Inventor's Notes on Whole Brain Photobiomodulation with the Vielight Neuro – a Transcranial-Intranasal Light Therapy Combination

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Introduction

The Vielight Neuro is the first device in the world that comprehensively directs therapeutic light energy into the brain from a combination of transcranial (through the skull) and intranasal (via the nasal channels) locations. This document is the basis of my patent and sets out to explain the concepts behind the invention of the Vielight Neuro transcranial-intranasal combination light therapy device. I am now taking the next step of proving the concepts used in this device. **Until the concepts are proven by controlled clinical studies, I am not claiming that it will work as well as intended. Therefore, any statements of medical indications are merely to present to the reader the direction that I am taking.**

The problems I am attempting to address (and the issues they create)

Many critics of the pharmaceutical industry believe there are few effective medications for many chronic neurologic conditions. Some best-selling investigative authors are of the view that the available medications for psychiatry are either no better than placebos or could even be harmful.[1]

Hence many patients with neurological conditions seek alternative therapies due to the chronicity of their condition and the lack of full relief from conventional therapies.[2] These conditions may include traumatic brain injury (TBI), stroke, multiple sclerosis (MS), schizophrenia, autism, insomnia, post-traumatic stress disorder (PTSD), dementia and Alzheimer's disease (Alzheimer's), Parkinson's disease (Parkinson's) and numerous other neurological conditions and disorders.[3]

My attention is directed to Alzheimer's because it is one of the most devastating diseases.[4] Alzheimer's shares key denominators with many neurologic disorders through the Default Mode Network (DMN) of the brain. Therefore, success in treating Alzheimer's using the methodology discussed here suggests that it may be used for other neurologic disorders.

The Vielight Neuro is based on the fundamental concept of *photobiomodulation* (PBM), commonly known as *low level light therapy* (LLLT). Multiple potential outcomes with PBM have been demonstrated in numerous published science literature; for example neuronal rehabilitation is achieved when appropriate light energy is delivered to the neurons.[5]

The photobiomodulation pathway

In photobiomodulation (PBM), damaged neurons repair themselves in the presence of low intensity red and near infrared (NIR) light.[6] Non-invasive transcranial light therapy or transcranial PBM devices are developed to deliver the red and NIR light to the neurons in the brain.[7] [8]

For over a decade, transcranial PBM has produced positive effects in laboratory animals and human subjects. Animal studies included acute traumatic brain injury (TBI),[9] [10] [11] Alzheimer's,[12] depression[13] and stroke,[14] [15] [16] [17] [18] while human studies, included TBI,[19] depression[20] and stroke[21] [22]. Further, low level light energy has been found to be safe for humans in the stroke studies, without the side effects often associated with medications.

In 2010, a group of PBM researchers reviewed animal studies and human clinical trials of LLLT for indications such as stroke, traumatic brain injury, degenerative brain disease, spinal cord injury, and peripheral nerve regeneration. They concluded that, "The introduction of affordable LED devices powered by rechargeable batteries will lead to many home-use applications of LLLT. The concept of "wearable" light sources is not far off. Moreover, the particular benefits of LLLT to both the central and peripheral nervous systems suggest that much wider use of LLLT could or should be made in cases of both brain diseases and injuries."[5] It appears that Vielight could be on the path to fulfilling this prediction.

The advantages of transcranial PBM

There is sufficient data from studies on transcranial PBM for me to develop applications with this modality. Unlike the possible adverse side effects of prescription medication, LLLT has no reported adverse effects, or events that can be directly attributed to laser or light therapy. The high benefit to risk ratio of LLLT has been clearly demonstrated and should be better appreciated by medical professionals in the rehabilitation and physical medicine specialties.

The shortcomings of transcranial PBM

On the other hand, transcranial light therapy devices are not ready for daily use and are available mainly in research labs where they are expensive, require training, and are powered by the mains.

More importantly, it is unlikely that photons from traditional transcranial positions on the head can reach the important primal regions of the brain that are located on the underside of the brain. This is because these regions are located in areas of the brain that are closer to the nasal section versus the scalp. Amongst other functions, these primal regions govern memory, behaviour and emotions. Therefore, they determine the "person" in everyone. The nuclei in these ventral areas (including the hippocampus, entorhinal cortex and the ventral medial prefrontal cortex) form important subdivisions of the key network of the brain called the Default Mode Network (DMN). This will be discussed below.

Intranasal pathway - the missing jigsaw piece

Since light penetrates significantly deeper into the brain from an intranasal position (in the nose) than from transcranial (on the head) locations[6], it is logical that a light source located in the intranasal position is crucial if one is looking for a comprehensive PBM treatment of the brain.

On its own merit, researchers have already found that Intranasal Light Therapy has positive outcomes with neurologic conditions such as insomnia,[23] mild cognitive impairment,[24] Alzheimer's disease,[25] Parkinson's disease,[26 27 28 29] schizophrenia,[30] migraine and headaches,[31 32] and stroke (cerebral infarction)[33 34 35 36] in humans. For more details, please see http://www.mediclights.com/wp-content/uploads/2014/07/The-Potential-of-Intranasal-Light-Therapy-for-Brain-Stimulation.pdf.

Unlike the transcranial method, photons from the nasal cavity can be efficiently directed to brain tissue because the scalp and hair are not present there to be barriers. The abovementioned studies and case reports support this theory.

Employing the same argument, photons from an intranasal source are unlikely to reach areas distal from the nasal cavity, such as the dorsal cortical areas around the top of the head.

