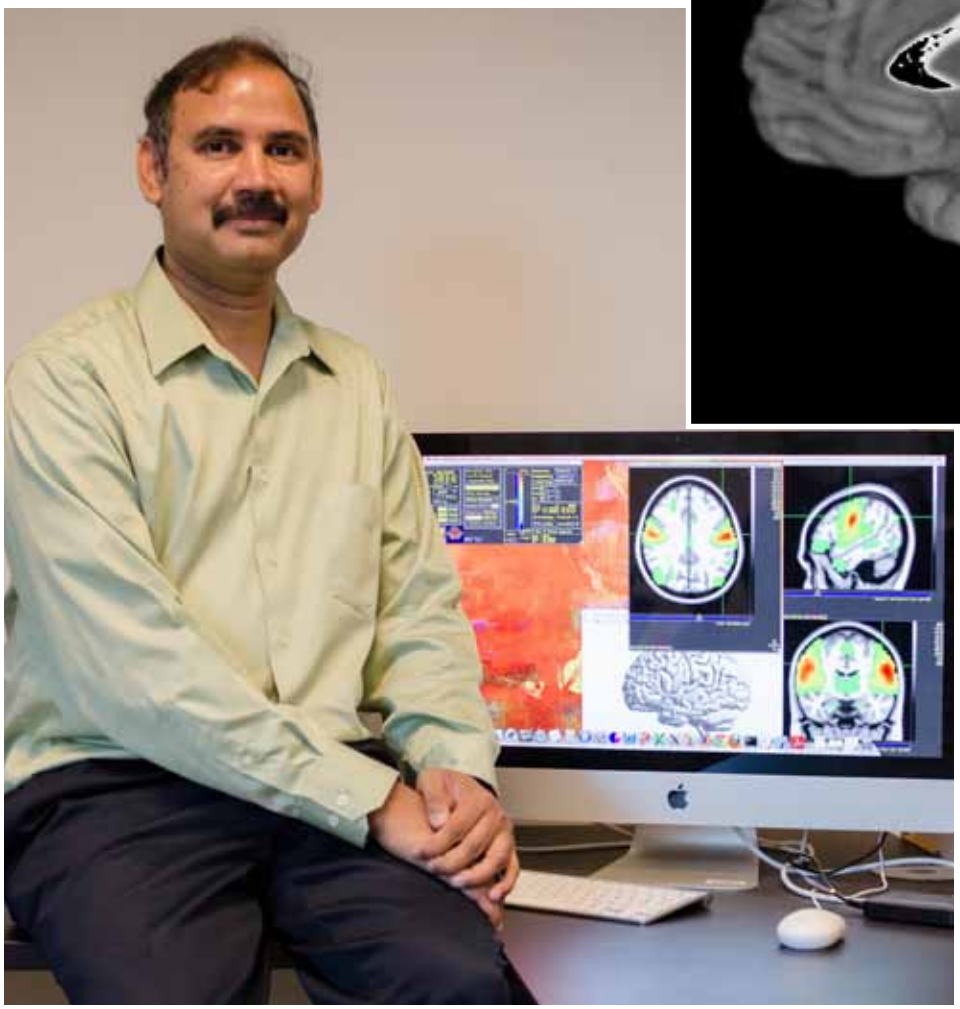


PHOTO: RICKY KHARAWALA

ABOVE: *Stimulated with a visual-attention task, the normal parietal cortex functional activity seen was captured using functional magnetic resonance imaging. Such activity impaired by traumatic brain injury can be improved with therapy. NJIT researchers are developing instruments and techniques for studying the effectiveness of various therapeutic interventions.*

LEFT: *Professor Bharat Biswal, chair of NJIT's Department of Biomedical Engineering, is at the forefront of imaging brain function.*

inspiration from Chandra, he has decided to pursue a PhD at NJIT, focusing on TBI.

Citing the growing awareness of TBI from combat, sports injuries and other causes, Kuriakose says, "There is such potential for having a real, positive effect in the lives of people who have been injured. Once you learn about the possibilities, it's hard to turn away from the challenges."

IMAGING FUNCTION AND INJURY

Professors Bharat Biswal and Tara Alvarez are looking at TBI, particularly mild TBI, from yet another perspective. Biswal is chair of NJIT's Biomedical Engineering Department and has a joint appointment in the Radiology Department at Rutgers New Jersey Medical School. He is expert in fMRI – functional magnetic resonance imaging. This technique allows mapping the responses of a normal living brain to various stimuli, and how brain function is affected by injury and different forms of therapy. Biswal is a pioneer in understanding not only what regions of the brain are functionally active, but also in learning how different regions interact to form networks.

Speaking of TBI, Biswal says "We need to learn more about the relationship between the specific parts of the brain affected by a traumatic event and resulting changes in the ability to function." Working with Professor Charles Prestigiacomo, chair of the Department of Neurological Surgery and director of the Neurological Surgery Residency Program at Rutgers New Jersey Medical School, Biswal has conducted major imaging studies of the brain after severe TBI funded through the National Institutes of Health.

Biswal also has collaborated with Alvarez, director of NJIT's Vision and Neural Engineering Laboratory, on her research into the connection between vision and mild TBI. Alvarez's research is funded through a previous CAREER grant and a current major instrumentation grant from the National Science Foundation. In addition, Alvarez and Biswal are working with colleagues at Salus University and the University of California–Berkeley to advance development of more effective methodologies to improve vision dysfunction, especially for those afflicted by TBI.

