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Associations of ambient illumination with mood: Contribution of ophthalmic dysfunctions

G. Jean-Louis[a,b,*], D. Kripke[c], C. Cohen[a], F. Zizi[a,b], A. Wolintz[a,b]

[a]*Department of Psychiatry and Ophthalmology, SUNY Downstate Medical Center, 450 Clarkson Avenue (Box 58), Brooklyn, NY 11203-2098, United States*

[b]*Sleep Center, Kingsbrook Jewish Medical Center, NY, United States*

[c]*Department of Psychiatry, University of California, San Diego, CA, United States*

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Abstract

Evidence suggests that ocular pathology could reduce light-stimulated neuronal signaling to the suprachiasmatic nuclei. This study investigated associations of ambient illumination with moods, while considering the contribution of ophthalmic dysfunctions. Seventy Black (59%) and White (41%) Americans participated in the study. Their average age was 68.27±5.97 years; 73% were women. Baseline data included: physical health, mood, and sociodemographics. Ophthalmic factors including visual acuity, visual field defects, intraocular pressure, vertical and horizontal cup-to-disk ratios, and nerve-fiber-layer thickness were assessed at SUNY Downstate's eye clinic. The following week, participants wore the Actiwatch-L at home to monitor ambient illumination and sleep. Cosine analyses were performed on the logarithm of measured illumination, yielding the mesor and acrophase of daily illumination exposure. Sleep was estimated with an automatic scoring algorithm. Of the sample, 25% reported visual impairment and 85% reported good to excellent health; 27% were visually impaired according to American criteria. Partial correlation analyses showed an inverse correlation of daily illumination levels to depressed mood [r_p=−0.33, P<0.05], when age, sex, ethnicity, income, BMI, diabetes, hypertension, respiratory disease, and habitual sleep duration were controlled. With further control for ophthalmic factors, the magnitude and significance of the correlation diminished [r_p=−0.26, NS]. Individuals receiving daily illumination later in the day reported more depressed moods [r_p=0.36, P<0.01]; of note, this correlation was not significant after control for the covariates [r_p=0.18, NS]. Regression analysis indicated that the ophthalmic factors explained 13% of the variance in depression. Our results show that both the level and timing of ambient illumination are associated with mood. Furthermore, they suggest that visual impairment has a mediating effect on the associations of ambient illumination with depression, supporting the notion that ocular pathology lessens the efficacy of daily illumination in promoting positive moods.

Keywords: Illumination; Light exposure; Depression; Mood; Eye; Ophthalmic

1. Introduction

A naturalistic, population-based study demonstrated that San Diego adults receiving low ambient illumination levels were likely to report depressed moods [1,2]. This was not surprising, as numerous clinical and experimental studies have shown that bright light exposure reduces depressed moods among patients experiencing seasonal or non-seasonal depression [3–13]. Indeed, even outdoor illumination exposure has proven effective in improving subjective mood [14].

A long-standing concern has been that individuals with ophthalmic dysfunctions might require greater illumination exposure than persons with healthy eyes in order to achieve circadian entrainment and to maintain positive moods [15]. Ocular pathology [16–19] could reduce light-stimulated neuronal signaling to the suprachiasmatic nuclei (SCN). The SCN constitute the predominant circadian pacemaker

* Corresponding author. Department of Psychiatry and Ophthalmology, SUNY Downstate Medical Center, 450 Clarkson Avenue (P.O. Box 58), Brooklyn, NY 11203-2098, United States. Tel.: +1 718 270 4035; fax: +1 718 270 2972.

E-mail addresses: gjean-louis@downstate.edu, jeanlouisg@yahoo.com (G. Jean-Louis).

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that controls most circadian rhythms including melatonin, rest-activity, body temperature, cortisol, sleep–wake cycle, and heart rate [20–27].

In blind persons with complete absence of light perception, the SCN have a propensity to free-run, [23,28,29] so that their biological rhythms are desynchronized from the solar day [28–30]. Research in this population reveals that the consequences of desynchronized SCN include sleep disturbances and depressed moods [28,30–34]. Among visually impaired individuals, however, the consequences of malsynchronized SCN have not been empirically assessed. There are suggestions that visual impairment might cause dampened endogenous rhythms, depression, and sleep disturbances [28,30,35–49].

