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Extra Visual Function of the Human Eye

PD Gupta[1*] and K Pushkala[2]

[1]Founder Director, Iladevi Cataract and IOL Research Centre, Ahmadabad, India

[2]Department of Zoology, SDNB Vaishnav College for Women, Chennai, India

1. Abstract

The eye is part of the sensory nervous system. However, there are a number of organ systems that also work with the eye. The retina is the only tissue in mammals that regulates photoreception due to the presence of photoreceptors, the rods and cones and performs both visual and non-visual functions Light plays a fundamental role in the behavior of almost all organisms. In addition to visual processes, light also induces important physiological responses. People with mild vascular disease that causes damage to the retina in the eye are more likely to have problems with thinking and memory skills. Everyone has a natural body clock that they are born with and all organs in the body operate according to biological rhythms. Our experiments with ophthalmic mutant rats also showed that the loss of vision also hampered their physiological activities and their rhythmicity was also disturbed. The menstrual cycle disturbances and age of menarche are regulated by many factors; nevertheless, blindness is one of the most impotent factors in regulating biological clock dependent functions.

The human eyes are the only organs in the body capable of "seeing"- wavelengths of light and turning it into visual images. We can't "see" or get a visual image to the brain without eyes. The eye-like ability of skin to sense light by using a receptor (Cryptochrome) but failed to form image.

Photoreceptors contain chemicals that change when they are hit by light. This causes an electrical signal, which is then sent to the brain along the optic nerve. Different types of photoreceptor allow us to see an enormous range of light and colours.

There are two types of photoreceptors in the human retina, rods and cones. Rods are responsible for vision at low light levels (scotopic vision). They do not mediate colour vision and have a low spatial acuity. The blind: People who have lost their sight have different experiences. Some describe seeing complete darkness, like being in a cave. Some people see sparks or experience vivid visual hallucinations that may take the form of recognizable shapes, random shapes and colours, or flashes of light. An afterimage is an image that continues to appear in the eyes after a period of exposure to the original image. Afterimages occur because photochemical activity in the retina continues even when the eyes are no longer experiencing the original stimulus.

2. Physical and Chemical Aspects

The "Human Eye" is a special sense organ compared to the rest other four sense organs present on the body Some parts of the eye are richly supplied with blood whereas others are completely devoid of it. In addition to its "Camera Box" for image formation it is also

*Corresponding author: Purshottam Das Gupta, Founder Director, Iladevi Cataract and IOL Research Centre, Ahmadabad, India, E-mail: pdg2000@hotmail.com

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associated with many other parts for other than camera functions [1]. Its defence system is also unique [2]. The eyes are sense organs that detect and respond to light stimulus giving us sense of sight. Vision depends on detecting light and the photoreceptors perform the function.

The photoreceptors, present on retina (rods and cones), detect light stimuli, colour differentiation, the perception of depth and converts light energy to nerve impulses which are then transmitted to the brain for interpretation. In other words, the eye is an important organ but plying "Passive role" in seeing process. For example, in the eye all tissues are healthy and light conditions are satisfactory, but optic nerve is damaged brain cannot compute the image and the person do not see it [3]. The lighting environment and the timing of the lighting have impact on human physiology and behaviour [4]. These effects of light are transmitted via a novel class of photoreceptors in the mammalian retina, which was discovered not long ago. As the sunlight decreases at the close of the day, the visual system sends signals to the suprachiasmatic nucleus. Next, the SCN sends signals to the pineal gland to increase the production of the hormone melatonin [5]. Since then, it has become evident that light also plays an important role in regulating Non-Image Forming (NIF) functions such as circadian rhythms, alertness, well-being and mood [5,6].

