the same wavelength region to obtain a reference effective irradiance (W/m^2), and the received effective irradiance and the reference effective irradiance thus obtained are compared.

[0035]

In this light measurement method, a received effective dose (J/m^2) obtained by multiplying the received effective irradiance (W/m^2) by a radiation duration (seconds) and a received reference effective dose (J/m^2) obtained by multiplying the reference effective irradiance (W/m^2) by the radiation duration (seconds) are compared. With this comparison, the light measurement method is advantageous to quantitatively evaluating the changes in the body that occur by the absorption of light by OPN5 present in the retina of the person.

[0036]

In this light measurement method, the measurement is performed by a measurement unit, and the measurement unit is provided to eyeglasses, an earphone, a wristwatch, a chest badge, or other article worn on a body, worn on the body itself, or attached to an installation near or around the body, on the basis of a form of each of the one or two or more light sources that radiate the light. According to this invention, attachment in the above-described mode is selected and performed as desired on the basis of an installation form (light source form, light source installation position, and the like) of the light source that radiates the light, and thus is not likely to interfere with daily life and makes it easy to measure the spectral data of the light received by the eyes and the body.

[0037]

(6) A light measurement device according to the present invention comprises a measurement unit that measures spectral data of light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum, a calculation unit that compares the spectral data of the light measured by the measurement unit and data of the OPN5 absorption spectrum stored in advance, and an output unit that displays results of the comparison on a display device or outputs the results as data.

[0038]

This invention is a device that executes the light measurement method of the above-described (5) and, among the measurement unit, the calculation unit, and the output unit constituting the device, at least the measurement unit is built into the light measurement device, but the calculation unit and the output unit may be built into the light measurement device or may not be built into the device but rather provided in an external device or external equipment.

Effect of the Invention

[0039]

According to a first light radiation system of the present invention, each light source is regulated, making it possible to radiate light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum to an irradiated subject. As a result, the first light radiation system is advantageous to activation of OPN5 present in a retina of a person who is the irradiated subject.

[0040]

According to a second light radiation system of the present invention, it is possible to radiate light in which a received effective spectral irradiance to be calculated is 0.2% or more of a reference effective spectral irradiance to the irradiated subject. As a result, the second light

(3) A light radiation system (third light radiation system) according to the present invention includes a light radiating means including one or two or more light sources that radiate light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum, and a light measuring means for measuring spectral data of the light and comparing the spectral data of the light and data of the OPN5 absorption spectrum. One or two or more conditions selected from an installation position, a radiation direction of the light, a wavelength range of the light, an irradiance of the light, a radiation time frame of the light, and a radiation duration of the light of each of the one or two or more light sources are regulated on the basis of results obtained by the comparison.

[0049]

(4) A light radiation method according to the present invention includes radiating, to an irradiated subject, light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum from one or two or more light sources that radiate the light, comparing spectral data of the light obtained by receiving the radiated light and data of the OPN5 absorption spectrum, and regulating radiation conditions of the light (one or two or more conditions selected from an installation position, a radiation direction of the light, a wavelength range of the light, an irradiance of the light, a radiation time frame of the light, and a radiation duration of the light of each of the one or two or more light sources) on the basis of results of the comparison.

[0050]

(5) A light measurement method according to the present invention includes measuring spectral data of light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum, comparing the measured spectral data of the light and data of the OPN5 absorption spectrum stored in advance, and displaying results of the comparison on a display device or outputting the results as data.

[0051]

(6) A light measurement device according to the present invention includes a measurement unit that measures spectral data of light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum, a calculation unit that compares the spectral data of the light measured by the measurement unit and data of the OPN5 absorption spectrum stored in advance, and an output unit that displays results of the comparison on a display device or outputs the results as data.

[0052]

[Components]

Hereinafter, components of each aspect of the above-described invention will be described in detail. It should be noted that each component is related to the respective aspects of the present invention and thus, in the following, will be described in order thereof and not in the order of the aspects.