Therefore, outcomes can be enhanced if intranasal PBM is combined with transcranial PBM. This leads to the next question: "How can we incorporate transcranial LEDs with the intranasal LED to create an efficient and effective device?"

This leads us to consider only targeting selected areas of the brain, which are the hubs of the key networks, primarily the Default Mode Network (DMN) and secondarily, the Salience Network (SN). Treat these busy and extensively connected hubs and we would be treating the whole-brain.

Default Mode Network (DMN)

The DMN is of particular interest because it has been associated with Alzheimer's disease, autism, schizophrenia, depression, chronic pain and other neurologic diseases before 2010.[37] Since then disorders such as Parkinson's,[38 39] multiple sclerosis (MS)[40] and post-traumatic stress disorder (PTSD) have been added to the list.[41] Although the secrets of brain networks are being unveiled by the day along with better diagnoses, sadly there is still no breakthrough treatment.

Since the early discovery of the DMN, there have been many studies suggesting various nodes (or "hubs") where there are high levels of activity and connectivity. So, the health of the whole network is closely dependent on the health of the hubs. To simplify my quest for a set of hubs of the DMN to work with, I have chosen the hubs that are common denominators in published studies such as those done by Raichle[42] and Greicius[43]. Recently, Raichle further identified these regions as "subdivisions". These are the ventral medial prefrontal cortex, the dorsal medial prefrontal cortex, the posterior cingulate cortex, the precuneus, the lateral parietal cortex and the entorhinal cortex.[44] These are shown in Figure 1 below.

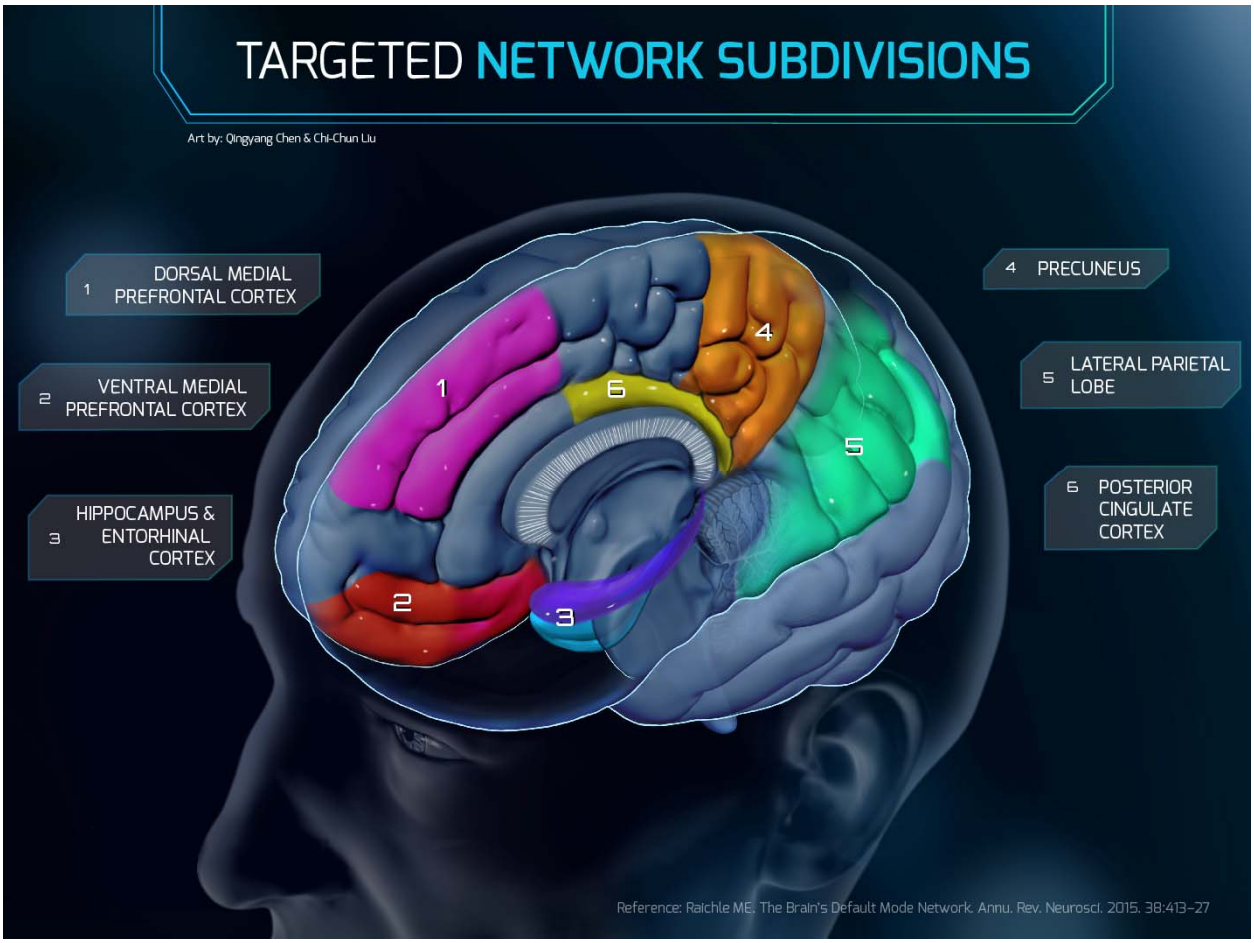

Figure 1: Default Mode Network targeted subdivisions

The narrowing of target areas to just a few subdivisions allows us to use fewer light sources to efficiently achieve virtual whole-brain stimulation. This set of targets forms the foundation for the locations of LED sources in our design of the Vielight Neuro as shown in Figure 2 below.