3. Non-Visual Photoreceptors

Photoreceptors Photoreceptors contain chemicals that change when they are hit by light. Many laboratories have localised specialized photoreceptors in unexpected places, such as the central nervous system or in the skin internal organs, (pineal) outside of the eyes [7-10]. These "extraocular photoreceptors" are referred to as "nonvisual" photoreceptors. Different types of photoreceptor allow us to see an enormous range of light: from starlight to full sunshine and all the colours of the rainbow. In humans there are three different types of cone cell, distinguished by their pattern of response to light of different wavelengths. The light sensing Photoreceptors are located in the retina. This eye-like ability of skin to sense light through photoreceptors triggers the production of melanin within hours, more quickly than previously thought [6], in an apparent rush to protect against damage to DNA.

The pineal gland is a small, pea-shaped gland in the brain [11,12]. The adult pineal gland weighs less than 0.2 g and its principal function is to produce about 30 µg per day of melatonin, Its function isn't fully understood What's fascinating is that the interior of the pineal gland actually has retinal tissue composed of rods and cones (photoreceptors) inside its interior lining just like the eye and is even wired into the visual cortex in the brain. The photoreceptors of the retina strongly resemble the cells of the pineal gland [12,13].

The primary function of the pineal gland is to produce melatonin a hormone that helps regulate biological rhythms such as sleep and wake cycles. Melatonin production is stimulated by darkness and inhibited by light [11]. Light sensitive nerve cells in the retina detect light and send this signal to the suprachiasmatic nucleus (SCN), synchronizing the SCN to the day-night cycle. Nerve fibers then relay the daylight information from the SCN to the paraventricular nuclei (PVN), then to the spinal cord and via the sympathetic system to superior cervical ganglia (SCG) and from there into the pineal gland [11,14]. There is some evidence that DMT is also produced endogenously, in other words, it is produced naturally in the body, specifically in the pineal gland in the brain. Rick Strassman has theorised that the human pineal gland is capable of producing the hallucinogen N,N-dimethyltryptamine (DMT) under certain circumstances [15,17].

Recent incarnations of these notions have suggested that N,N-dimethyltryptamine is secreted by the pineal gland at birth, during dreaming and at near death to produce out of body experiences. Scientific evidence, however, is not consistent with these ideas. It is clear that very minute concentrations of N,N-dimethyltryptamine have been detected in the brain, but they are not sufficient to produce psychoactive effects. Alternative explanations are presented to explain how stress and near death can produce altered states of consciousness without invoking the intermediacy of N,N-dimethyltryptamine [15-17].

4. Imbalance of Melatonin

Melatonin is one hormone responsible for our body's daily cycle. When night falls and there is less light input to the SCN, the production of melatonin, the hormone responsible for making us feel sleepy, goes up. When it's dark, more melatonin is secreted, which signals the brain to go into sleep.

In summer when the sun only goes down for a few hours at night in Scandinavian countries; most of the residents in those countries suffer with reduced melatonin levels. Low levels are also observed in various diseases, such as types of dementia, some mood disorders, severe pain, cancer and diabetes type 2 [5]. A common symptom of insufficient melatonin signalling is sleep disturbances [18]. Sleeplessness and insomnia are often due to a lack in melatonin. Alcohol, caffeine, stress and blood sugar imbalances could also lead to melatonin deficiency [19]. On the other hand, too much melatonin causes extremely sleepy during unintended times or cause intense dreams or nightmares. Some additional symptoms of a melatonin overdose may include: crankiness, head ache.

In addition to visual processes, light also induces important physiological responses in the majority of animals, such as pupil constriction, pineal melatonin suppression and the entrainment of circadian rhythms [20,21]. Light plays a fundamental role in the behaviour of almost all organisms, with detection mechanisms that are likely to be universally mediated by opsin-based photopigments and the biochemical photo cascades they activate. Skin is able to detect light by using a Photoreceptor [8]. This eye-like ability of skin to sense light triggers the production of melanin within hours Photoreceptors contain chemicals that change when they are hit by light. This causes an electrical signal, which is then sent to the brain along the nerve. Different types of photoreceptor allow us to see full spectrum of light. Beyond mediating vision, light also has a crucial role in regulating circadian rhythms [22].

