



NeuroSpectral Regulation for Migraine

## **WHITE PAPER**

# **Illuminating the Role of Neural Light Sensitivity in Headaches and Migraines**

<https://nsrmigrainerelief.com>

*“The light sensitivity triggering headaches and migraines isn’t always based in the eye. We need greater awareness about the effects from light sensitivity that originate in the brain.”*

Dr. Adam Anderson, Cornell University

# Preface

Headaches and migraines are debilitating neurological conditions that affect many millions of people worldwide.<sup>1</sup> Beyond their associated acute pain, they can have far reaching chronic impacts on individuals' physical, cognitive, emotional, and social well-being, as well as significantly impair an individual's quality of life.<sup>2</sup> Additionally, the financial burden of medical expenses and lost wages associated with headaches cause substantial stress, frustration, and feelings of hopelessness when no relief can be found.<sup>3</sup>

An underappreciated aspect of these conditions is the association between light sensitivity, known clinically as photophobia, and the occurrence, duration, and severity of headaches. In this white paper, we explore the connection between headaches, migraines, and photophobia, delve into potential mechanisms, discuss management strategies, and shed light on the often overlooked role of the brain as one potential source of light sensitivity.

In defining two different forms of light sensitivity, retinal and neural, we discuss their distinct treatment approaches, including a special focus on the pain modulating capacity of specific wavelengths of light for neurally-based photophobia. By understanding the relationship between different forms of light sensitivity and headaches and migraines, we are advancing in our ability to diagnose, manage, and alleviate the burden of these debilitating disorders.

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# 1. Introduction

Photophobia is characterized by an abnormal sensitivity to light. While it is most associated with migraines, other health issues can also lead to photophobia. These include cluster and tension headaches, dry eyes, ocular irritation, blepharospasm (involuntary eyelid spasms), traumatic brain injuries, and central nervous system disorders.<sup>4</sup> People with photophobia often find bright lights, changes in lighting conditions, and flickering lights particularly bothersome.<sup>5</sup>

Light sensitivity itself can significantly impact an individual's quality of life, often making daily life challenging, whether that is going outdoors or looking at a computer screen. Abnormal light sensitivity can exacerbate discomfort and pain in individuals experiencing headaches and migraines. More than a symptom during a headache or migraine, for some, light is a persistent source of difficulty that can trigger future episodes and contribute to chronic disability. Understanding the role of light sensitivity in headaches and migraines is crucial for effective diagnosis and management.

Mike



Mike was referred from the Intrepid Spirit Center on Camp Pendleton after experiencing his military connected traumatic brain injury. *"Before coming here, [I was having] migraines, crushing headaches, blurred vision from a distance, blurred vision up close, just unbearable symptoms."* As a Marine, he had to spend a lot of his time outdoors where the light was painful and exacerbated his headaches and other symptoms. Mike has now been able to get back to enjoying his life. ***"I'm not having headaches regularly anymore."***



Becky

Becky, a 41-year-old stay-at-home mom of four children, remembers always suffering from bright lights and nausea. She struggled in school, particularly with reading and comprehension, and started getting severe migraines after a concussion at the age of 14, *"I saw every doctor you could imagine, and they could never figure out what was going on. I was on every medication, infusions, emergency injections, preventatives, and nothing touched these migraines."* Becky was in and out of hospitals, was diagnosed with complex migraines, lived a life where her blinds were drawn all the time, because light bothered her so much. This all changed after she got NeuroSpectral filters, ***"It's been two years since I've had a migraine, and now I work part-time, and I volunteer at my kids' schools which I've never been able to do before. I got these filters and my whole life has changed, has changed for the better, and I can function and I feel human again."***

## 2. Prevalence of Light Sensitivity in Headaches and Migraines

Light sensitivity is a common symptom reported by individuals suffering from headaches and migraines, whether these headaches and migraines are a lifelong occurrence or secondary to brain injury or concussion. While light sensitivity is common to tension-type and cluster headaches, it is a central diagnostic feature of migraines, with upwards of 90% of individuals experiencing photophobia during migraine attacks.<sup>5</sup> Between attacks, people with migraines are generally more light-sensitive than others during non-attack periods.<sup>6</sup> Visual stimuli such as flickering lights, repetitive patterns, glare, bright lights, and computer screens can worsen photophobia. While dark sunglasses can reduce the experience of glare or sensitivity, they often are not a cure or an effective prevention for headaches and migraines.

