

# Exploring the relationship between humans and lighting beyond physics: the case of traditional Japanese interior lighting

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## Abstract

The complex and deep relationships that people have had with lighting throughout the ages in various parts of the world are difficult to grasp from a scientific point of view due to an incredible intertwining of physical, technological, physiological, psychological, sociological, aesthetic, cultural, historical, and geographical factors, as well as the difficulty of accessing accurate sources of information. However, studying this relationship between humans and light in all its dimensions is fruitful at a time when lighting technologies and the design of urban environments are undergoing major changes. This study attempts to initiate a transdisciplinary reflection on these issues through the example of interior lighting in traditional Japanese housing before the advent of electric lighting, supported by scientific contributions from multiple disciplines and the literary testimony of Junichirō Tanizaki in *In Praise of Shadows*.

## Keywords

Lighting, Architecture, skin appearance, literature.

## 1. Introduction

The color of an object is incredibly complex to evaluate due to the many physical, perceptual, contextual, and cultural factors that influence it. This is especially true for human faces, since the process of vision learning during the first weeks of life [[1, 2] makes us particularly perceptive at detecting, recognizing, and analyzing in subtle detail, sometimes unconsciously. The difficulty even increases when it comes to assessing the chromatic quality of lighting, as it is rarely analyzed as such but rather through the appearance it gives to objects and people [3]. The criteria for assessing a lighting environment thus go far beyond the scope of objective evaluation methods that can be defined by physics or colorimetry; they are also based on a complex mix of geographical, historical, physiological, psychological, aesthetic, cultural, sociological and anthropological factors, which are all the more difficult to discern as they are most often expressed through imprecise language, marked by subjectivity. Lighting is also perceived in terms of what it allows us to see or do, imposing some constraints or favoring some ways of being and acting. At every moment in history and in every region of the world, humans have been molded by their relationship with light, a complex relationship governed by contextual constraints, influenced by technological advances in living spaces and artificial lighting solutions, influenced also by cultural factors in which self-image might play a significant role. It therefore seems appropriate to consider lighting from a transdisciplinary scientific perspective, beyond what physics and colorimetry can offer, and it is this type of comprehensive approach that the example studied below of lighting in traditional Japanese houses, before the advent of electric lighting, attempts to initiate. This inevitably confronts 21st-century European physicists with serious obstacles to experimental verification due to the temporal and geographical distance, but it does, however, benefit from an exceptional testimony: the book *Inei*

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*raisan* (陰翳礼讃) by Junichirō Tanizaki, published in Japan in 1933 [4], available in English since 1977 through the translation by Thomas J. Harper and Edward G. Seidenstieker entitled *In Praise of Shadows* [5], from which the excerpts below are taken, or in French through the translation by René Sieffert, entitled *Eloge de l'Ombre*, published in the same year [6]. In this subjective essay on the Japanese relationship with light, written sixty years after Japan opened its borders to the world after remaining almost completely closed for two centuries [7], Tanizaki reflects on Japanese identity between tradition and modernity, a modernity marked by Westernization in all aspects of society.

But what can we reconstruct of these vanished luminous environments and the relationship that the Japanese who lived in them might have felt? What scientific answer can be given to this question? The preliminary study presented here will not go beyond the stage of questioning and gathering hypotheses. But it already has the merit of highlighting the particularities of this unique mode of lighting and of raising questions that deserve to be explored further.

## 2. The dimness of Japanese interiors

Traditional Japanese architecture is based on a wooden structure. Inside, the floor is covered with tatami (畳) made of rice straw, and the removable partitions are made of translucent paper, called shōji (障子), or opaque paper, called fusuma (襖). Although brick was introduced from China 1,400 years ago and Japan has good clay deposits for brick making, wood remained almost exclusively used for a long time, not only because of the abundant forest cover throughout the country and the difficulty of extracting stone, but also for seismic and climatic reasons—wood is a very good thermal and hygrometric regulator, in hot and humid summers as well as in cold and dry winters [8]. The fragility of these materials, and the lack of glass windows until the country's Westernization during the Meiji era [9], led to the interiors being protected from the rain by imposing roofs that extended significantly beyond the exterior facades thanks to large eaves (figure 1). Tanizaki described the design of the dwelling based on this roof:

*(...) what first strikes the eye is the massive roof of tile or thatch and the heavy darkness that hangs beneath the eaves (...) In making for ourselves a place to live, we first spread a parasol to throw a shadow on the earth, and in the pale light of the shadow we put together a house.*

Tanizaki also associated this prominence of the roof with architectural constraints:

*There are no doubt all sorts of reasons—climate, building materials—for the deep Japanese eaves. The fact that we did not use glass, concrete, and bricks, for instance, made a low roof necessary to keep off the driving wind and rain.*



**Figure 1:** Eave in Tenju-an Zen temple in Kyoto.

and highlights the contrast with Western housing design, in one of the many comparisons between Japan and the West that pepper his essay:

*If the roof of a Japanese house is a parasol, the roof of a Western house is no more than a cap, with as small a visor as possible so as to allow the sunlight to penetrate directly beneath the eaves.*

It should be noted that the word “sunlight” here translates the Japanese word *nikkō* (日光), which occurs twice more in the original Japanese text, each time to discard it: “*sunlight never penetrates*” (*nikkō o shahei su* – 日光を遮蔽す), “*putting the sunlight at still greater a remove*” (*nikkō o tōnokeru* – 日光を遠のける). The kanji character 光 is one of two characters used in Japanese to refer to light, with a connotation associated with physical light: it is found in the words “light” (*hikari* – 光り), “shine” (*hikaru* – 光る), “lighting” (*saikō* – 採光), “ray of light” (*kōsen* – 光線), “luster” (*kōtaku* – 光沢), and “optics” (*kōgaku* – 光学). The other character, 明, has a connotation more associated with perceived light: it is found in the words “light” (*akari* – 明り), “brightness” (*akarusa* – 明るさ) or “dim light” (*hakumei* – 薄明), as well as in Meiji (明治). It is interesting to note that the use of these two characters follows nearly the same semantic dichotomy than the two terms for light in Latin, *lux* and *lumen* [10], which could be likened to the terms *hikari* and *akari* respectively, even though the cultural contexts of the two languages are somewhat different.

This arrangement of architectural elements inevitably results in a very dark interior, as the light passing under the eaves and through the surrounding platform (*engawa* - 縁側) is diffused by the *shōji* (see figure 2):

*The little sunlight from the garden that manages to make its way beneath the eaves and through the corridors has by then lost its power to illuminate, seems drained of the complexion of life. It can do no more than accentuate the whiteness of the paper.*



**Figure 2:** Photograph of a room surrounded by movable paper partitions (*shōji*).

According to Tanizaki, Japanese culture did not only accommodate this obscurity, it sublimated it into art:



*(...) a light room would no doubt have been more convenient for us, too, than a dark room. The quality that we call beauty, however, must always grow from the realities of life, and our ancestors, forced to live in dark rooms, presently came to discover beauty in shadows, ultimately to guide shadows towards beauty's ends.*

Another excerpt shows how difficult it was for light to reach the back rooms of the house:

*And surely you have seen, in the darkness of the innermost rooms of these huge buildings, to which sunlight never penetrates, how the gold leaf of a sliding door or screen will pick up a distant glimmer from the garden, then suddenly send forth an ethereal glow, a faint golden light cast into the enveloping darkness, like the glow upon the horizon at sunset. In no other setting is gold quit so exquisitely beautiful.*

This excerpt mentions that the walls opposite the opening to the outside are often gilded with gold leaf (see example in Figure 3), following a trend that appeared during the Momoyama period (16th century) and which Paine and Soper explain as a solution to the problem of lighting in deep rooms [11].