Figure 2: Locations of LEDs for whole-brain stimulation

With this knowledge, we now have a clearer path to purposeful product engineering. This configuration is more efficient and results in a comprehensive and portable neuro-PBM device which includes an intranasal source. We have even removed the need to be powered by the mains. Instead, rechargeable batteries similar to those used in cell phones are used to allow for portability.

The Salience Network and other networks of the brain

Neurodegenerative illnesses such as Alzheimer's and Parkinson's target the DMN, whereas behavioural variant disorders such as frontotemporal dementia (FTD) targets the more forward located (anterior) Salience Network (SN). While the DMN is identified with the whole brain, the SN emphasizes the anterior of the brain, which are anchored by the anterior insula and the anterior cingulate cortex.[45]

While it appears that the DMN and SN may be different from each other, they are connected to each other in many activities. The SN plays an important role in driving the switches between default mode

and central executive networks.[46] These networks are thought to be heavily involved in handling novel situations outside the domain of some of our 'automatic' psychological processes.[47]

As further insight, we need not be concerned with possible adverse responses when the photons are delivered to other networks. Instead, the outcomes may be positive. However, for particular disorders such as FTD, there could be further advantages from targeting the hubs of the SN as opposed to the DMN.

Photobiomodulation stimulating neurons and cells to heal

How can we be sure that photons delivered to these hubs or subdivisions do anything?

To answer this question, we have to consider PBM and the associated neurological disorders. Firstly, PBM stimulates cells (neurons included) in lesions to heal. Secondly, many neurologic disorders are identified with lesions in the hubs of the DMN. We shall examine each of these points.

Research in PBM has established that PBM accelerates wound healing[48] because the cells with mitochondria respond to light in the red and near infrared (NIR) spectrum.[49] The neurons in the brain are cells with mitochondria.

To demonstrate neuronal response, Erlicher et al showed that weak light attracts the leading edge of growth cones of a nerve cell. When a beam of light is positioned in front of a specific area of a nerve's leading edge, this would draw its growth towards the direction of the light, as well as enhance its overall growth. [50] This phenomenon would be repeated in later experiments. [51] In summary, nerve cells appear to "feed" on low energy light.

The next study provides further evidence of this phenomenon. Researchers found that cells repair themselves when they are exposed to low energy red light (Figure 3). The neurites of neurons that were shortened by oxidative stress would re-elongate. The data suggest that red light irradiation protects the viability of cells and stimulates neurite outgrowth in cases of oxidative stress.[52]

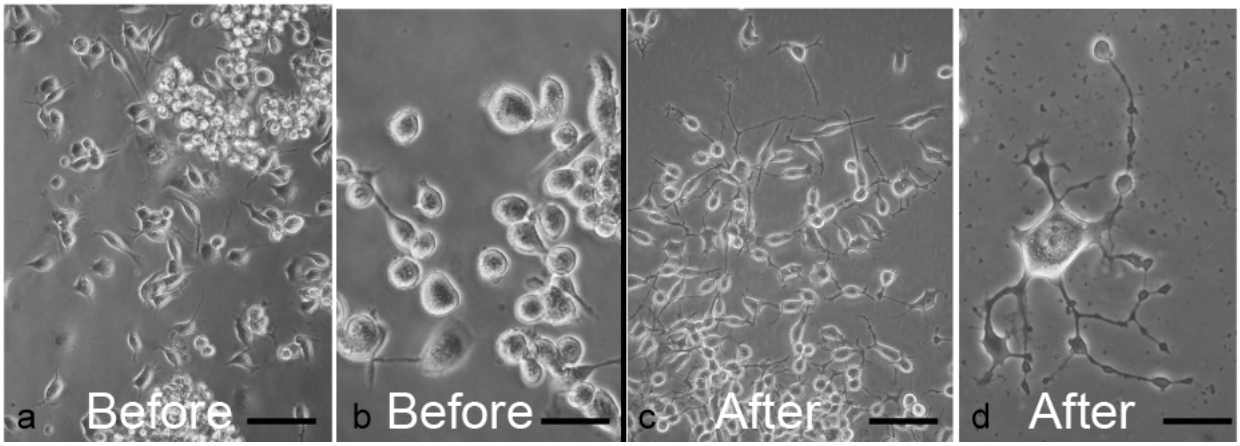

Figure 3: Neurite elongation experiment: in-vitro post-oxidative stress. [6]

With the above research, I believe that if we can deliver low level energy red and NIR light energy to neurons functioning at sub-optimal level, we can expect a healing response. Hence, a device that directs NIR light energy at targeted lesions could theoretically stimulate their healing.

Next, Let us examine what neurologic conditions and disorders are associated with hub lesions.

Neurologic disorders associated with hub lesions

Crossley et al proposed that brain disorders are manifested in lesions in the network hubs, and specifically identified nine brain disorders:[53] schizophrenia,[54] Alzheimer's disease,[55] frontotemporal dementia,[56] Parkinson's disease,[57] temporal lobe epilepsy,[58] Gilles de la Tourette syndrome,[59] acute brain injury (coma),[60] and migraine[61]. Following this data, I hypothesize that if we can treat these lesions, we can also treat these disorders.