Since joining the NJIT faculty in 2001, Alvarez has applied her expertise as a

"INSTEAD OF TELLING PATIENTS AFFECTED BY MILD TBI THAT YOU'LL GET BETTER IF YOU JUST REST, AND HOPING FOR THE BEST, WE HAVE TO BECOME BETTER AT MAPPING AND UNDERSTANDING HOW TBI PHYSICALLY CHANGES THE BRAIN..." *– Professor Tara Alvarez*

biomedical engineer to building innovative instrumentation for helping to understand and treat vision problems. These include visual field neglect in stroke patients, which manifests itself with symptoms like seeing only one half of a clock, and convergence insufficiency, a dysfunction that impairs the ability to read because of blurred vision and related fatigue.

More recently, the link between vision and mild TBI has become Alvarez's primary area of research. Her work, carried out with Biswal and Prestigiacomo, confirms that about 25 percent of TBI patients will have vision dysfunction such as blurry vision, and that eye-movement patterns can be related to impairment.

Going forward, Alvarez intends to investigate mild TBI more deeply, also teaming with Nancy Chiaravalloti and Mayur Bhavsar '03. Chiaravalloti is director of the Neuropsychology and Neuroscience Laboratory and the Traumatic Brain Injury Laboratory at the Kessler Foundation Research Center. Bhavsar is a doctor of optometry with the Veterans Affairs New Jersey Health Care System. fMRI will be a key tool in this effort, which will engage patients in studies of vision dysfunction and the relationship between vision and impaired memory.

The memory problems of former star quarterback Brett Favre, most likely related to TBI, made news in late 2013. Favre, who is in his mid-40s, spoke about experiencing serious memory loss he fears may be related to numerous concussions on the field. He expressed dismay over episodes such as not being able to remember that his daughter had participated in a youth soccer program.

"We know more about moderate TBI because people are more obviously affected," Alvarez says. "Mild TBI is a greater mystery. We need better instrumentation to quantify dysfunction because the damage to the brain tends to be more subtle and diffuse. Instead of telling patients affected by mild TBI that you'll get better if you just rest, and hoping for the best, we have to become better at mapping and understanding how TBI physically changes the brain, and better at mapping the brain's response to therapy."

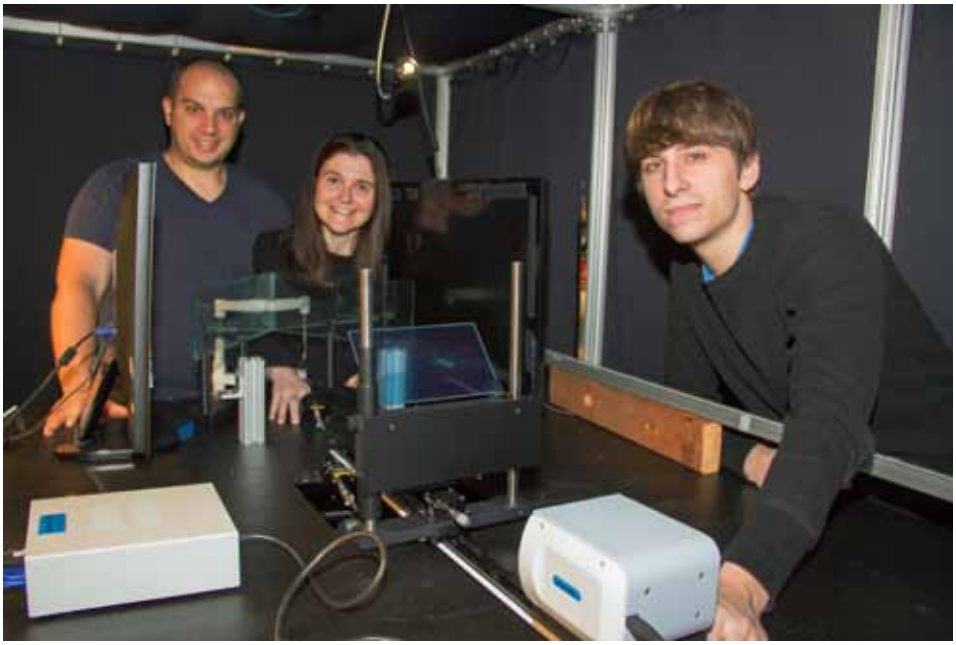


PHOTO: JED MEDINA

*Vision and brain-injury researcher Professor Tara Alvarez with biomedical engineering students Stephen Lestrange (left) and Nic Thibodeaux.**

Bhavsar, who assisted Alvarez with convergence research as an undergraduate biology major, is now collaborating with her team to study brain injury as part of his clinical work with veterans who have mild TBI. The brain can respond in a positive way after an injury by building new neural pathways to compensate for damage, a capacity often referred to as neural plasticity. And therapeutic intervention can facilitate this neural remapping to help alleviate double and blurry vision with visual fatigue caused by TBI.

"Vision-training therapy does work for TBI patients," Bhavsar says. "But we have yet to understand the underlying mechanisms by which therapy achieves a sustained reduction in vision symptoms. Such knowledge can lead to better therapies for improving the quality of a patient's daily life."

GROWING CONNECTIONS

The NJIT faculty members at the forefront of TBI research are marshaling talent and resources that not only span diverse departments and disciplines at the university. They are integrating the expertise of colleagues at other major institutions in the state – the Kessler Foundation, Rutgers, and the Veterans Affairs Health Care System. Indicative of the growing awareness of TBI as a health issue, the outreach also is international. Alvarez is connecting with researchers in France and Germany through an open-access initiative intended to promote collaborative TBI investigation and discussion of results.

While comprehensive in scope and varied in the research involved, the TBI program that NJIT is advancing does have one defining objective in Pfister's estimation. "We want New Jersey to be known as the preeminent center for traumatic brain injury research and treatment. That's what we are all working towards." ■

Author: Dean L. Maskevich is editor of NJIT Magazine.

http://biomedical.njit.edu

**Dorman honors scholar*