**Figure 3:** Gilded partitions at the back of the rooms in Ninna-ji Temple in Kyoto.

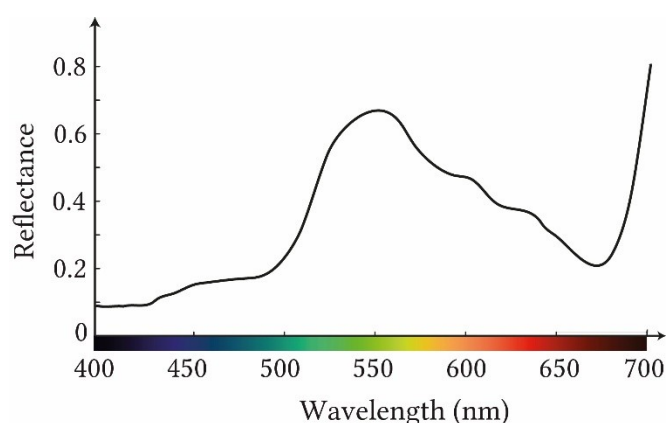
The two previous excerpts mainly mention the fact that the light entering the room comes from the garden. This is always the case when Tanizaki refers to light coming from outside, using expressions such as “light from the garden” (*niwa no akari*) or “reflection from the garden” (*niwa kara no hansha*). It is worth noting that he uses here the word *akari*, or “felt light,” as opposed to the character 光 previously used to refer to sunlight from which one must protect oneself.

One may wonder whether the rejection of direct sunlight could be linked to a particular skin intolerance to solar radiation in Asian subjects (said *Mongoloids* in ethnic classifications [12]) compared to European subjects (said *Caucasians*). Literature in dermatology shows that Japanese people may be prone to erythema (sunburn) before melanogenesis (tanning) [12, 13, 14] and that

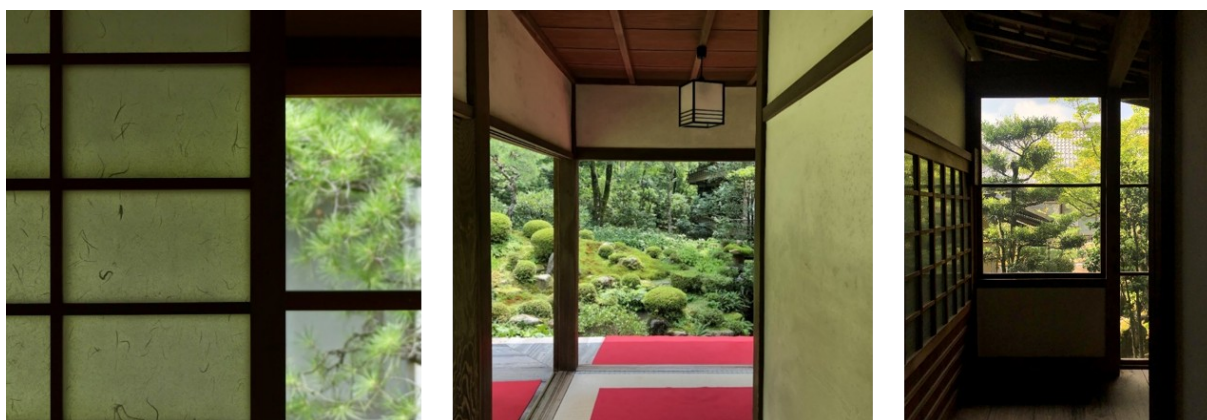
tanning in Asians may be more pronounced and longer lasting than on Caucasian skin of the same phenotype in the Fitzpatrick phenotypic classification [15, 16]. However, no significant biological risk appears to justify a difference in behavior with regard to light between Asia and Europe [17].

### 3. Natural light tinted with chlorophyll

It is easy to see when visiting the few traditional Japanese houses that remain in their original state that the openings rarely allow a glimpse of the sky, but almost always intercept a garden or some element of vegetation (Figure 5). It is therefore certain that the light entering the home after being filtered by the chlorophyll in the plants takes on a green hue, even if this is not perceptible to the naked eye (due to chromatic adaptation, as explained below) and would need to be verified by physical measurements using a spectroradiometer. The filtering of light through foliage is a concept in itself in Japan, called *komorebi* (木漏れ日), which García and Miralles describe as “an abstract work of art created by nature” [18]. The concept encompasses light spots on the ground, beams formed in mist, spatial and temporal fluctuations in illumination caused by wind in the foliage, and spectral filtering caused by plant components. The impact of this spatial, spectral, and temporal filtering on human well-being and blood pressure has even been quantified [19, 20]. Figure 4 shows the spectral distribution of light filtered by a plant leaf, where the intensity in the medium wavelengths (green to orange light, from 530 to 600 nm) largely dominates that in short wavelengths (blue light, below 500 nm) and long wavelengths (red light, above 630 nm), the latter being absorbed by chlorophyll [21].