Ischemia and oxidative stress are identified with these lesions. However, with the use of PBM, neurons recover from damage due to these stresses. Take the case of Alzheimer's-related lesions, transgenic mice with Alzheimer's recovered memory function and cognition function with transcranial PBM. Autopsy on the brains of these mice revealed a reduction of the lesions associated with the biomarkers, Aβ plaques and neurofibrillary tangles.[12]

We should be reminded that these studies could not direct photons specifically at each identified lesions due to the difficulty imposed by the small brain size of the lab mice. It would be accurate to consider this as whole brain irradiation. Likewise, we can expect to arrive at similar results if we carry out whole-brain PBM, at least for Alzheimer's, on humans. Other published animal studies that involve the use of whole-brain transcranial PBM are related to traumatic brain injury, Parkinson's and stroke. Using the same reasoning, we expect similar results with human brains with these conditions too. Directing NIR to the appropriate hubs would allow us to achieve that.

However, not all neurologic conditions can tolerate whole brain treatments. For example, strokes that have a hemisphere lesion, such as one caused by middle cerebral artery ischemia or hemorrhage, have to be approached differently. Dr. Margaret Naeser, the Research Professor of Neurology at Boston University, related her experience in a personal communication, that bilateral PBM can result in an adverse or negligible outcome but unilateral treatment on the same side of the lesion produces good outcomes.

Opportunity for portability

For a long time, I thought it would be difficult to build an effective and portable device with a transcranial system, so I focused on the intranasal light therapy devices that I co-invented earlier (with patents issued and pending). Although the intranasal devices target some of the most important nuclei located in the ventral (under) side of the brain, they are incomplete because the dorsal (or upper) areas have been ignored. With new understanding of the DMN, there is now an opportunity to create a portable and affordable transcranial system by targeting these locations.

Now we can consider the choice of the wavelength and other parameters for the light.

Determining the parameters

1. Wavelength

Light is an electromagnetic (EM) wave. A general principle about electromagnetic waves and penetration is that the longer the wavelength, the deeper the penetration. Radio waves are also EM waves, but at the longer end of the EM range. The penetration of radio waves is so deep that they are able to easily penetrate buildings, but shorter light waves are blocked by walls. Likewise, we would expect far infrared light with its longer waves, to penetrate more deeply than red or near infrared (NIR) light with their short wavelengths. However, for tissues such as central nervous system (CNS) tissues, other components such as blood and water play significant roles in determining the depth of penetration. Researchers in the field of PBM have determined that the ideal wavelengths for CNS tissues are around 810 nm.

Dr. Juanita Anders (who is also one of our science advisors) and her research collaborators investigated the wavelength dependence of light scatter and absorbance in intraparenchymal brain tissue using 660, 808, and 940nm wavelengths was investigated. Their research indicated that 808 nm wavelength light demonstrated superior CNS tissue penetration.[8] This is also reflected in an earlier study which showed that wavelengths of around 810 nm penetrated deepest into the tissues of the spinal cord (Figure 4).

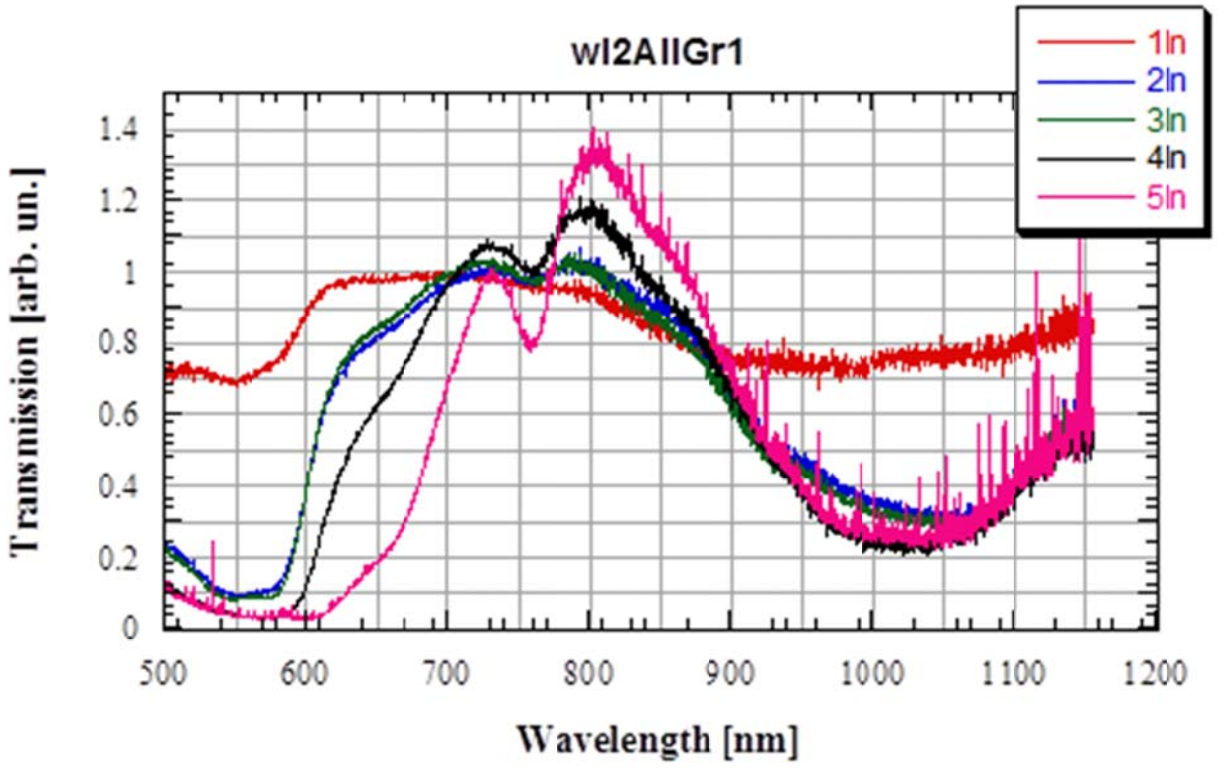

Figure 4: CNS Tissue Penetration[62]