It bears noting that an experimental bright light study found improvement of circadian rhythm functions only among Alzheimer's patients with intact vision, but not among visually impaired patients [50]. Additionally, there is evidence that older adults exhibit resistance to light treatments, a characteristic which might explain why their circadian rhythms tend to be malsynchronized [51–56]. These findings have suggested that the biologic effects of ambient illumination may be attenuated by ophthalmic dysfunctions. In the present study, we investigated associations of ambient illumination with moods, while considering the contribution of ophthalmic dysfunctions as explanatory factors.

2. Materials and methods

2.1. Participants

Seventy Black (59%) and White (41%) Americans participated in the study; 73% were women and 27%, men. Their average age and BMI were 68.27±5.97 years and 27.68±5.72 kg/m^2, respectively. Individuals responding to study advertisement in communities surrounding SUNY Downstate Medical Center in Brooklyn, New York completed baseline questionnaires. Volunteers were included in the study if they had no current eye diagnosis, their self-stated race was Black or White, were 606 years old or older, and provided informed consent. They were excluded if they indicated major depression or lithium use, sleep apnea, drugs that influence endogenous melatonin, a history of ocular surgery or laser treatment, or impaired cognitive or functional ability. Respondents who met study criteria provided informed consent and were compensated for participating in the study. They underwent a comprehensive eye exam at SUNY Downstate's Eye Clinic and provided sleep and illumination data. Institutional Review Boards at UCSD and SUNY approved the study.

2.2. Procedures

At baseline, physical health was assessed with the Comprehensive Assessment and Referral Evaluation (CARE). This instrument is used to assess physical disability and has been used extensively in investigations involving older individuals in minority populations. It has shown good construct validity [57] as well as concurrent and predictive validity [58]. In the present analysis, five sub-scales were included: vision disorder, respiratory disease, diabetes, hypertension, and sleep disorder (Cronbach α=0.80; 0.86; 0.82; 0.91; and 0.92, respectively). We used a modified version of the vision disorder subscale of the CARE, which amalgamates answers to 11 yes/no questions about vision problems; a cut-off score of 4 and above was used to define subjective visual impairment (α=0.80) [59].

Depressed moods were assessed with the 30-item Geriatric Depression Scale (GDS) [60]. It comprises five main factors described as: sad mood, lack of energy, positive mood, agitation, and social withdrawal. According to one study that examined depressed moods among adults (≥60 years old) attending primary-care clinics, the GDS had a sensitivity of 100% and a specificity of 84% in screening for major depression, using a cut-off score of 10 [61]; lower specificity has been found when a cut-off score of 11 was used [62]. When the Center for Epidemiologic Studies-Depression Scale was administered to the same sample, a sensitivity of 92% and a specificity of 87% were noted using a cut-off score of 21.

To assess ophthalmic dysfunctions, several exams were performed yielding data on visual acuity, visual field defects, intraocular pressure, vertical and horizontal cup-to-disk ratios, and nerve-fiber-layer thickness. A trained technician carried out eye exams. Photos were graded by an ophthalmologist, and eye diagnoses were rendered using both medical and ophthalmic data.

Visual acuity was obtained using the Snellen chart; higher scores represented worse acuity. For visual field testing, the SITA standard program of the Humphrey Field Analyzer was used, allowing estimation of ocular nerve loss [63–65]. Results from the Ocular Hypertension Treatment Study indicated that 97% of all visual field examinations were reliable [66]. Tonometry was used to assess intraocular pressure [67,68]. The Egna–Neumarkt glaucoma study revealed that the sensitivity and specificity of tonometry in recognizing glaucoma (cut-off between 21 and 22 mm Hg) were 80% and 98%, respectively [67]. Indirect ophthalmoscopy and fundus photography were used to examine the retina and the macula [68–70]. Vertical and horizontal cup-to-dish ratios in the optic dish were derived. Results of the Early Treatment Diabetic Retinopathy Study indicated agreements rates ranging from 78% to 83% between retinal specialists and photographic graders [71]. Peripapillary nerve-fiber-layer thickness was assessed as a means to indicate atrophy of the retinal ganglion cells with a scanning laser polarimeter (Nerve Fiber Analyzer GDX) [72,73]. One study has shown that the GDX can detect glaucomatous eyes with a sensitivity of 71% and a specificity of 91% [74].

During the week that followed eye exams, participants wore an actigraph (Actiwatch-L, Mini Mitter) at home to