**Figure 4:** Spectral distribution of light reflected by a plant leaf, whose shape is characteristic of filtering by chlorophyll [22].



**Figure 5:** Examples of openings onto plants and garden. The photographs reveal the green hue of the light hitting the shōji or walls.

The green tint of the lighting is clearly visible in the photographs shown in Figure 5, although it is undoubtedly attenuated to a considerable extent by the automatic white balance of the digital cameras used (Panasonic Lumix DMC-FZ300, Apple iPhone 8), which tends to eliminate any color cast in the images. On the other hand, unless they are warned and paying close attention, visitors to these places may not notice this greenish shade, or may not even perceive it at all, due to the perceptual phenomenon of *chromatic adaptation* which let light source or the brightest object in the field of vision look white [23], cumulated with the phenomenon of *color constancy* which allows the color of objects to be perceived independently of the hue of the lighting [24]. Consistently, Tanizaki does not mention this green hue in his essay. He focuses on the whiteness (shiro - 白) of the *shōji*, although these almost always appear green in digital photographs (see Figures 2 and 5).

However, it is surprising that this distinct lighting color has been so widespread and tolerated by the Japanese, given that it is unpopular, even disliked, by Europeans. Jost *et al.*, in a study in which individuals from various geographical backgrounds around the world were asked to evaluate the subjective quality of LED lightings with different spectral distributions while looking at themselves in a mirror, clearly indicate that skin color is one of the most important factors influencing the acceptability of a lighting installation: consciously or unconsciously, it is often a criterion for evaluating the color quality of light sources [3]. Here again, we may wonder to what extent the appearance of the skin, particularly that of the face, influences these perceptions, given that psychologists attest to the importance of skin texture and facial details in human aesthetic preferences [25]. The special place that human faces occupy in the learning of vision in infants [[1, 26] could explain this acuity in the perception of details and sensitivity to very slight variations in color [27]. Interestingly, Tanizaki also hypothesized that skin color influenced the aesthetic orientation related to lighting in traditional dwellings. He explicitly asks the question:

*Why should this propensity to seek beauty in darkness be so strong only in Orientals?*

and, after contrasting the Japanese, who contented themselves with the lighting imposed on them by environmental and architectural constraints, with Westerners, who constantly sought to innovate in artificial lighting techniques, he added:

*But beyond such differences in temperament, I should like to consider the importance of the difference in the color of our skin.*

#### 4. Skin whiteness

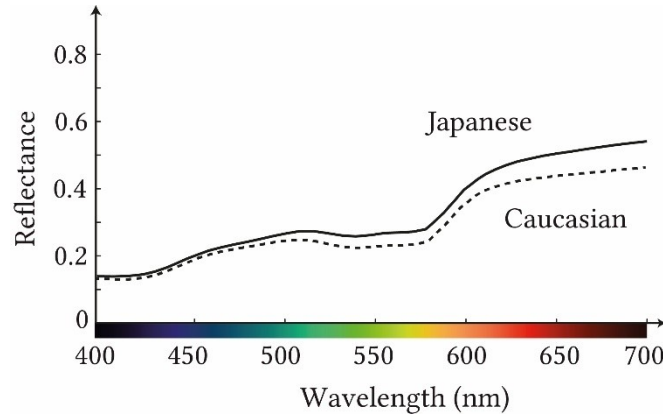
The complexion of Japanese individuals is on average slightly more yellowish than the one of Caucasians, due to a higher proportion of the orange form of melanin, *eumelanin*, compared to the other more widespread and more neutral-colored form, *pheomelanin* [25]. This is translated in spectral reflectance measurements carried out by Lu *et al.* on large cohorts of individuals from different geographical and ethnic backgrounds [28]. Figure 6 shows the average curves for Caucasian and Japanese individuals: Japanese skin reflects slightly more light than Caucasian skin, except at short wavelengths. This clearly indicates a more yellow and, on average, lighter skin tone, even though there is a wide variety of skin colors within each category, particularly for genetic reasons related to evolution and adaptation to the UV content of daylight at different latitudes [15].