When tested on live rats, photons between 630 nm and 800 nm have been shown to penetrate up to 28 mm of tissues with relatively low transparencies such as skin, connective tissue, muscle, bone, and spinal cord with 6% of the total energy density detectable in the subdermal layers.[62]

How far light can travel through tissue depends on both the wavelength and the optical properties of the target tissue. Abdo et al determined the maximum penetration of light in the gray and white matter of the brain to be the wavelengths in the NIR spectrum.[63]

A growing number of studies on CNS tissues and neurons using 808 nm or 810 nm have produced highly efficacious outcomes (Figure 5).[64]

One such study showed transcranial light therapy with a 808 nm laser diode attenuated amyloid plaque development in the transgenic mouse. This suggests possible efficacy of this therapeutic method using 810 nm for the all-important Alzheimer's disease in humans.[65]

Transcranial low-level light/laser therapy studies relevant to neuroprotection and cognitive enhancement.

Date	Reference	Relevance	Source	Parameters	Effects
2004	Lapchak et al. [22]	Embolic stroke	Laser	808 nm, 25 mW/cm^2, 15,000 J/cm^2, continuous	Improved motor function and reduction in effective clot dose for stroke 3 h after clot injection (rabbit)
2006	De Taboada et al. [23]	Atherothrombotic stroke	Laser	808 nm, 7.5 mW/cm^2, 0.9 J/cm^2, 2 min per point	Improved modified neurological score at 14, 21, and 28 after MCAO (rat)
2006	Oron et al. [24]	Atherothrombotic stroke	Laser	808 nm, 7.5 mW/cm^2, 0.9 J/cm^2, 2 min per point	Improved neurological scores 14 and 21 days after MCAO; increased subventricular zone cell proliferation and migration after (rat)
2007†	Lampl et al. [15]	Ischemic stroke	Laser	808 nm, 1 J/cm^2 per point	Improved clinical outcome at 90 days after ischemic stroke (human)
2007	Lapchak et al. [25]	Embolic stroke	Laser	808 nm, 25 mW/cm^2, 15,000 J/cm^2, pulsed at 1 kHz	Improved motor function, decreased effective clot dose for stroke 6 h after clot injection (rabbit)
2007	Oron et al. [26]	Traumatic brain injury	Laser	808 nm, 10 or 20 mW/cm^2, 1.2–2.4 J/cm^2, single point for 2 min	Improved motor behavior 5 days after closed-head injury, and decreased brain lesion size from 12.1% to 1.4% at 28 days after injury (mouse)
2008*	Michalikova et al. [27]	Mild cognitive impairment, Alzheimer's disease	Laser	1072 nm, 6 min × 10 days	Improved acquisition of working memory for spatial navigation in middle-aged mice (mouse)
2008	Lapchak et al. [28]	Embolic stroke	Laser	808 nm, 25 mW/cm^2, 15,000 J/cm^2, pulsed at 1 kHz	No worsening of hemorrhage incidence, volume or survival after treatment with tPA (rabbit)
2008	Ahmed et al. [29]	Epilepsy	Laser	808 nm and 830 nm, 5.5 W/cm^2, 3.1 W/cm^2 and 2.8 W/cm^2, 30 J/point, 11 J/point and 5 J/point	Decrease in cortical aspartate, glutamate and taurine and decreased hippocampal GABA (rat)
2009†	Zivin et al. [16]	Ischemic stroke		808 nm, 1 J/cm^2 per point	No improvement in mRS or NIHSS scores, no differences in mortality or adverse events at 90 days (human)
2009	Moreira et al. [30]	Traumatic brain injury	Laser	660 nm and 780 nm, 952 mW/cm^2, 3 J/cm^2 and 5 J/cm^2	Altered interleukin and tumor necrosis factor aplpha concentrations in brain and plasma at 1 day after cryogenic brain injury (rat)
2009*†	Schiffer et al. [11]	Depression, prefrontal functions	LED	810 nm, 250 mW/cm^2, 60 J/cm^2	Decreased depression scores, increased prefrontal blood flow (human)
2010	Lapchak et al. [31]	Embolic stroke	Laser	808 nm, 25 mW/cm^2, 15,000 J/cm^2, pulsed at 1 kHz	Increased cortical ATP (rabbit)
2010	Uozumi et al. [32]	Anoxic brain injury	Laser	808 nm, 1.6 W/cm^2, 4320 J/cm^2	Increased cerebral blood flow and decreased hippocampal and cortical neuronal death after BCCA0 (mouse)
2010*†	Naeser et al. [14]	Traumatic brain injury	LED	633 nm and 870 nm, 22.2 mW/cm^2, 13.3 J/cm^2	Improved cognition of 2 patients with chronic mild traumatic brain injury after 2–4 months of treatment (human)
2010	Shaw et al. [33]	Parkinson's disease	Laser	670 nm, 40 mW/cm^2, 2 J/cm^2 in four fractions	Reduction in substantia nigra dopaminergic cell loss after MPTP toxicity (mouse)
