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Researchers' papers find concept of using light to image, potentially treat PTSD

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Hanli Liu, UT Arlington professor of bioengineering Credit: UT Arlington

After years of studying the effects of near-infrared light on veterans with post-traumatic stress disorder or traumatic brain injuries, a team led by a University of Texas at Arlington bioengineer has published

groundbreaking research in Nature's *Scientific Reports* that could result in an effective, long-term treatment for brain disorders.

Professor Hanli Liu was the primary investigator on the project. Her team of graduate students and a research associate, Fenghua Tian, worked with co-investigators Alexa Smith-Osborne, a UTA social work associate professor; Francisco Gonzalez-Lima, a psychology professor at UT Austin; and Fu Lye Martin Woon, a former assistant professor of psychiatry at UT Southwestern; to show potential intervention using light in brain disorders including post-traumatic stress disorder.

Their research is funded in part by a UT System BRAIN or Brain Research through Advancing Innovative Neurotechnologies seed grant titled, "Transcranial light therapy and imaging of prefrontal cognition in PTSD."

With the UT System's support, Liu's interdisciplinary collaborative team has not only investigated the brain imaging capability of light but also revealed the therapeutic rationale for potentially improving cognitive functions of patients with PTSD. The first paper resulting from the seed funding is published online and titled, "Interplay between up-regulation of cytochrome-c-oxidase and hemoglobin oxygenation induced by near-infrared laser."

As in the first study, the team used a human forearm as a biological model instead of the human brain to avoid confounding factors due to such anatomical structures as the scalp and skull. The paper outlines their discovery that shining near-infrared light on the subject's forearm increases production of cytochrome-c-oxydase, a protein inside the neurons that stimulates blood flow. This discovery shows great potential that NIR or infrared light also will work within the brain.

"This is the first time that effects of light stimulation have been

quantified on living human tissue," Liu said. "The next challenge is to apply what was learned in a simpler system to the brain, where the light must pass through the scalp and the skull, as well as the brain. In the past several years, we have used the knowledge gained in the NIR field to detect, monitor and understand certain brain disorders, such as PTSD. But we have never utilized NIR light for treatment."

Now the team is moving to report and publish its findings of transcranial NIR stimulation on the human brain by quantifying production of cytochrome-c-oxydase and increase of blood flow. It would support a novel, non-invasive treatment with imaging ability, especially for memory, which could really help veterans who suffer from PTSD.

The UT BRAIN initiative was approved by the UT System Board of Regents in 2014 and supports a virtual UT System Neuroscience and Neurotechnology Research Institute that promotes trans-disciplinary, multi-institutional research projects focused on neuroscience and neurotechnology. It has provided a total of $5 million with a $100,000 per grant in a 2-year period of Sept.1, 2015 to Aug. 31, 2017.

Eight days prior to that paper, Liu and her team published another paper in *Scientific Reports*, titled, "Prefrontal responses to Stroop tasks in subjects with post-traumatic stress disorder assessed by functional near infrared spectroscopy."

That paper outlined Liu's work to understand how the brains of people suffering from PTSD are different from a healthy group of non-PTSD sufferers using a Stroop test.

Stroop tests are attention tests that are commonly used in psychology.

Liu measured blood flow in the left side of the dorsal lateral prefrontal cortex of subjects' brains and found that those suffering from PTSD

don't have the ability to pay attention and also have insufficient blood flow in that area of the brain. Michael Cho, chair of UTA's Bioengineering Department, says that Liu's continuing focus on using NIR light to detect, monitor and potentially treat brain injuries underscores the UTA's focus on health and the human condition contained within the Strategic Plan 2020: Bold Solutions | Global Impact.

"Dr. Liu and her collaborators have made incredible strides in identifying how the brain is affected by trauma, as well as how to treat disorders such as PTSD noninvasively with light," Cho said. "This is truly innovative, groundbreaking research, and the results are a testament to Hanli and the input of her collaborators."

Liu, a Fellow of the American Institute for Medical and Biological Engineering and a member of the UTA Academy of Distinguished Scholars, joined UTA's College of Engineering in 1996 and has secured more than $11 million as principal investigator or co-PI in research funding during her career. Her work is focused on medical instrumentation and imaging, minimally invasive and noninvasive spectroscopy and imaging of tissue, optical diffuse imaging for cancer prognosis, and brain activities.

She has studied PTSD extensively with Smith-Osborne and Tian, and they have applied a portable brain-mapping device that allows them to "see" where memory fails student veterans with PTSD. That research led the team to connect with Gonzalez-Limam and further discovered that shining low-level light on the brain by placing the light source on the forehead can stimulate and energize neurons to function more effectively. When cells are stimulated with light, they remain stimulated for a lengthy period of time even after the light is removed. The approach differs from other therapies that use magnets or electric shocks and has the potential to yield effective, longer-lasting treatments.

More information: Xinlong Wang et al. Interplay between up-regulation of cytochrome-c-oxidase and hemoglobin oxygenation induced by near-infrared laser, *Scientific Reports* (2016). DOI: 10.1038/srep30540

Amarnath Yennu et al, Prefrontal responses to Stroop tasks in subjects with post-traumatic stress disorder assessed by functional near infrared spectroscopy, *Scientific Reports* (2016). DOI: 10.1038/srep30157

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