## 3. Mechanisms of Underlying Light Sensitivity

The exact mechanisms underlying light sensitivity in headaches and migraines are not fully understood. However, several mechanisms have been suggested, including retinal sensitivity to light, dysfunction of the trigeminal nerve pathway,<sup>7</sup> and abnormalities in neurotransmitter levels (e.g., serotonin) and cortical processing of light.<sup>8</sup> These mechanisms may interact with genetic, environmental, and individual factors while some are acquired following traumatic brain injury or under challenging and stressful experiences.

### Hannah



Hannah sustained a brain injury when she was 14 years old. From that point on, she struggled with visual processing, *“everything in my environment is moving all the time so I’m always dizzy, and lights hurt.”* Her symptoms made school difficult and even interfered with her ability to keep a job. Feeling constantly overstimulated, Hannah would be overcome with emotion and constantly burst into tears. ***“I got these glasses, and now...I get out of bed easier. I have more energy. When I put on my glasses, I feel calmer and more relaxed, and it’s easier to just exist.”***

## Two Categories of Light Sensitivity

We consider below two broad categories of light triggered headache and migraine, one largely originating from the peripheral nervous system (the retina of the eye) and the other from the central nervous system (the brain). Each of these two systems has the ability to independently impact headache and migraine symptomology.

### Retinal

Special retinal photoreceptors, the intrinsically photosensitive retinal ganglion cells (ipRGCs), are an evolutionarily old part of the eye that detects light to regulate a variety of rhythms, from sleep-wakefulness to core body temperature. They are consistently tuned to a narrow band of the visual spectrum corresponding to blue-green colors. These ipRGCs are not related to the conscious experience of "sight". Even in individuals who are blind, light sensitive ipRGCs can be a source of headaches and migraines.<sup>9</sup>

### Neural

Another source of light sensitivity is more specific to the brain and is related to over excitation of the visual cortex to light. This neural sensitivity can be innate or acquired, and is highly variable across individuals in the portion of the visual spectrum that causes light sensitivity.<sup>10</sup> Neural light sensitivity is related to the conscious experience of light. It results from variation in the visual brain's sensitivity to light wavelengths and is also more likely to be the origin for acquired light sensitivity, especially after brain injury.



Whether light sensitivity originates in the retina or the brain, it is not the perception of a specific color, e.g., green, blue or red, which is the source of photophobia. It is the sensitivity to specific wavelengths of electromagnetic radiation, i.e., light. Light sensitivity to both the sun and artificial light exists even though the light is perceived as "white" or colorless, because these light sources contain all the visible wavelengths, including the specific wavelengths that are the source of irritation for the retina and brain.

## 4. Impact of Light Sensitivity on Headache and Migraine Symptoms

**Light sensitivity can significantly increase headache and migraine symptoms, leading to increased pain, discomfort, and functional impairment.**

Exposure to bright or flickering lights during a migraine attack can intensify head pain, worsen nausea and vomiting, and prolong the duration of symptoms. It is important to note that photophobia may contribute to and increase the likelihood of headache and migraine recurrence.<sup>11</sup>



At the end of her senior year in college, Nicole experienced a severe concussion after falling out of a moving car and striking the back of her head on the concrete. For years she struggled with severe light sensitivity, visual disturbances, headaches and ocular migraines. *“I just knew I had some type of vision problem. I went to the optometrist twice and he said my eyes were fine, but I just knew something was off. I avoided reading, avoided looking at the sky, lights, anything bright.”* Simple daily activities, such as working on the computer, reading, and going outside in the sun would trigger her visual disturbances and migraines. ***“Now, with my glasses, I can read. The words on the page don’t move, the white on the pages don’t jump, I can be outside, and I haven’t had an ocular migraine since I got them.”***



Light sensitivity



Reading problems



Attention and  
concentration problems



Strain and fatigue



Headaches and  
migraines



Print or  
environmental  
distortions



Problems with  
depth perception



## Symptom or Trigger?

For some, light sensitivity is a symptom of migraines, exacerbating headache pain. Others experience photophobia just before, during, or after a migraine attack, needing to seek refuge in a dimly lit room. It is lesser known that light sensitivity can also be a trigger for headaches and migraines. Even healthy sunlight can be a source of daily stress for the brain, contributing to future migraine episodes and increasing their recurrence.