2011	Yip et al. [34]	Ischemic stroke	Laser	660 nm, 8.8 mW, 2.6 J/cm^2, 13.2 J/cm^2 and 26.4 J/cm^2, pulsed at 10 kHz	Increased expression of antiapopotic factors Akt, Bcl-2 and pBAD and decreased expression of pro-apoptotic factors caspase 3 and caspase 9 1 hr after ischemia and reperfusion induced by transient unilateral MCAO (rat)
2011*	Ando et al. [35]	Traumatic brain injury	Laser	810 nm, 50 mW/cm^2, 36 J/cm^2, continuous, pulsed, 10 Hz or 100 Hz	Improved neurological severity score and body weight; smaller lesion volumes, reduced helplessness at 4 weeks (mouse)
2011*	De Taboada et al. [20]	Alzheimer's disease	Laser	808 nm, 0.5 W/cm^2, 2.8 W/cm^2 and 5.6 W/cm^2; 675 J/cm^2, 336 J/cm^2 and 672 J/cm^2, continuous and pulsed, three fractions per week for 6 months	Decreased escape latency in Morris water maze memory task, decreased brain amyloid load and pro-inflammatory cytokines, Decreased CSF and plasma b-amyloid, increased brain ATP concentration and oxygen consumption (mouse)
2012	Quirk et al. [36]	Traumatic brain injury	LED	670 nm, 50 mW/cm^2, 15 J/cm^2, 3 or 10 daily fractions	Improved locomotor behavior, decreased pro-apoptotic and increased anti-apoptotic gene expression, increased GSH (rat)
2012	Wu et al. [37]	Traumatic brain injury	Laser	665 nm, 730 nm, 810 nm and 980 nm, 150 mW/cm^2, 36 J/cm^2, one fraction	Improved neurological severity score and accelerated neurological recovery with 665 nm and 810 nm, 4 weeks after treatment (mouse)
2012	Oron et al. [38]	Traumatic brain injury	Laser	808 nm, pulsed at 100 Hz, one fraction	Improved neurological severity score, increased survival, smaller brain infarct volumes, from 5–28 days after trauma (mouse)
2012	Khuman et al. [39]	Traumatic brain injury	Laser	800 nm, 500 mW/cm^2, 60 J/cm^2, one fraction	Improved spatial memory, decreased microglial activation two days after trauma (mouse)
2012*	Rojas et al. [4]	PTSD, specific phobia	LED	660 nm, 9 mW/cm^2, 5.4 J/cm^2, daily dosing after extinction for four days	Enhanced extinction of fear-conditioned memories, decreased renewal of conditioned-fear, increase prefrontal oxygen consumption and energy metabolism capacity (rat)
2013*†	Barrett and Gonzalez-Lima [13]	Prefrontal cognitive functions, depression	Laser	1064 nm, 250 mW/cm^2, 60 J/cm^2	Improved sustained attention/psychomotor vigilance, improved visual memory retrieval, improved affect (human)
2013	Xuan et al. [40]	Traumatic brain injury	Laser	810 nm, 25 mW/cm^2, 18 J/cm^2, 1, 3 or 14 doses	Improved neurological severity scores and wire grip and motion test scores, smaller brain lesions sizes, decreased degeneration, increased BrdU-positive cells at 14 days (mouse)
2013	Moro et al. [41]	Parkinson's disease	LED	670 nm, 5.5 mW/cm^2, 2 J/cm^2 in four fractions	Improved locomotor activity and preserved tyrosine hydroxylase-positive cells in the substantia nigra pars compacta (mouse)

Abbreviations: ATP = adenosine triphosphate, BCCAO = bilateral common carotid artery occlusion, GSH = reduced glutathione, LED = light-emitting diode, MCAO = medial cerebral artery occlusion, MPTP = 1-Methyl-4-phenyl-1,2,3,6-tetrahydropyridine, mRS = modified Rankin scale, NIHSS = Neurological Institute of Health Stroke Scale, tPA = tissue plasminogen activator, * = studies testing cognitive effects, † = studies with human subjects.

Figure 5: Transcranial light therapy studies [64]

2. Pulsed frequency

The efficacy differences between pulsed and continuous wave light are not entirely clear but the research is tilted in favor of pulsed waves.[66]

Generally, ultra-short pulses can penetrate deeper when pulses are intermittent but set at a higher power. Pulsing, as opposed to continuous exposure, prevent the undesirable thermal effect (building up of heat) when a relatively high power is used. In turn, high powered pulsed light would result in more cellular energy (ATP), as demonstrated in a study on rabbits.[67]

Another mechanism of action involves the pulsed photons promoting chromophores to excited states in the upper tissue layer. This opens the way for more photons to enter into the tissue during the next pulse. In contrast to continuous wave, superior results were obtained when lasers at 808 nm were pulsed at 100 Hz and 1000 Hz.[68]

In the lab of another one of our science advisors, Michael Hamblin, the least stress scores from traumatic brain injury were obtained with 810nm lasers pulsing at 10 Hz, rather than at 100 Hz. The authors also suggested that light therapy has an antidepressant activity.[69]