Tanizaki, on the other hand, used the concept of whiteness, by specifying that Japanese skin whiteness, compared to Westerners' skin whiteness, is "*tinged by a slight cloudiness*". He also pointed out that white skin is a sign of nobility and refinement, which undoubtedly explains why Japanese people protect themselves from direct sunlight :

*From ancient times we have considered white skin more elegant, more beautiful than dark skin.*

Bihaku (美白), literally "beautiful white" or "white beauty," is an ancient Japanese concept referring to the whiteness of the skin, attested as early as the 11th century in the famous Tale of

Genji (Genji mongatari – 源氏物語). It came back into fashion during the Meiji era, coinciding with the Westernization of the country, and became a concept in cosmetics promoted by the media, sometimes promoting skin whitening techniques [29,30,31]. This attraction to whiteness may be linked to the general preference of Asians for the color white, which seems to be preferred over all other colors according to a study involving 490 Chinese, Japanese, and Indonesian individuals [32].



**Figure 6:** Average spectral reflectance of the skin of 188 Japanese individuals and 172 Caucasian individuals, after [28].

Most probably, Tanizaki did not pay attention to the details revealed by the high-resolution hyperspectral images acquired with the system developed by Lou Gevaux et al. [33], some of which are shown in Figure 7. They illustrate the significant difference in appearance of a Caucasian face when illuminated exclusively by blue, green, amber, or red light. Blue light, which is poorly reflected by the skin, reveals all surface granularity. Under green or amber light, blood vessels become very visible, especially around the eyes, due to the absorptance peak of oxyhemoglobin between 500 and 550 nm [34]. Under red light, granularity, blood vessels, and all other details disappear—the skin diffuses the light deeply and gives a very bright and translucent appearance. These images may explain the general human preference for lighting with a high red light content: according to some studies of Caucasian individuals, facial redness, which a human observer seems able to perceive through minute variations in hue (around 0.5 units of  $\Delta E_{1976}$ ), is more attractive and associated with good health [27,35]. We can also understand why Caucasians dislike lighting with a high green light content, which highlights blood vessels: although this has not been proven, nor is it easy to test, even an unconscious perception of facial vascularization is likely to cause an unpleasant sensation [36].

But what about Asian faces? In the absence of images of comparable quality to those shown in Figure 7 for Japanese individuals, it is difficult to predict whether blood vessels would stand out as much on their faces, given the possible differences in skin structure. Studies based on hyperspectral imaging, when not focused on the infrared range for automatic face recognition [37], have lower spatial resolution and therefore do not show the same level of detail [35]. The scientific literature on dermatology does not highlight any notable biological differences that would allow us to know whether facial vascularization is more or less visible than on Caucasian faces. Perhaps it is just as visible, which would explain the use of face powder by Japanese women, as mentioned by Tanizaki? The stratum corneum, the outermost layer of the skin that acts as a barrier to the outside world, appears to be thinner in Asian individuals [12, 38], although this does not necessarily imply a difference in appearance. Color science, on the other hand, has clearly shown that while all humans tend to prefer lighting with a high red light content, Caucasians rate lighting with a high green light content very negatively, while Asians rate it much more positively [3,39], because it makes the redness of the complexion less pronounced [40, 41].





**Figure 7:** Spectral images of a Caucasian face (top row) and detail around the eye (bottom row), under four monochromatic light sources. From left to right: 420 nm (blue), 540 nm (green), 590 nm (amber), 660 nm (red). After [33].