[0053]

[OPN5, OPN5 Absorption Spectrum]

Opsin 5 (OPN5) is a photoreceptor protein and is present in the human retina. As shown in Fig. 1, OPN5 exhibits an absorption spectrum having a peak at 380 nm. In the present invention, the "OPN5 absorption spectrum" is defined as the absorption spectrum of OPN5 shown in Fig. 1. This Fig. 1 is cited from Fig. 5A in "Kojima D, Mori S, Torii M, Wada A, Morishita R, et al. (2011), UV-Sensitive Photoreceptor Protein OPN5 in Humans and Mice.

efficiency. Light having a low relative luminous efficiency is light that is not too bright. "Light that is not too bright" is light that is not bright for the person who is the irradiated subject. Even if such light is radiated, the person will not recognize or will find it difficult to recognize the brightness, and thus such light is advantageous in facilitating long-period radiation directed toward the person. "Radiation of light having a wavelength of 400 nm or less or 410 nm or less and having a low relative luminous efficiency" include cases in which the light is radiated from a light source that does not emit or substantially does not emit light exceeding 400 nm or exceeding 410 nm. As such a light source, violet light of 360 nm to 400 nm or light of 350 nm to 410 nm is particularly preferred. Further, even in a case in which the light is radiated from a light source including a filter that blocks light having a wavelength exceeding 400 nm or exceeding 410 nm or a case in which light having a wavelength exceeding 400 nm or exceeding 410 nm is emitted, it is possible to radiate light having a wavelength of 400 nm or less or 410 nm or less.

[0060]

The relative luminous efficiency, according to "Change of Brightness of Colored Lights Measuring by the Direct Comparison Method" (Masanori Takase, Katsunori Okajima, Keiji Uchikawa, and Mitsuo Ikeda, Japanese Journal of Optics, Vol. 19, No. 3, 1990), for example, can be measured using methods such as a direct comparison method, a flicker photometry method, an iteration method, a minimally distinct border (MDB) method, and an absolute threshold method. The standard CIE relative luminous efficiency function is described as mainly determined using the flicker photometry method, and typically is evaluated using the direct comparison method and the flicker photometry method. It should be noted that the data for the relative luminous efficiency (spectral luminous efficiency) is listed in Appendix Table 8 of "https://elaws.e-gov.go.jp/download?law_unique_id=404M50000400080_20161001_000000000000000&file_type=PDF_H1." The relative luminous efficiency (relative luminous efficiency in a bright location) is standardized by light having a wavelength of 555 nm (green light) and, from this table, for example, a relative luminous efficiency of 0.01 or less corresponds to a wavelength region of less than 430 nm on the short wavelength side. Thus, humans perceive green light as the brightest, and the sensation of brightness decreases whether the wavelength increases or decreases from that point. The relative luminous efficiency is obtained by, given 1 as the brightness at a wavelength of 555 nm, expressing the brightness of other wavelengths having the same energy as comparison values. Fig. 3 shows a standard photopia relative luminous efficiency. There are individual differences in how people actually perceive light that is not bright, making it difficult to ascertain relative values on the vertical axis shown in Fig. 3. However, the light having a wavelength of 400 nm or less or 410 nm or less described above has a wavelength lower than the wavelength region of less than 430 nm, which has a relative luminous efficiency of 0.01 or less, and thus can be regarded as light having an even lower relative luminous efficiency and at least a relative luminous efficiency of less than 0.01. Light having a wavelength of 400 nm or less or 410 nm or less with a relative luminous efficiency of such an ultra-low value can be considered light that is not bright in comparison with light in other wavelength regions in which the relative luminous efficiency exceeds 0.01, regardless of individual differences. As a result, in a case in which light is radiated to a person without causing a sense of brightness, such light is advantageous to allowing both direct radiation and long-period radiation. It should be noted that, in this application, the irradiated subject, the person, and the eyes of the person have the same meaning and can be used interchangeably.

