

White Paper

Bilateral Cervical Photobiomodulation for Vagus Nerve Stimulation Using the Vielight Vagus Device

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Introduction

The vagus nerve plays a central role in autonomic regulation, inflammation control, mood modulation, and overall homeostasis. Vagus nerve stimulation (VNS) has emerged as a promising approach for enhancing autonomic balance, reducing systemic inflammation, improving mental health, and supporting neuroplasticity. It is gaining recognition for its therapeutic potential in a wide array of clinical conditions, including depression, epilepsy, anxiety, PTSD, and chronic inflammation, as well as for enhancing general well-being and cognitive performance [Yap et al., 2020; Johnson & Wilson, 2018].

Historically, VNS required surgical implantation of electrodes or, more recently, the use of electrical transcutaneous approaches—both of which present challenges in terms of safety, tolerability, and user convenience. The Vielight Vagus introduces an innovative, non-invasive potential alternative by leveraging photobiomodulation (PBM) to target the cervical branches of the vagus nerve bilaterally, using pulsed near-infrared light. Its efficacy is subject to controlled clinical studies that are being planned.

Disclaimer

The Vielight Vagus is marketed as a low-risk general wellness device and does not make medical claims. The medical and scientific content presented in this white paper is intended to provide the biological and mechanistic rationale for its design. Clinical efficacy claims will be made only upon completion of rigorous studies and appropriate regulatory clearances.



Device Overview

The Vielight Vagus is a non-invasive PBM device that delivers:

- **Target:** Bilateral cervical branches of the vagus nerve, beneath the sternocleidomastoid (SCM) muscles
- **Delivery:** Hands-free headset form factor, consistent anatomical placement
- **Website:** <https://www.vielight.com/devices/vagus/>
- **Patent status:** <https://www.vielight.com/wp-content/uploads/2023/12/Vielight-Vagus-Patent.pdf>

Early Experimental Outcomes

We conducted early experiments with PBM at 810 nm at 50 mW/cm², delivering different pulse frequencies and achieved a significant increase in vagal tone at 100 Hz, but not at the 20–30 Hz range commonly used in electrical stimulation. These results support outcomes observed in electrical VNS studies (Sclocco et al., 2020; Yokota et al., 2022).



Comparison with Electrical VNS Technologies

1. Advantages Over Auricular VNS (aVNS)

- aVNS targets the auricular branch of the vagus nerve, which arises from the superior jugular ganglion and represents a minor projection of the vagal network [Badran et al., 2019]. While it connects to central vagal circuits, it provides an indirect route of stimulation [Kaniusas et al., 2019].
- In contrast, the cervical vagus nerve contains the main afferent fibers projecting directly to the nucleus tractus solitarius (NTS), suggesting a more robust and comprehensive pathway for vagal engagement [Ali et al., 2024].
- aVNS devices may also be less convenient due to ear clip placement and often cause some irritation [Kim et al., 2022].

- The Vielight Vagus provides a comfortable, non-sensory, hands-free user experience and does not interfere with sensory perception or mobility.

2. Advantages Over Non-invasive Cervical Electrical VNS Devices

Electrical cervical VNS requires current to pass through the skin, often producing noticeable sensations such as muscle twitching and discomfort.

- Conductive gels are typically required for proper electrical coupling, adding inconvenience.
- The Vielight Vagus uses PBM to stimulate the vagus nerve indirectly, with no sensory perception, no need for gel, and no risk of electrical overstimulation.
- PBM is not associated with neural fatigue and is suitable for repeated use without discomfort or adaptation.

Scientific Rationale and Mechanisms of Action

The Vielight Vagus is novel, and available literature does not yet fully explain its mechanisms. The discussion below presents hypothetical rationales that require validation.

Foundational Mechanisms

Initial tests suggest that PBM produces responses associated with VNS. PBM has been shown to stimulate afferent fibers via photochemical pathways involving mitochondrial activation (through cytochrome c oxidase), intracellular calcium signaling, and modulation of reactive oxygen species (ROS), resulting in similar outcomes to VNS [Hamblin, 2016; Karu, 1999].

PBM Has Different Mechanisms from Electrical Stimulation

Unlike electrical stimulation, which causes direct depolarization, PBM achieves comparable outcomes by photoactivation of ion channels and metabolic enhancement [Zhang et al., 2024; Yan et al., 2025]. This makes PBM a complementary neuromodulation strategy with distinct advantages in safety and non-invasiveness [Farazi et al., 2024].