### Circadian Rhythm Disruption

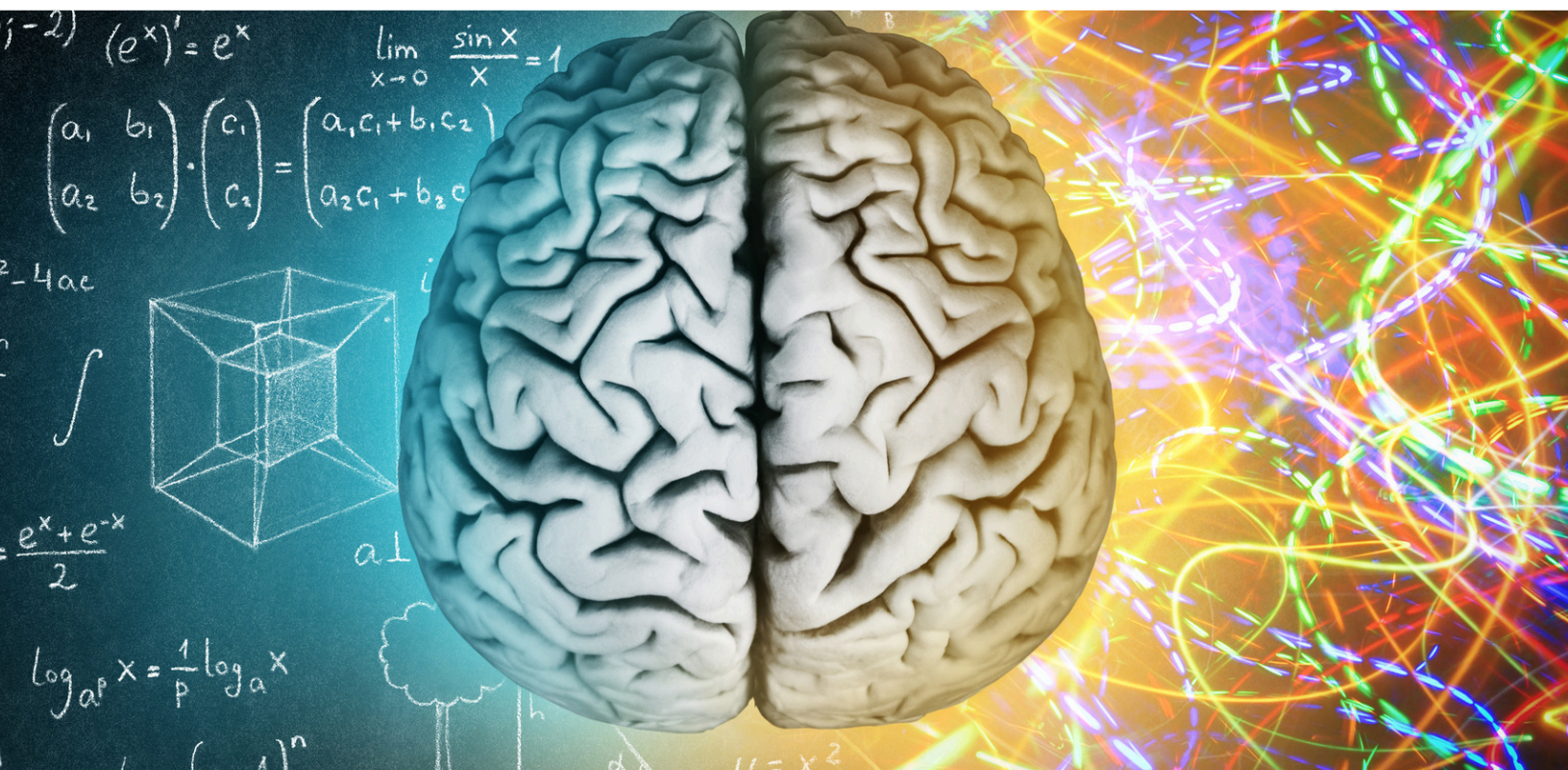
Migraine attacks are often associated with disruptions in the circadian rhythm, which ipRGCs help regulate. Irregular sleep patterns, jet lag, and shift work, which can disrupt the circadian rhythm, are known triggers for migraines in some individuals.<sup>12</sup>

### Neurotransmitter Release

ipRGCs project to various brain regions involved in pain processing and modulation, such as the hypothalamus and the trigeminal nucleus. Activation of ipRGCs can lead to the release of neurotransmitters, such as glutamate and pituitary adenylate cyclase-activating polypeptide (PACAP), which may contribute to the development of migraines.<sup>8</sup>

