SPECTRA OF THE MONTH

RADIOMETRIC CHARACTERIZATION OF SEASONAL AFFECTIVE DISORDER THERAPY LAMPS

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INTRO

BACKGROUND OF APPLICATION

Last month, we discussed how multiple studies have correlated exposure to blue light with negative effects, such as the suppression of melatonin production. This month, we wanted to cover some of the benefits associated with increased light exposure. In the 1980s, a psychiatric condition called seasonal affective disorder, or SAD, was first recognized and characterized by hypersomnia, hyperphagia, and weight gain in the fall and winter months that remitted in the spring and summer. The initial study that described these symptoms also pointed to a potential treatment by increasing exposure to bright white full-spectrum fluorescent light. This light simulated daylight and resulted in a statistically significant antidepressant effect, and when patients were crossed over to a dim yellow light, these effects markedly reverted, indicating that the type of light was critical. Since then, bright light therapy, or BLT, has been widely administered and optimized, with many companies selling affordable options online to compete with more expensive, clinically tested devices. We wanted to measure one of these more inexpensive lamps to determine exactly what the light output may be, in both qualitative and quantitative means, and how that correlates to improved mood with increased exposure.

This experiment aimed to measure the light output of a SAD therapy lamp using a radiometrically-calibrated spectrometer. The calibrated measurements were compared to counts in Scope mode to determine potential differences between the two measurements, mainly to demonstrate how an irradiance calibration accounts for varying efficiency across the spectral range of the instrument. The therapy lamp used for this experiment (Figure 1) was purchased from an online store, as clinical devices are more expensive and difficult to acquire.

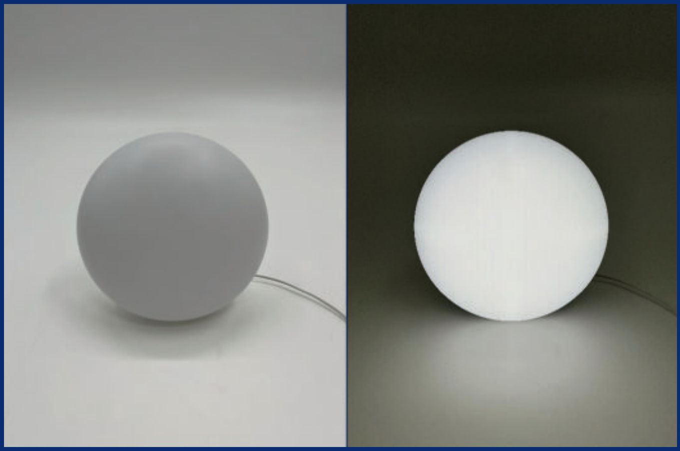

FIGURE #1 Seasonal Affective Disorder (SAD) therapy lamp used for this experiment, both disengaged (left) and engaged (right).

DESCRIPTION OF SPECTROSCOPY SETUP

The setup for this experiment (Figure 2) was based around our latest spectrometer, the AvaSpec-VRS2048CL, commonly known as the Varius. This spectrometer contains patented technology and an improved optical bench design that demonstrates improved accuracy and reliability across various applications, outperforming its predecessors. Like the Nexos, this device is built using our new semi-automated manufacturing technique that enables us to produce high volumes of these instruments with exceptional efficiency, consistency, and reproducibility unit-to-unit. The Varius offers USB3.0 and gigabit ethernet data transfer, either a 2048-pixel or 4096-pixel CMOS linear array detector, ultra-low stray light as low as 0.1%, and a signal/noise ratio of up to 375:1. Furthermore, this spectrometer can be customized with a wide range of gratings (13 total available) and the replaceable slit option is now standard for non-OEM units, which provides even more flexibility for a variety of application needs. The unit used in this experiment was a broadband unit, with a 300-1100 nm wavelength range and a 50-micron slit installed. This configuration is ideal for measurements that span a wide spectral range, such as the present study that recorded radiometric measurements across the entire visible range. This configuration utilized a VA grating as opposed to a UA grating, which trades off detection of the UV region from 200-300 nm for higher grating efficiency from 350-1100 nm. The range of the spectrometer was narrowed to 400-850 nm in the presented plots to focus on the spectral range where signal was detected.