source is provided at a position where the light is radiated to the irradiated subject as the diffused light diffused by the diffusing material, the irradiance of the light is regulated in accordance with a distance and/or an angle from the light source and the diffusing material to the irradiated subject, or a diffusion angle and/or a transmittance of the diffusing material, and (iv) in a case in which the light source is provided at a position where the light is radiated to the irradiated subject as the reflected light reflected by the reflecting material, the irradiance of the light is regulated in accordance with a distance and/or an angle from the light source and the reflecting material to the irradiated subject, or a reflection angle and/or a reflectance of the reflecting material. The irradiance of the light is regulated by each of such (i) to (iv), making it possible to deliver light having the irradiance necessary to activate OPN5 to the person.

[0078]

(Reflecting material)

The reflecting material is a member that reflects the light radiated in the present invention in a specific direction. For example, light having a wavelength of 400 nm or less or 410 nm or less is not reflected by a reflecting material that reflects normal white light. Therefore, a special reflecting material that reflects light having a wavelength of 400 nm or less or 410 nm or less is provided, making it possible to reflect the light by the reflecting material and radiate the light toward the person even in a case in which such light is not directly radiated toward the person or cannot be directly radiated due to installation constraints.

[0079]

In a case in which the light source cannot be disposed at a position that allows the light to be directly radiated toward the eyes due to installation circumstances of the light source, the special reflecting material described above is installed at an appropriate position, making it possible to radiate the reflected light toward the eyes. For example, for the deskwork illustrated in Fig. 6, the light source 10 is desirably installed in front of the eyes. However, in a case in which the light source cannot be installed in front of the eyes, preferably the reflecting material 11 is provided in front of the eyes and the light is reflected and directed toward the eyes by the reflecting material 11. The reflecting material denoted by reference sign 11 in Fig. 6 is an example of a reflecting material that reflects light from a light source suspended from the ceiling toward the eyes. With utilization of a fixed, movable, or portable reflecting material, for example, the reflecting material has the advantage of increasing the degree of freedom in the light source installation location. Thus, the light source is desirably installed at a position where the light emitted from the light source is directly radiated to the eyes, but in other cases, the reflecting material is preferably utilized to radiate the light toward the eyes.

[0080]

The reflecting material can be installed by applying resist ink onto a plate material or a wall. Specifically, examples include a high ultraviolet reflective white resist ink manufactured by Okamoto Glass Co., Ltd, and the like. In an experiment in which a reflecting material formed by applying the white resist ink at a thickness of 20 μm onto a glass substrate is irradiated with NSPU510CS (shell-type LED, peak wavelength: 375 nm) manufactured by Nichia Corporation at an irradiance of 69 μW/cm² and a distance of 10 cm from the reflecting material, the reflectance can be increased by approximately 2.9 times.

[0081]

(Directionality)

Regarding the directionality of the light, desirably the light source is installed and the

"https://www.nrel.gov/grid/solar-resource/spectra.html").
[0096]

From Fig. 11 (C), it can be seen that a maximum value of the effective spectral irradiance is 0.93 W/m²/nm (value at 402 nm). The effective irradiance, as mentioned above, has an integrated value of 57 W/m² in the wavelength region of 280 to 500 nm. An effective dose when exposed to AM1.5G sunlight for three hours per day is a value obtained by multiplying the 57 W/m² described above by 10,800 seconds, which is understood to be 615,600 J/m² (= 615.6 kJ/m²). It should be noted that, given approximately 1 W/m²/nm as the maximum value of the effective spectral irradiance, 10 W/m²/nm, which is 10 times thereof, can be set as the maximum value. The effective irradiance, assuming a time when this effective spectral irradiance is a square-type spectrum, can be calculated as 10 W/m²/nm x 220 nm = 2,200 W/m², and the effective dose in a case of radiance for three hours per day at this effective irradiance can be set as 21,600,000 J/m² (= 21.6 MJ/m²).
[0097]

