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A large, semi-circular graphic in the background, rendered in a light grey color. It consists of a dense network of interconnected nodes, each represented by a small starburst or multi-pointed shape, connected by thin lines. The overall shape is reminiscent of a brain's neural network or a complex data structure.

Enhancing Brain Functions with Near Infrared Light

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Founder & CEO, Vielight Inc.

June 2018

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The logo for Vielight features a stylized red starburst or multi-pointed shape above the word "VIELIGHT" in a bold, red, sans-serif font.

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Enhancing Brain Functions with Near Infrared Light

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Introduction

There are a number of methods considered to possibly enhance brain functions – brain training and mindfulness practices are common ones. Substance-based methods include hallucinogens in the form of plant extracts and drugs. Transcranial direct current stimulation (tDCS) and transcranial magnetic stimulation (TMS) are two groups of well-researched non-invasive brain stimulation methods. All of these are promising in their own ways and have presented brain enhancement qualities.¹ However, the science and reproducibility of the electrical-based stimulation methods have been questioned.²

In the world of brain enhancement discussion, photobiomodulation (PBM), also known as low level light therapy (LLLT) has attracted little attention, but this could be its time. PBM involves delivering light, often near infrared (NIR) light to the cells (including neurons) to modulate tissue functions. The cellular mechanisms have been well researched.³ Animal studies have presented cognitive improvements and recovery from brain insults of various kinds. However, most of the human studies have not been well-controlled, and to many, have not shown sufficient reasons to be headlined.³ This is starting to change with the newer studies and PBM is building its cache of merits to be recognized as a “new way” to enhance brain functions.



Fig. 1
is an illustration of a popular method of transcranial PBM. Vielight Neuro Alpha/Gamma in use

The Fundamental Case for PBM

There are a few factors that support PBM using NIR light for brain enhancement:

- Its fundamental mechanisms of action based on photons modifying mitochondrial functions have largely been borne out in outcomes as expected.⁴ Mitochondria health is increasingly recognized as fundamental in medicine.⁵
- The photon is non-chemical, non-synthetic and non-mechanical. When activating the mitochondria in small doses, it modulates tissues without major side effects. Its life-harnessing activity appears to be a legacy from early life on earth that started with photosynthesis.⁶
- The effects of transcranial PBM have been found to be systemic and generally agnostic in treating the different types of brain insults.⁷
- Emerging evidence are presenting the effect of PBM on the electrophysiology potential of the brain¹¹ as well as enhanced blood perfusion¹², filling some of the earlier gaps in the understanding and validation of brain PBM mechanisms.

Literature on Evidence

High level literature reviews have identified a number of neurological, psychiatric and neurodevelopment conditions that may be addressed by transcranial PBM, as shown in Table 1.

Investigations into the enhancement of normal human brains with NIR light are relatively recent. With NIR light delivered to the forehead in a controlled study, the subjects demonstrated improved memory and mood. The treatment method also showed the subjects improving in executive functions.¹⁰ When the right forehead was treated, it improved attention biased modification (ABM) in people with depression.¹¹ Directing NIR light to

Type of brain disorder			
Traumatic Acute stroke	Neurodegenerative Alzheimer's disease	Psychiatric Depression (major, bipolar, suicidal ideation)	Neurodevelopmental Autism (autism spectrum disorder)
Chronic stroke	Parkinson's disease	Psychosis (schizophrenia)	Attention deficit hyperactivity disorder (ADHD)
Acute TBI	Other dementias (vascular, Lewy bodies, frontotemporal)	Post traumatic stress disorder (PTSD)	
Chronic TBI	Chronic traumatic encephalopathy	Addiction	
Global ischemia	Amyotrophic lateral sclerosis (Lou Gehrig's disease)	Insomnia	
Coma (vegetative state)	Primary progressive aphasia		
Birth trauma (neonatal stroke)	Prion diseases (Creutzfeldt-Jakob)		
"Chemo-brain"	Huntington's disease		

Table 1: List of brain disorders that may in principle be treated by transcranial PBM⁸

the brain also improves reaction time.¹² Functional near infrared spectroscopy (fNIRS) has measured increased cerebral oxygenation in the brain after a single transcranial PBM¹³, which provides an explanation for the increased performance observed. Quantitative electroencephalography (qEEG) maps have also shown increased electrophysiology power.⁵

In summary, PBM with NIR light appears to have positive effect on both diseased and healthy brains. It now leaves us to determine what else may be possible with NIR light.