When the light is visible, I have avoided using it in the pulsing mode on humans because of the possibility of photosensitive epilepsy events. Instead, pulsed invisible near infrared light at 810 nm LED is used in the Neuro and the "810 Infrared" models. When these devices are placed in their positions such as the nasal cavity and head for treatment, the risk for photosensitive epilepsy is even lower.[70]

In addition, pulsed mode comes with a "duty-cycle", which is the on-off relative interval. I have chosen a 50% duty-cycle for our NIR devices because it closely resembles the even square waves of brain oscillation. My hypothesis is that this facilitates entraining the brain into the alpha wave (between 8 to 10 Hz). Although there are no clinical data, the alpha state is suggested to have antidepressant quality as well as a booster of the immune system. In summary, the main reason for adopting 10 Hz pulsed mode remains the significantly low stress scores when animals' injured brains were exposed to 810 nm light energy pulsing at 10 Hz.[69]

3. Energy dose

PBM response is generally thought to be dependent on the energy delivered to the cells or in our case, the neurons. The dose of energy (Joules/cm^2), sometimes called energy density, is a function of the power (in W) and time (sec). Too little energy produces no effect but too much energy may be inhibitory or cause adverse effects. There is no consensus on the exact amount of power to be used but researchers have chosen to use either 4 J/cm^2 [71] or 3J/cm^2 in animal studies.[72]

When we deliver light energy to the neurons, the light energy has to penetrate various layers of tissues. As an illustration, light has to penetrate the hair and scalp in the transcranial areas while light only has to penetrate soft tissues inside the nose. Since photons dissipate as soon as they hit the tissues the

actual dose delivered to the targeted areas is unknown. For the Neuro, I opted for a relatively high power of 25 J/cm^2 to land on the targeted areas of the brain because most of it will be dissipated before landing in the targeted deeper lying areas of the brain. Our field tests showed no side effect on humans. Since the outcomes have been positive, we can assume that some of the energy has reached the intended targets. For the nasal diode where the barriers are less, I have halved the dose to 14 J/cm^2, and we have observed positive outcome from this as well.

The treatment time is 20 minutes. Shorter treatment times require higher power but may create the undesirable thermal effect. Many healers believe the body requires 20 to 30 minutes to produce a healing response.[73]

Summary of parameters

In summary, the preferred set of parameters consists of an 810 nm LED light source, pulsing at 10 Hz with 50% duty cycle for 20 minutes.

These parameters are the specifications for the Vielight Neuro.

Opportunities for expanding the efficacy of the Neuro

The Neuro has been designed to treat the brain. Available data show us that the 810 nm wavelength travels deeper into brain tissues by mainly bypassing blood and water.[74] Therefore when positioned in the nasal cavity, a large portion of the NIR light should theoretically reach the brain directly.

Compared to the Neuro's near infrared light of 810 nm, photons from the shorter wavelength visible red such as 633 nm (from the "Vielight 633 Red" light emitting diode (LED) model) and 655 nm (from the "Vielight 655 Prime" low level laser model) do not have the same penetrative ability of the 810 nm wavelength. Also, these wavelengths are not absorbed by blood (haemoglobin) and water (Figure 6 and 7).

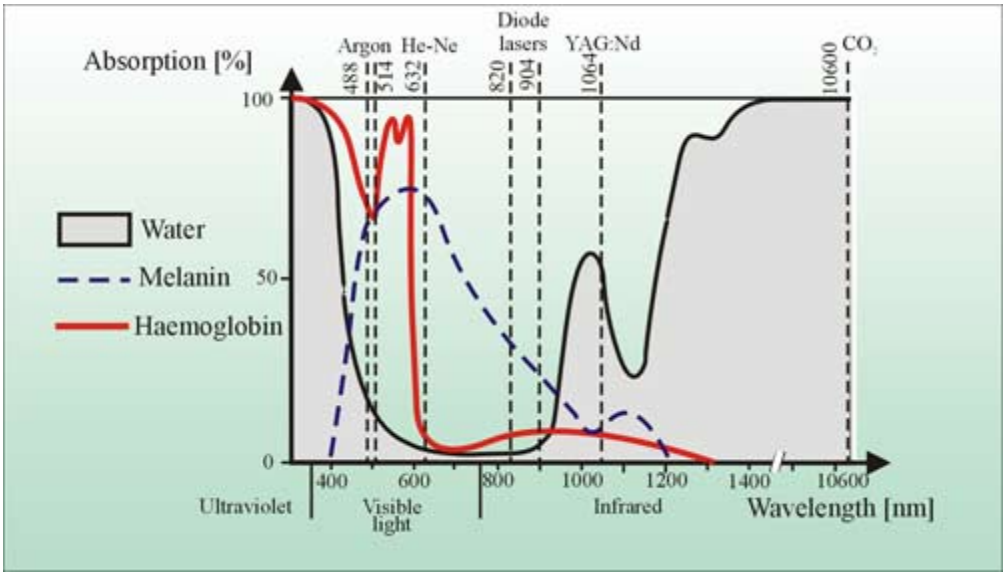

Figure 6: Absorption percentages for different laser wavelengths[75]