## 5. Contrast effects

In his praise of whiteness, Tanizaki repeatedly emphasized contrast effects, which can be more directly associated with the perceptual mechanisms of vision and are undoubtedly more universal in this respect, such as the *simultaneous contrast* theorized by French chemist Michel-Eugène Chevreul (1786, 1889) [42, 23]. Tanizaki referred in particular to the blackening of teeth with lacquer by women of high rank, said *O-haguro* (お歯黒), which by contrast enhances the whiteness of the face:

*I know of nothing whiter than the face of a young girl in the wavering shadow of a lantern, her teeth now and then as she smiles shining a lacquered black through lips like elfin fires.*

It seems that this fashion, depicted in Kitagawa Utamaro's beautiful print from the late 18th century (Figure 8), was already out of fashion by the time Tanizaki wrote *In Praise of Shadows*. There is no evidence of it in photographs from the period available online, even on Japanese websites. Tanizaki however seems to have been familiar with this practice during his childhood.

The contrast effects seem to be enhanced by the dim lighting typical of Japanese houses at that time. Tanizaki described it as follows:

*A woman of the middle or upper ranks of society seldom left her house, and when she did she shielded herself from the gaze of the public in the dark recesses of her palanquin. Most of her life was spent in the twilight of a single house, her body shrouded day and night in gloom, her face the only sign of her existence.*

It is difficult to imagine, from a subjective tale like this, the degree of darkness in which these people lived, and even more difficult to estimate the luminosity. If the illuminance was as low as suggested in this excerpt, one might wonder about the vision conditions that applied: *photopic vision*, when cone cells in the retina are activated allowing color perception, requires a certain illuminance, around 100 lux [43]; below this threshold, vision switches to the *mesopic* mode, or even to a *scotopic* mode, corresponding to night vision, in which color perception is greatly reduced or even cancelled. Perhaps this low brightness enhances the whiteness due to the absence of color sensation?





**Figure 8:** Application of o-haguro (Kanetsuke – 鉄漿付). Ukiyo-e print by Kitagawa Utamaro from the series Ten Portraits of Women (Fujin Sōgaku Jittai - 婦人相学十躰), produced in 1792–1793.

In another context related to Noh theater, this time more luminous, Tanizaki depicted chromatic simultaneous contrast effects based on the complementary colors red and green:

*(...) the flush of red in the cheeks of a child actor can emerge with extraordinary freshness—an effect which in my experience is most striking against a costume in which green predominates.*

*The perfect harmony of the yellow skin with garments of a subdued green or brown forces itself upon our attention as at no other time.*

Notice that these two excerpts are among the few places in the original text in Japanese where the character denoting the green color, 緑 – *midori*), is used. It appears a third time in reference to the color of a kimono, and a fourth time in the writing of a surname. The green hue of the interior lighting is clearly not mentioned in *In Praise of Shadows*, and we will probably never know whether this is because he did not perceive it, or because the cultural codes of his time encouraged him to focus on whiteness (69 occurrences of the character 白 – *shiro* meaning white), or because electric lighting, which was already widespread at the time, had already changed the lighting environments in which he lived.

## 6. Conclusions

The diverse elements brought together here from physics, literature, history, architecture, geography, and medicine teach us that lighting has always taken forms linked to the many geographical and technical constraints that humans have had to contend with. They also teach us that these lighting methods are not neutral in terms of how we see ourselves and others: the interaction of light emanating from these luminous environments with the skin of the face plays an important role, giving rise to particular feelings and behaviors that permeate culture. Addressing these issues in the most scientific way possible, with reliable experimental data (e.g. comprehensive measurements of spectral irradiances in remaining traditional housings from Japan and elsewhere in the World, and exploration of opensource skin reflectance database) and more robust knowledge would require extending physical and psycho-physical studies based on places, people, and elements

available today—assuming that these remain representative of the period under consideration—and would obviously require the participation of Japanese people and Japanologists, geographers and historians, anthropologists, designers, and researchers from many other disciplines. It is not clear that the subject is capable of mobilizing so much attention from so many people, but at a time when LED technology is bringing a variety of lighting colors unprecedented in history, when smart lighting allows these colors to be customized to suit the user's preferences, and when the greening of urban environments in the name of reconnecting with nature is inspiring architectural and urban planning projects [44], considering the relationship between humans and light in all its dimensions through a transdisciplinary approach seems particularly desirable and fruitful.

## Declaration on Generative AI

The author has not employed any Generative AI tools.

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