As described above, an effective irradiance integrated within the wavelength range of 280 to 500 nm was 57 W/m² for sunlight and 3.3 W/m² for violet light. For such values, examples of minimum values include 0.01 W/m²/nm for the effective spectral irradiance, 0.1 W/m² for the effective irradiance, and 1,000 J/m² for the effective dose. Further, examples of maximum values include 10 W/m²/nm for the effective spectral irradiance, 2,200 W/m² for the effective irradiance, and 21.6 MJ/m² (M stands for million) for the effective dose. It should be noted that the effective irradiance is a value in a case of radiance for three hours.
[0098]

The light spectral data can be calculated by comparison in all or part of a specific wavelength region of the OPN5 absorption spectrum. Thereby, even in a case in which the received light includes various light spectral data, it is possible to calculate the light spectral data by comparison with all or part of the wavelength region of the OPN5 absorption spectrum, and thus apply the method to any evaluation in which the wavelength region of the light is specified using a filter or the like. As a result, the method can be utilized as a measurement device for clearly defining whether the physical effects through OPN5 are related to the received effective spectral irradiance across the entire wavelength region of the OPN5 absorption spectrum, related to the received effective spectral irradiance in a specific wavelength region of the OPN5 absorption spectrum, or the like. It should be noted that, for example, as a method of specifying a wavelength region of the light by using a filter or the like, it is also possible to specify a specific wavelength region such as that of violet light or the like having the wavelength region of 360 to 400 nm, for example.
[0099]

In the example described above, the spectral irradiance of the spectrum of the light actually received is set as the spectral irradiance of each wavelength in the wavelength region of 280 nm to 500 nm, but the wavelength range may be set within a specific range. For example, in the calculation unit, during comparisons in the wavelength region, the received effective spectral irradiance may be determined by integration in the wavelength region (W/m²), and integration of the received effective irradiance and integration of the reference effective spectral irradiance in the same wavelength region may be performed. The results may then be compared and evaluated.
[0100]

What is claimed is:

[Claim 1]

A light radiation system comprising:

one or two or more light sources that radiate light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum,

one or two or more conditions selected from an installation position, a radiation direction of the light, a wavelength range of the light, an irradiance of the light, a radiation time frame of the light, and a radiation duration of the light of each of the one or two or more light sources being regulated.

[Claim 2]

A light radiation system comprising:

one or two or more light sources that radiate light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum,

a spectrum of the light received by an irradiated subject being regulated so that a received effective spectral irradiance ($W/m^2/nm$) calculated as a product of a spectral irradiance ($W/m^2/nm$) of each wavelength in a wavelength region of 280 nm to 500 nm of the light and a relative absorbance of data of the OPN5 absorption spectrum, on a per wavelength basis, is 0.2% or more of a reference effective spectral irradiance ($W/m^2/nm$) calculated as a product of a spectral irradiance ($W/m^2/nm$) of a sunlight spectrum defined by AM1.5G and a relative absorbance of the OPN5 absorption spectrum, on a per wavelength basis.

[Claim 3]

A light radiation system comprising:

a light radiating means including one or two or more light sources that radiate light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum; and

a light measuring means for measuring spectral data of the light and comparing the spectral data of the light and data of the OPN5 absorption spectrum,

one or two or more conditions selected from an installation position, a radiation direction of the light, a wavelength range of the light, an irradiance of the light, a radiation time frame of the light, and a radiation duration of the light of each of the one or two or more light sources being regulated on the basis of results obtained by the comparison.

[Claim 4]

The light radiation system according to any one of claims 1 to 3, wherein

the light is light including 380 nm that is the peak wavelength of the OPN5 absorption spectrum.

[Claim 5]

The light radiation system according to claim 4, wherein

the light has a wavelength of 400 nm or less or 410 nm or less.