The Potential in Selective Modulation

PBM can modulate the brain in several ways:

1. Blood perfusion, more so in the areas surrounding the source of light¹³
2. Activation of neuronal repair, restoration, growth and reduction of inflammation⁸
3. Increase in neurotransmitter activity⁸
4. Beneficial modification of microglia activity¹⁴
5. Entrainment of selective brain oscillations
6. Potential for modulating focal synchrony/coherency

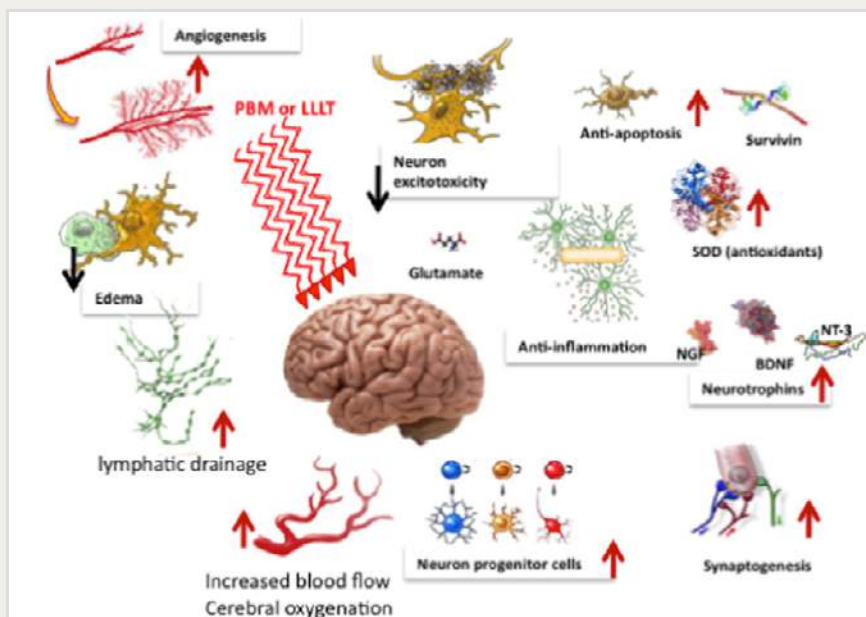


Fig. 2. Tissue specific processes that occur after PBM and benefit a range of brain disorders. BDNF, brain-derived neurotrophic factor; LLLT, low level light therapy; NGF, nerve growth factor; NT-3, neurotrophin 3; PBM, photobiomodulation; SOD, superoxide dismutase.⁸

Most of the literature have presented the potential of PBM with NIR light in the first four listed items above. Fig. 2 below identifies tissue processes and benefits.

For items 5 and 6 on the list, Vielight and its collaborators are finding that by invoking a specific pulse rate at 810 nm NIR wavelength, they can significantly influence brain oscillations. In a publication-pending study, gamma pulse rate at 40 Hz can consistently and significantly upregulate the higher oscillations of gamma, beta and alpha; and downregulate theta and delta. This is presented in Fig. 3 below. Specific locations can also be entrained to have more or reduced coherence.

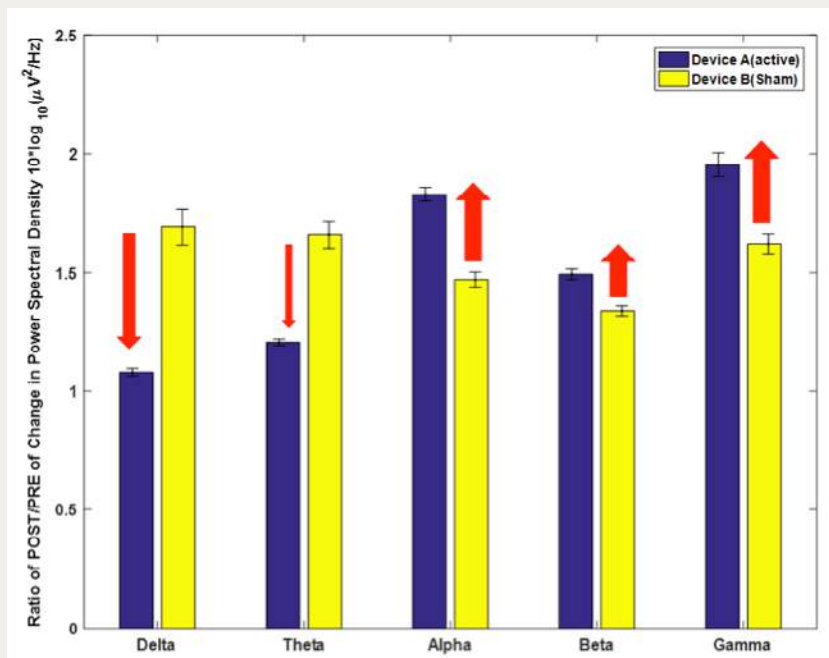


Fig. 3: Invoking 40 Hz with 810 nm wavelength upregulates gamma, beta and alpha brain waves, and downregulates theta and delta waves (the findings are pending publication)

As discussed, delivery of NIR can improve reaction time and improved performance. High frequency in the beta and gamma ranges have been associated with memory and mental performance¹⁵, although temporary. High level meditators also present persistent gamma with high power.¹⁶ It is therefore reasonable to assume that entrainment with gamma frequency pulses can modulate the brain for high performing mental states in mindfulness.

Conclusion and Expectation for the Future

The data supports the understanding that PBM can enhance brain function, whether the brain has suffered insults or healthy. However, there is much to be discovered. Because the brain seems to respond to PBM delivered in specific ways, it is possible that in the future we may be able to personalize treatments or even selectively alter mental states.

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