Potentially Similar Pathways with Electrical Stimulation

1. Activation of the Nucleus Tractus Solitarius (NTS)

The NTS is the primary brainstem hub for afferent vagal signaling. fMRI studies (Yakunina et al., 2020) have demonstrated robust NTS activation with cervical VNS. Sclocco et al. (2019) further showed that vagal stimulation modulates multiple brainstem structures including the NTS, dorsal motor nucleus of the vagus (DMNV), and periaqueductal gray (PAG). The PAG plays a crucial role in descending pain and stress modulation [Benarroch, 2012].

2. Modulation of Heart Rate Variability (HRV)

Bretherton et al. (2022) confirmed that non-invasive VNS increases parasympathetic HRV markers such as RMSSD and high-frequency (HF) power. PBM may produce similar effects by enhancing vagal tone through mitochondrial and anti-inflammatory mechanisms. A meta-analysis also linked increased HRV with mental health resilience [Shaffer & Ginsberg, 2017].



Other Advantages of the Vielight Vagus

1. Advantages of Bilateral Stimulation

Traditional VNS targets the left vagus nerve due to concerns over the right vagus's influence on the sinoatrial node [Kreuzer et al., 2012]. PBM has not been shown to depolarize nerves directly and poses no known cardiac risk, permitting bilateral application. This may enhance afferent signaling and autonomic balance.

2. Relevance of 100 Hz Pulsing

Gamma frequencies (30–100 Hz) have been associated with cognitive processing [Herrmann et al., 2010]. Yokota et al. (2022) found that 100 Hz tVNS elicited stronger parasympathetic responses than lower frequencies. While PBM does not induce direct firing, 100 Hz pulsed light may entrain or harmonize with neural oscillations or modulate firing thresholds. Early tests of PBM-VNS show superior results at 100 Hz compared to the conventional 20–30 Hz range used in electrical stimulation.

3. Tissue Penetration and Irradiance

The cervical vagus nerve lies 1.5–2.5 cm beneath the skin [Polak et al., 2014]. Near-infrared light at 810 or 1064 nm effectively penetrates to this depth [Tedford et al., 2015]. The Vielight Vagus delivers energy densities shown in PBM literature to stimulate mitochondrial activity without thermal effects [Hamblin, 2016]. The irradiance level of 50 mW/cm² is based on internal investigational data.

Other Helpful PBM Mechanisms of Action

- Mitochondrial upregulation via cytochrome c oxidase [Hamblin, 2016]
- Increased ATP and nitric oxide release [Karu, 1999; Hamblin, 2016]
- Modulation of calcium channels and ion transport [Zhang et al., 2014]
- Systemic anti-inflammatory effects [Shamloo et al., 2023]

VNS Applications for Consideration in Future Investigation

Parallel investigations with PBM-VNS could explore outcomes seen in the VNS literature:

- Enhancement of HRV and autonomic regulation [Bretherton et al., 2022]
- Support for stress and anxiety management [Clancy et al., 2014]
- Chronic fatigue syndrome [Rodriguez et al., 2023]
- Adjunctive therapy for inflammatory conditions [Tracey, 2002]
- Post-TBI autonomic dysfunction correction [Shi et al., 2013]
- Parkinson’s disease and movement disorders [Evancho et al., 2024]
- PTSD [Bremner et al., 2020]
- Depression [Rush et al., 2005]
- Migraine and cluster headaches [Silberstein et al., 2016]
- Irritable bowel syndrome (IBS) [Bonaz et al., 2019]
- Long COVID symptoms [Zheng et al., 2024]

Conclusion

The Vielight Vagus represents a next-generation, non-invasive VNS modality that combines the safety and bioenergetic advantages of PBM with the benefits of cervical vagus nerve stimulation. Compared to auricular and electrical cervical methods, it offers a comfortable, gel-free, and sensation-free experience with promising potential for autonomic and systemic benefits. Its bilateral 100 Hz pulsed approach—grounded in emerging science—provides an innovative path for HRV modulation and neurophysiological enhancement. The device’s usability supports its integration into home-based clinical research. VNS applications will be featured in Vielight’s future investigations.

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