[Claim 6]

The light radiation system according to any one of claims 1 to 3, wherein

the one or two or more light sources are disposed at one or two or more positions selected from a position where the light is radiated toward an irradiated subject who is a radiation target, a position in a field of view of the irradiated subject, a position along the subject's visual line, a position where the light is radiated to the irradiated subject as diffused light diffused by a diffusing material, and a position where the light is radiated to the irradiated subject as reflected light reflected by a reflecting material.

[Claim 7]

The light radiation system according to claim 6, wherein,

for each of the one or two or more light sources,

(i) in a case in which the light source is provided at a position where the light is radiated toward the irradiated subject, the irradiance of the light is regulated in accordance with a distance and/or an angle from the light source to the irradiated subject,

(ii) in a case in which the light source is provided at a position in the field of view of the irradiated subject or a position in the visual line direction from the irradiated subject side, the irradiance of the light is regulated in accordance with the distance and/or the angle from the light source to the irradiated subject,

(iii) in a case in which the light source is provided at a position where the light is radiated to the irradiated subject as the diffused light diffused by the diffusing material, the irradiance of the light is regulated in accordance with a distance and/or an angle from the light source and the diffusing material to the irradiated subject, or a diffusion angle and/or a transmittance of the diffusing material, and

(iv) in a case in which the light source is provided at a position where the light is radiated to the irradiated subject as the reflected light reflected by the reflecting material, the irradiance of the light is regulated in accordance with a distance and/or an angle from the light source and the reflecting material to the irradiated subject, or a reflection angle and/or a reflectance of the reflecting material.

[Claim 8]

The light radiation system according to any one of claims 1 to 3, wherein

each of the one or two or more light sources is selected from a structure-attached light source attached to a floor (including underfoot), a wall, a ceiling (including a suspended ceiling), or other structure; an installation-attached light source attached to a desk, a table, a partition (divider, screen), a shelf, a desktop member, a personal computer (PC), a display, a PC keyboard, a television, an audio device, or other equipment or installation; a built-in or attached light source of a portable PC, a tablet, a smartphone, or other mobile terminal; a body-accessory-attached light source detachably mounted or attached to a vision correcting aid, eye protective equipment, face protective equipment, neck hanging accessory, ear hooking accessory, head-attached equipment, or other body accessory; and a functional device-attached light source attached to a functional device for augmented reality (AR), virtual reality (VR), or mixed reality (MR) (including goggles, a headset, and other functional devices).

[Claim 9]

The light radiation system according to any one of claims 1 to 3, wherein

the one or two or more light sources are regulated in orientation or position manually or automatically.

[Claim 10]

The light radiation system according to claim 3, wherein

a received effective spectral irradiance ($W/m^2/nm$) found from a product of the spectral data ($W/m^2/nm$) of the light and the data of the OPN5 absorption spectrum, on a per wavelength basis, is calculated.

[Claim 11]

The light radiation system according to claim 10, wherein

a reference effective spectral irradiance ($W/m^2/nm$) found from a product of a spectral irradiance ($W/m^2/nm$) of a sunlight spectrum defined by AM1.5G and the OPN5 absorption spectrum, on a per wavelength basis, is calculated and compared with the received effective spectral irradiance ($W/m^2/nm$).

[Claim 12]

The light radiation system according to claim 3, wherein

the spectral data of the light is calculated by comparison in all or part of a wavelength region of the OPN5 absorption spectrum.

[Claim 13]

The light radiation system according to claim 12, wherein,

during comparison in the wavelength region, the received effective spectral irradiance ($W/m^2/nm$) is integrated in the wavelength region to obtain a received effective irradiance (W/m^2), the reference effective spectral irradiance ($W/m^2/nm$) is similarly integrated in the same wavelength region to obtain a reference effective irradiance (W/m^2), and the received effective irradiance and the reference effective irradiance thus obtained are compared.