### Thalamocortical Dysrhythmia

Some research suggests that migraine pathology involves dysregulation of thalamocortical networks, leading to abnormal sensory processing, due to altered connections between the visual thalamus and the cortex.<sup>13</sup>



## 5. Diagnosis and Assessment of Light Sensitivity

Diagnosis of light sensitivity in headaches and migraines typically relies on patient-reported symptoms and clinical evaluation. Professionals may assess the severity and impact of photophobia using standardized questionnaires, such as the Light Sensitivity Questionnaire (LSQ) or the Photophobia Assessment Questionnaire (PAQ). Additionally, ophthalmological or neurological examination, such as assessing abnormally pronounced pupillary responses to light or altered visual evoked potentials, can provide direct physiological cues of light sensitivity and overactivity in the visual cortex. **While questionnaires are informative, they consider photophobia largely as one condition. The diagnosis of different forms of photophobia is achieved through sensory and perceptual testing of its wavelength specificity.**

### Retinal

ipRGCs are selective to a narrow range of light wavelengths. They are particularly sensitive to short-wavelength light, most strongly in the range of around 460 to 480 nanometers. This range corresponds to the blue part of the visible light spectrum. ipRGCs can also respond to light outside this range, albeit with less sensitivity. As such, demonstrating symptoms to this color range of light is an important diagnostic indicator. While causing discomfort, this light should not create much visual disturbance as ipRGCs are not related to the experience of sight.

### Neural

Photophobia can also originate from neural-visual processing of light. This thalamocortical dysregulation is often associated with other visual processing deficits and a hyper-reactive visual cortex. The range of wavelengths triggering this type of visual processing problem is triggered by a selective range of wavelengths, unique to everyone. As such, irritating wavelengths are highly dependent on the individual's brain, and not the narrow spectrum of the ipRGCs. Related to the cause of physical discomfort, these wavelengths can create disturbances for which the brain must adjust, making visual processing challenging under various lighting conditions.

**In-person testing is critical for diagnosing the different forms of photophobia. It allows an examination of the wavelength specificity that 1) creates subjective relief, and 2) provides objective changes in both perception and physiological measures, including autonomic and central nervous system activity—which can be assessed in a certified clinician's office.**



## 6. Management and Treatment Strategies

### Acute Management

During an episode, treating light sensitivity in headaches and migraines involves a multifaceted approach aimed at reducing symptom severity and improving comfort. This may include lifestyle modifications to minimize exposure to triggering stimuli, such as wearing sunglasses, using tinted screens, and creating a dark and quiet environment during migraine attacks. Pharmacological interventions, such as nonsteroidal anti-inflammatory drugs (NSAIDs), triptans, and calcitonin gene-related peptide (CGRP) inhibitors, may also help alleviate photophobia and other migraine symptoms. Additionally, behavioral therapies, relaxation techniques, and biofeedback training may be beneficial in quieting the symptoms evoked by sensitivity to light and enhancing coping mechanisms.

### Prevention

Between episodes, addressing light sensitivity in headaches and migraines requires a different strategy. It is impractical to avoid light altogether, as the visual system needs light for normal everyday function. Deprivation of sufficient daylight disrupts healthy physiology and mood causes chronic stress.

### Sunglasses

Wearing sunglasses with polarized lenses outdoors reduces light exposure but is not preventative. Exceptionally dark lenses keep the brain in perpetual night. It also does not address the underlying problem—the need to selectively filter only the wavelengths of light that are irritating to the retina or the brain.

### Connor



Connor was an Engineering student at the University of Southern California and has had severe chronic migraines all his life. *"I have struggled with light sensitivity. I get intense head pain most days, and then sometimes, it'll get up to the point where I can't go outside or walk or move for days."* On a typical day he would go to his morning class, but by noon he was feeling so bad that he would have to go home and go to bed. He wouldn't be able to leave his bed until it would get dark. ***"But with these [glasses] my resting pain level is down nearly to zero. These glasses have single handedly removed 90% of the pain that I was in. It has been a life-changing thing for me, so I'm incredibly grateful."***

## Blue Light Filters

To address retinal sources of photophobia, the use of blue light filters on electronic devices to minimize strain or “blue blocker” (FL-41) lenses and specialized variants (TheraSpecs, Avalux, etc), target the ipRGC activating wavelengths and their derivatives. Unlike sunglasses, such blue light filters diminish the ipRGC irritating wavelengths and let through light that can be neutral or even sources of relief. These filters are appropriate and can be highly effective when matched with an ipRGC diagnosis as the source of photophobia.