5. Functional Aspect

Rat Model

It is well known fact that blind cannot see; now the other function, i.e., without eyes, is there any effect on functioning of circadian rhythms? Sometimes back we developed genetically an ophthalmic (blind rat) and studied the effect of light on various conditions [23]. Light–dark (LD 12:12), continuous dark (DD) and light (LL) conditions. Both normal and mutant an ophthalmic animals showed nocturnal increases in serum melatonin levels and in the number and diameter of SRC and their vesicles in the pinealocytes in LD. The daily rhythms persisted even upon transfer to DD both in normal and mutant rats, whereas in LL, the nocturnal elevation of both the parameters disappeared. These observations suggested that congenitally blind rats can perceive light. The studies of these parameters in both normal and mutant rats in reversed-LD conditions confirmed that pineal rhythms can be entrained by light–dark cycles in congenitally an ophthalmic mutant rat through a non-visual system for light perception.

Mammalian cryptochromes perform both light-dependent and light-independent functions in the regulation of the circadian clock. Several observations demonstrate the light-dependent role of mammalian CRY proteins. Knockout mice lacking one or both CRY genes have a reduced or abolished ability to induce expression of genes such as per and the protooncogene c-fos in response to light [8,23]. Moreover, the pupils of mutant mice lacking both CRY1 and CRY2 have reduced reflex responses to light [23].

On the other hand, the CRY1 CRY2 double mutant mouse shows an apparently normal rhythmicity in light-dark cycling conditions, but it loses rhythmicity instantaneously and completely in free-running (always dark) conditions [23]. These observations indicate that the CRY proteins play an essential and light-independent function in the mammalian central circadian oscillator and that cryptochromes are not the only photoreceptors mediating light control of the clock. The fact that cryptochromes are integral parts of the mouse central oscillator makes it almost impossible to test directly their role in the light entrainment of the clock.

Photopigments governing circadian photoreception have been localized to the inner retina. The relative abundance of CRY2 transcripts, coupled with CRY2 localization to the inner retina, supports a photoreceptive role for CRY2 in human retina. Furthermore, the discovery that CRY2 is also localized within the cytoplasm of some cells in the granule cell layer (GCL), suggests that it may perform a function separate from its known nuclear role in the transcriptional feedback loop underlying the molecular mechanisms.

The increased lens filtering does not necessarily lead to a decreased non-visual sensitivity to light. The lack of age-related decrease in non-visual sensitivity to light may involve as yet undefined adaptive mechanisms [24].

Human Model

An afterimage is an image that continues to appear in the eyes after a period of exposure to the original image. Afterimages occur because photochemical activity in the retina continues even when the eyes are no longer experiencing the original stimulus. A common afterimage is the spot of light one sees after a camera flash has been fired. Afterimages can be an interesting visual phenomenon to observe. They can also be an important tool for helping researchers better understand how colour vision and the visual perceptual system work. Daily retinal light exposure is necessary for the synchronization of the circadian rhythms with the external 24 hr solar environment. This daily synchronization process generally poses no problems for sighted individuals. However, most blind people with no perception of light, however, experience continual circadian desynchrony through a failure of light information to reach the hypothalamic circadian clock, resulting in cyclical episodes of poor sleep and daytime dysfunction. This desynchrony affects, meal timings (metabolism) [25], sleep wake, cycle and psychological disorders [26]. We have also observed the menstrual cycle disturbances and differences in the age of maturity in blind girls compared to sighted girls [27], in order to nullify other influencing factors, we have taken care socioeconomic and nutritional status while surveying the blind and sighted girls. And have reached the conclusion that blindness is one of the most impotent factors in regulating biological clock dependent functions [27].

The 24 hrs cycle that controls biological phenomena such as, body temperature, hunger and sleep and that clock is wired directly to the eyes, so light has a big effect on it. When your clock is off, it doesn't just mess up your sleep. Your hormones, digestion and even your immune system can take a hit, too. Scientists think fighting against your clock can make you sick. Some studies show connections between circadian rhythms that are out of whack and conditions like cancer, diabetes, bipolar disorder and obesity.

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