[Claim 14]

The light radiation system according to claim 13, wherein

a received effective dose (J/m^2) obtained by multiplying the received effective irradiance (W/m^2) by the radiation duration (seconds) and a received reference effective dose (J/m^2) obtained by multiplying the reference effective irradiance (W/m^2) by the radiation duration (seconds) are compared.

[Claim 15]

The light radiation system according to claim 3, wherein

the measurement is performed by a measurement unit, and the measurement unit is provided to eyeglasses, an earphone, a wristwatch, a chest badge, or other article worn on a body, worn on the body itself, or attached to an installation near or around the body, on the basis of a form of each of the one or two or more light sources that radiate the light.

[Claim 16]

A light radiation method comprising:

radiating, to an irradiated subject, light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum from one or two or more light sources that radiate the light;

comparing spectral data of the light obtained by receiving the radiated light and data of the OPN5 absorption spectrum; and

regulating radiation conditions of the light (one or two or more conditions selected from an installation position, a radiation direction of the light, a wavelength range of the light, an irradiance of the light, a radiation time frame of the light, and a radiation duration of the light of each of the one or two or more light sources) on the basis of results of the comparison.

[Claim 17]

The light radiation method according to claim 16, further comprising:

a light measuring means for measuring the spectral data of the light and comparing the spectral data of the light and the data of the OPN5 absorption spectrum,

a received effective spectral irradiance ($W/m^2/nm$) found from a product of the spectral data of the light and the data of the OPN5 absorption spectrum, on a per wavelength basis, being calculated.

[Claim 18]

A light measurement method comprising:

measuring spectral data of light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum;

comparing the measured spectral data of the light and data of the OPN5 absorption spectrum stored in advance; and

displaying results of the comparison on a display device or outputting the results as data.

[Claim 19]

The light measurement method according to claim 18, wherein

the comparison is performed by a calculation unit, and a received effective spectral irradiance ($W/m^2/nm$) found from a product of the spectral data of the light and the data of the OPN5 absorption spectrum, on a per wavelength basis, is calculated in the calculation unit.

[Claim 20]

The light measurement method according to claim 19, wherein

a reference effective spectral irradiance ($W/m^2/nm$) found from a product of a spectral irradiance ($W/m^2/nm$) of a sunlight spectrum defined by AM1.5G and the OPN5 absorption spectrum, on a per wavelength basis, is calculated and compared with the received effective spectral irradiance ($W/m^2/nm$).

[Claim 21]

The light measurement method according to claim 18 or 19, wherein

the spectral data of the light is compared in all or part of a wavelength region of the OPN5 absorption spectrum.

[Claim 22]

The light measurement method according to claim 21, wherein,

during comparison in the wavelength region, the received effective spectral irradiance is integrated in the wavelength region to obtain a received effective irradiance (W/m^2), the reference effective spectral irradiance is similarly integrated in the same wavelength region to obtain a reference effective irradiance (W/m^2), and the received effective irradiance and the reference effective irradiance thus obtained are compared.

[Claim 23]

The light measurement method according to claim 22, wherein

a received effective dose (J/m^2) obtained by multiplying the received effective irradiance (W/m^2) by a radiation duration (seconds) and a received reference effective dose (J/m^2) obtained by multiplying the reference effective irradiance (W/m^2) by the radiation duration (seconds) are compared.

[Claim 24]

The light measurement method according to claim 18 or 19, wherein

the measurement is performed by a measurement unit, and the measurement unit is provided to eyeglasses, an earphone, a wristwatch, a chest badge, or other article worn on a body, worn on the body itself, or attached to an installation near or around the body, on the basis of a form of each of the one or two or more light sources that radiate the light.

[Claim 25]

A light measurement device comprising:

a measurement unit that measures spectral data of light having a wavelength in a wavelength region overlapping a peak wavelength of an OPN5 absorption spectrum;

a calculation unit that compares the spectral data of the light measured by the measurement unit and data of the OPN5 absorption spectrum stored in advance; and

an output unit that displays results of the comparison on a display device or outputs the results as data.