FIGURE #2 Experimental setup for lamp measurements.

The light source used for this experiment was the light emitted from a SAD therapy light set to full power. Additionally, our AvaLight-Hal-Cal-Mini was used to perform an irradiance calibration on the spectrometer in order to acquire radiometric measurements of the SAD therapy light. This NIST-traceable, compact, and affordable light source has a built-in diffuser, a cosine corrector with an SMA adapter, and comes with a calibration file that can easily be implemented in AvaSoft. Other accessories used for this experiment included a 600-micron core fiber, a cosine corrector, and a free-standing optical post to hold the fiber and cosine corrector in position and align it with the SAD therapy lamp. The measurement was taken at a specific distance in order to detect a sufficient amount of signal in the radiometric measurements while not saturating the spectrometer detector.

DESCRIPTION OF METHODOLOGY

The SAD therapy lamp used for this experiment was purchased from an online store, with no modifications made to it. While the lamp had a brightness adjustment, it was only measured at full brightness for ease of data reporting and to determine the output intensity at full power. Before collecting data, the spectrometer was irradiance calibrated using our AvaLight-Hal-Cal-Mini by directly connecting the spectrometer and fiber to the light source (Figure 3). The details of performing this type of calibration within AvaSoft are explained in section 4.9.4 of the AvaSoft 8 manual. After calibration, the fiber optic was left attached to the cosine corrector of the light source, and the cosine corrector was detached from the calibration source to be used for all measurements of the SAD therapy lamp. When measuring the SAD therapy lamp, the distance between the optical post holding the cosine corrector and the lamp itself was set to 15 cm, a distance determined to detect a sufficient amount of signal in the radiometric measurements while not saturating the spectrometer detector in the scope measurements.

FIGURE #3 Setup for irradiance calibration. The spectrometer was attached to the fiber optic cable, which was then attached to the calibration source. The calibration source had a cosine corrector in-line, which was the one used for all following radiometric measurements.

For data analysis, we used both Scope-Minus-Dark and Absolute Irradiance modes in AvaSoft, our custom software package. Scope-Minus-Dark mode is a common mode for many applications, as it subtracts the dark spectrum (what the spectrometer measures with no light source) from the raw counts (i.e., scope mode) for each wavelength. This helps minimize noise in the spectrum and better isolate and identify potential spectral peaks. For this experiment, the dark measurement was taken with the therapy lamp disengaged but overhead light still on in order to remove this ambient light from the reported measurements. Absolute Irradiance mode converts the raw counts measured by the spectrometer (i.e., scope mode) into an intensity measurement (µW/cm^2/nm) that can be used to rigorously quantify the data measured by the instrument. This conversion is done through the use of an irradiance calibration of the spectrometer, such as the one performed here with our AvaLight-Hal-Cal-Mini. For both measurements we used an integration time of 180 ms, which can be adjusted to increase or decrease the amount of light being measured at one time and affects the overall magnitude of the reported spectrum in Scope-Minus-Dark mode, while Absolute Irradiance mode remains unaffected since it quantifies radiometric values as a function of time. We set averaging to 10, meaning 10 values were averaged together to provide more consistent spectra results.

TEST DATA AND RESULTS

Displayed below are the spectral measurements of the SAD therapy lamp, both in corrected scope counts and radiometric intensity:

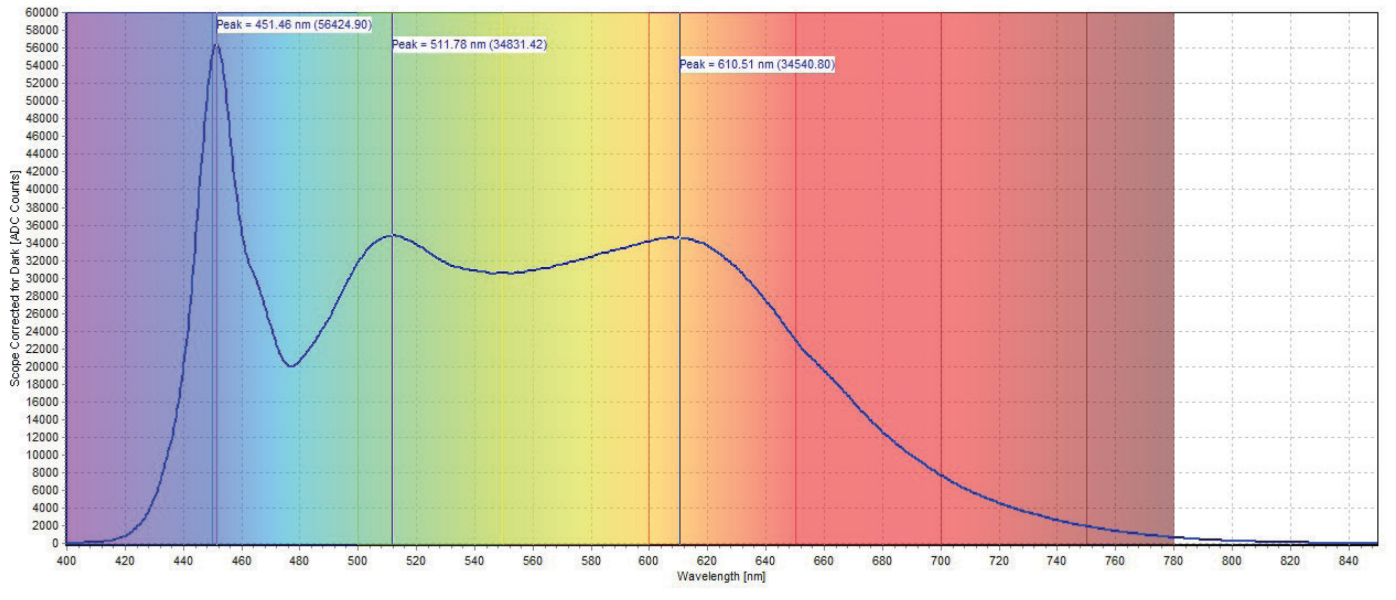

FIGURE #4: Scope-Minus-Dark spectrum of SAD therapy lamp.