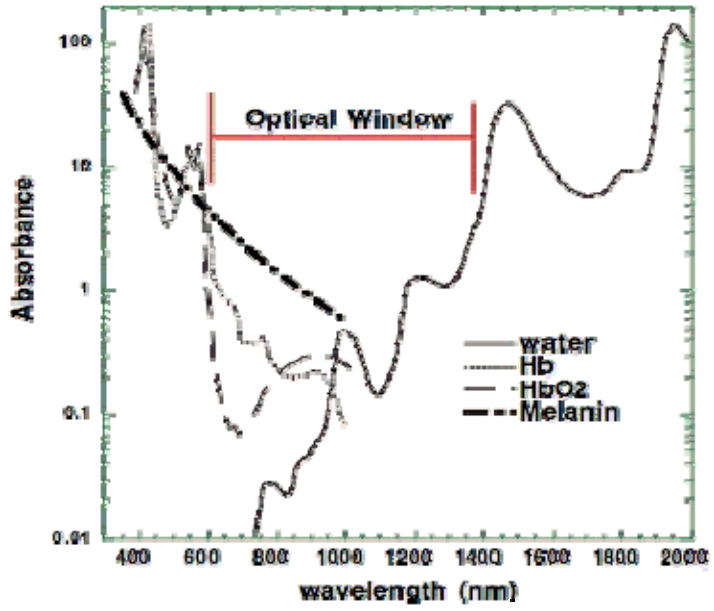

Figure 7: Optical window in tissue due to reduced absorption of red and NIR wavelengths (600-1200 nm) by tissue chromophores. [76]

Clinical studies show that visible red wavelengths are absorbed into the body's systems and utilized efficaciously. One of our science advisors, Dr. Timon Liu, observed many of these outcomes of intranasal light therapy on vascular diseases such as blood properties that affect hypertension and cholesterol

levels.[77] The systems have been modulated into a negative feedback loop that restores the homeostasis states of its functions.[78] This suggests that although the visible red photons are not penetrating past blood and water, they are distributed throughout the body in some way and modulating its systems. Some of these results are expressed as measurable improvements in the factors that affect the hypertension and blood fats profile (including cholesterol levels).[77]

There is no available instrument to help confirm the biophysics of how the light particles are distributed throughout the body. Eastern Europe and some parts of Asia have offered intravenous blood irradiation therapy – by injecting low energy red light directly into the vein. The outcomes have been outstanding in many cases in a systemic manner.[79] [80] Later, our team as well as other researchers found that by increasing the power of an intranasal equivalent, the outcomes are very similar to the intravenous method. As a result, the highly convenient intranasal method has largely replaced the invasive intravenous method.[81] [82]

Thus, low energy intranasal red light devices such as the "Vielight 633 Red" and "655 Prime" complements the Neuro and 810 Infrared models by addressing the body systems, while the latter systems address brain conditions.

The added value of the Vielight Neuro

Although we are obtaining outstanding results with the intranasal 810 for a variety of neurologic disorder, some users report no significant improvement. This leads me to hypothesize that photons need to be directed to key cortical areas not reachable from an intranasal source. This is where the transcranial diodes of the Neuro come in, as they can be placed on strategic locations, like the DMN.

Besides the need to reach hard-to-access locations in the brain, there is a need for more light to penetrate deeper into brain tissue into areas like the posterior cingulate cortex (important for Alzheimer's and a key hub in the DMN), the precuneus (a hub of the DMN) and to the substantia nigra (important for Parkinson's) and the brainstem. With our powerful transcranial diode using 810 nm LED diode, we are able to extract a consistent 41 mW of power at this time while the closest has been about 30 mW. This means that the Neuro delivers about twice the power of the 810 infrared intranasal model. This calculated higher power delivers deeper penetration into the without causing tissue damage.[83]

Our field test in this area appears to confirm this. Feedback received from the field indicates that it has been particularly helpful with brain fogginess, impaired cognition and chronic facial pain. As these are anecdotal experiences, the next stage is to carry out controlled studies for validation. In this respect, we have started a pilot study on Alzheimer's disease and dementia at the time of writing.

In summary, we are aiming to achieve, quicker and more consistent neurologic outcomes with the Neuro by directing therapeutic light energy with more energy and deeper penetrating ability to the hubs of the DMN.

Proposed protocol

Based on the theory of biphasic dose response, which basically says that low energy dose heals but high energy dose damages,[84] people who are very sensitive to electromagnetic energy or people with brain infections may experience a headache while using the Neuro. Based on this, I generally recommend that the Neuro be used for 20 minutes per treatment but not more than once every two or three days. The milder 810 Infrared intranasal device can be used daily to complement the Neuro.

Another point to consider is how do we maximise the benefits from the use of the Neuro or the 810 Infrared? Since the DMN is activated when we are not performing any task, and usually when our eyes are closed, we want to apply the Neuro or the 810 Infrared intranasal device s with our eyes closed.[85]

While using the Neuro, the circulatory and immune system can be treated using the Vielight 633 Red or the 655 Prime intranasal devices.

Conclusion

The above discussion suggests that there are solid scientific bases for us to use to design the Vielight Neuro to produce good neurological outcomes without major side effects. I have paid close attention to the parameters and locations of the diodes as the key factors to make the Neuro effective while making it portable and affordable. Further to this, anecdotal feedback and relevant published data have been good.

Unless we have strong direct clinical evidence, the medical community will be skeptical. I recognize this and have just now started on clinical studies to obtain the requisite evidence, the first of which is a pilot study on dementia and Alzheimer's. Until then, let us recognize the Neuro for what it is - a general wellness device that may improve the user's mental acuity that is safe for home-use. It complements the other Vielight general wellness devices that have been designed with somewhat different design objectives. Collectively, they offer a comprehensive and holistic approach to general wellness.

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