## Individualized Light Filters

To address neural and acquired sources of photophobia associated with a hyper-reactive visual cortex, headaches, and migraines, it is not sufficient to address the narrow band of wavelengths that activate the ipRGCs. The use of blue light and other notch filters not only leave untouched wavelengths that are triggers but, for some individuals, may also increase exposure to wavelengths that lead to future headache and migraine episodes. The alternative for these conditions is precision tinted lenses that have a wavelength filter formula unique to each individual.

## NeuroSpectral Regulation for Migraine

NeuroSpectral Regulation for Migraine (NSR-M) is a proprietary diagnostic and preventative solution for these neural-originating photophobic headaches and migraines. The NSR-M diagnostic procedure can determine an individual’s type of photophobia and whether standard lens filters or a NSR-M unique formula, from millions of potential options, is the right solution for your photophobia triggered headaches and migraines.

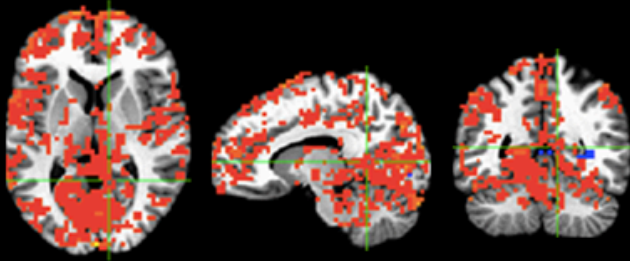
### Eliana



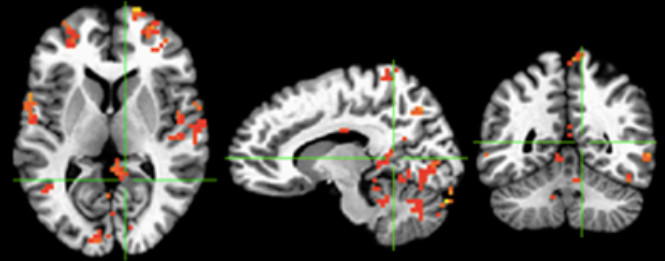
“They handed me a referral to a psychiatrist.”

By fifth grade, Eliana was struggling in school and getting daily headaches. Her mom said, “*She was taking Motrin on a daily basis. After our visits to all of the eye doctors, we got a referral to the neurologist. They prescribed migraine medication, and scheduled us for the first of a several MRIs. After all of this daily suffering, doctors visits, and tests, we were told that nothing was physically wrong. Then, they pulled me aside, told me all her problems were in her head, and handed me a referral to a psychiatrist.*” Eliana has not had a single day of headaches since receiving her glasses. She needs no medication, her grades are up in school, and her personality has changed - she is happier. ***“I can’t even recall the last time she’s taken any ibuprofen or any over-the-counter medication for a headache or being uncomfortable, and certainly no migraine medication. As I said very simply, she puts on the glasses and they’ve all disappeared. Literally, the glasses changed our life.”***

## Placebo Lens OVERACTIVE



## Individualized Spectral Filter NORMALIZED



Anderson, A., De Rosa, E., & Tosta, S. (2020, March). Precision-Tinted Spectral Filters Reduce TBI-Related Migraines and Visual Cortical Sensitivity. In JOURNAL OF HEAD TRAUMA REHABILITATION (Vol. 35, No. 2, pp. E199-E200). TWO COMMERCE SQ, 2001 MARKET ST, PHILADELPHIA, PA 19103 USA: LIPPINCOTT WILLIAMS & WILKINS.

## 7. Conclusion

Light sensitivity, clinically known as photophobia, is a common and distressing symptom associated with headaches and migraines. However, it is underappreciated that photophobia is not only a symptom during episodes but is also an everyday source of vulnerability towards future episodes. Unfortunately for some, the gift of sight is a source of pain.

Photophobia's impact on future symptom severity and quality of life underscores the importance of recognizing and addressing its presence in clinical practice. By understanding the mechanisms underlying photophobia and implementing appropriate management strategies, healthcare professionals can help alleviate the burden of headaches and migraines for affected individuals. Ongoing research is elucidating the pathophysiology of light sensitivity to better understand this vulnerability towards headaches and migraines. By appropriately diagnosing and addressing photophobia, we can educate individuals and clinicians to best improve the well-being of those living with these debilitating conditions.

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