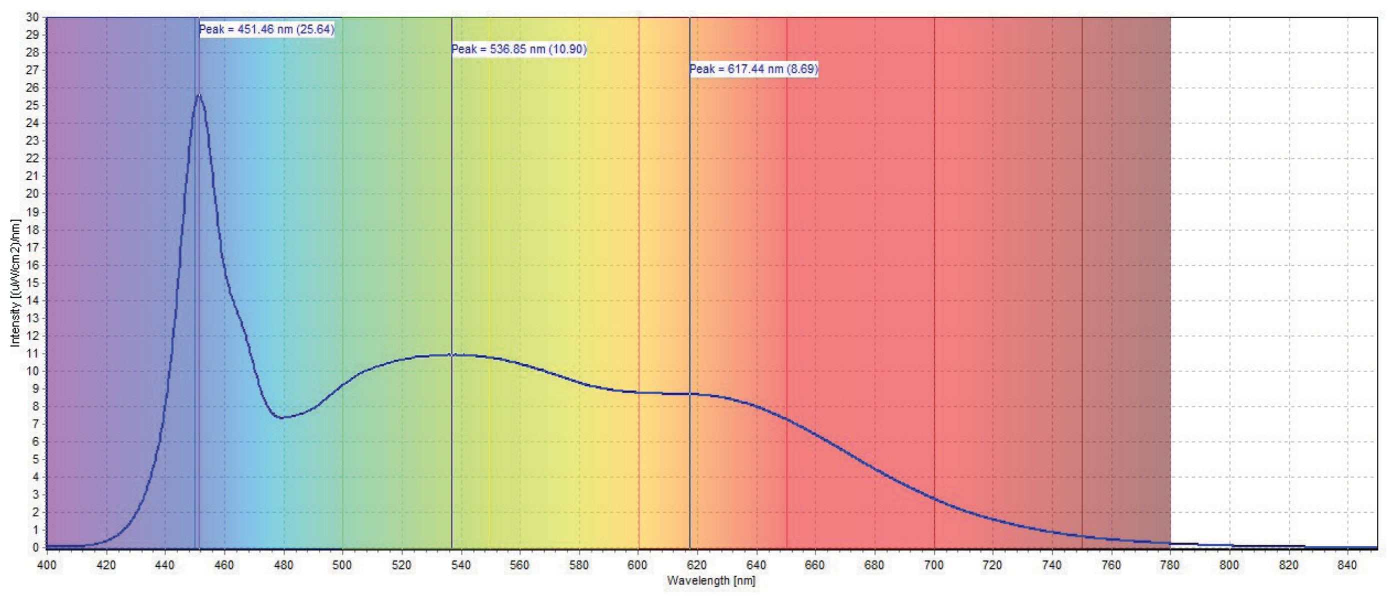

FIGURE #5: Absolute irradiance spectrum of SAD lamp.

ANALYSIS

The therapy lamp measurements in Scope-Minus-Dark and Absolute Irradiance mode showed similar spectral curves, both with peaks that were indicative of RGB LEDs. The Scope-Minus-Dark data showed peaks at 451.46 nm, 511.78 nm, and 610.51 nm (Figure 4). The peaks at 511.78 nm and 610.51 nm had around the same magnitude, and the 451.46 nm peak had about 60% more counts. The Absolute Irradiance data showed peaks at 451.46 nm, 536.85 nm, and 617.44 nm (Figure 5). This spectrum showed the 536.85 nm peak having a noticeably higher magnitude than the 617.44 nm peak, and the 451.46 nm peak being significantly higher magnitude than the other two peaks.

Further analysis of the data can be done regarding the peak locations for each data set. While both measurements show peaks at 451.46 nm, the other two peaks do not quite match, with 10-20 nm differences. The intensities are also noticeably different, with the 451.46 nm peak in the Absolute Irradiance measurement being much more intense relative to the other two peaks compared to the Scope-Minus-Dark measurement. This demonstrates the need for an irradiance calibration for certain applications, particularly radiometry. This difference in peak position and intensity is due to nonuniform efficiency along the signal chain, such as with the internal detector of the spectrometer, the internal grating or the instrument, or even the fiber optic cable. An irradiance calibration accounts for all these nonuniformities and variations in efficiency, giving the ability to measure in truly quantitative means. Some relative measurement techniques, such as reflectance and absorbance, can also somewhat account for these inefficiencies, since they are included in the associated dark and reference measurements. Regardless of the differences in peak locations and intensities, these three peaks can be tied to blue, green and red LEDs, respectively. A combination of these LEDs can create a full-spectrum white light, which is the exact type of light associated with bright light therapy. Additionally, the blue light output is significantly higher than the green and red light output, which is in line with the initial experiment that demonstrated switching to a dim yellow light reversed the benefits of exposure to these lamps. This could potentially be tied to the heightened awareness that results from blue light exposure as explored in our last Spectra of the Month. While this indicates that the light output of this lamp is what is used in more expensive models, further analysis and comparison to a clinical device could reveal differences, or indeed significant similarities, between the two lamps.

CONCLUSION

In conclusion, the present experiment highlights the use of our spectrometers to perform radiometric measurements, here specifically for a seasonal affective disorder, or SAD, therapy lamp. This radiometric measurement was compared to a scope count measurement to determine differences between the two measurement types. While both measurements showed clear peaks indicative of RGB LEDs, the two spectra showed peaks of differing magnitudes, demonstrating how an irradiance calibration is required to capture true quantitative, radiometric values of a light source. Despite this difference, both data sets showed LED peaks that resulted in full-spectrum white light, which is the type of light implemented in treating seasonal affective disorder. The AvaSpec-VRS2048CL is an ideal instrument for a broad range of applications and industries, including radiometric measurements. The AvaLight-Hal-Cal-Mini provides a compact solution for performing irradiance calibrations in the visible and NIR ranges. Please contact Avantes for more information on the configuration that is best suited for your data collection.

CONTACT

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