Society for Light Treatment and Biological Rhythms

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SLTBR 22ND ANNUAL MEETING PROGRAM

Thursday, July 1st, 2010

8:00-1:00 pm	Registration
9:00 - 11:30 am	**CME/DFP Course (in English; additional fee is required)** Introductory Course on Chronobiology, Sleep, Seasonality, and Psychopharmacological Interventions *Chairs: Siegfried Kasper & Matthaeus Willeit, Medical University Vienna, Austria*
9:00-9:45 am	**The biology of circadian and seasonal rhythms in psychiatry (Die Biologie zirkadianer und jahreszeitlicher Rhythmen in der Psychiatrie)** *Nicole Praschak-Rieder, Medical University Vienna, Austria*
9:45-10:15 am	**The chronobiology of sleep and sleep disorders (Die Chronobiologie von Schlaf und Schlafstörungen)** *Göran Hajak, University of Regensburg, Germany*
10:15-10:45 am	Break
10:45-11:30 am	**Psychopharmacological interventions in chronobiological rhythms (Psychopharmakologische Beeinflussung chronobiologischer Rhythmen)** *Siegfried Kasper, Medical University Vienna, Austria*
11:30-1:00 pm	Lunch (on your own)
1:00 - 1:30 pm	**President's Welcome** *Namni Goel, University of Pennsylvania, USA*
1:30 - 2:00 pm	**History of SAD (Local Chair's Welcome)** *Siegfried Kasper, Medical University Vienna, Austria*
2:00 - 4:30 pm	**Symposium I: Circannual Changes in Neurobiology and Psychopathology** *Chairs: Matthaeus Willeit & Nicole Praschak-Rieder, Medical University, Vienna, Austria*
2:00-2:30 pm	**Positron emission tomography imaging of seasonal changes in brain serotonin transmission** *Christoph Spindelegger, Medical University Vienna, Austria*

2:30-3:00 pm **Serotonin transporter promoter polymorphism and seasonal changes in brain serotonin transporter binding**
Jan Kalbitzer, Charité Berlin, Germany

3:00-3:30 pm **Seasonal changes in female reproductive function**
Konstantin Danilenko, Russian Academy of Medical Sciences, Russia

3:30-4:00 pm **Seasonal changes in suicide frequency: What biology can learn from epidemiology**
Martin Voracek, University of Vienna, Austria

4:00-4:30 pm **The relationship between the spring peak in suicides and depression**
Zoltán Rihmer, National Institute for Psychiatry and Neurology, Hungary

4:30-5:00 pm Break

5:00-7:00 pm **Poster session with discussion (wine and cheese)**

Friday, July 2nd, 2010

8:30-11:30 am Registration

9:00 - 11:00 am **Symposium II: How to Shift Circadian Rhythms with Light and Melatonin, PRCs, Night Shift Work and Sleep Deprivation**
Chair: Charmane Eastman, Rush University Medical Center, USA

9:00-9:30 am **Light and melatonin phase response curves (PRCs)**
Vikki Revell, University of Surrey, United Kingdom

9:30-10:00 am **Lighting up the days of night workers**
Marie Dumont, University of Montreal and Sacre-Cœur Hospital of Montreal, Canada

10:00-10:30 am **Helping night shift workers: rhythms vs. real life**
Charmane Eastman, Rush University Medical Center, USA

10:30-11:00 am **Sleep deprivation and the circadian clock**
Helen Burgess, Rush University Medical Center, USA

11:00-11:15 am Break

11:15-12:35 pm	**Oral Presentations I. Mechanisms of Alertness**
11:15-11:35 am	**T3111C polymorphism of the circadian core gene, *Clock,* predicts interindividual differences in affect, sleepiness, fatigue and executive functioning during baseline and chronic partial sleep deprivation in healthy adults** *N. Goel, S. Banks, L. Lin, E. Mignot, D.F. Dinges*
11:35-11:55 am	**Cognitive performance under rotating shift work – is the morning shift a risk factor?** *K. Pusch, A. Jessen, T. Roenneberg, M. Krifka*
11:55-12:15 pm	**Blocking short wavelengths of light does not impact alertness level in the middle or end of a sleep deprived night** *A. Sasseville, J. Houle, M. Hébert*
12:15-12:35 pm	**The pupillary reflex during short-term light exposure in vivo: is melanopsin bistability detectable?** *B. Sander, M. Stormly, A. Broendsted, C. Nissen, A. Kawasaki*
12:35-2:00 pm	Lunch (on your own)
2:00-3:20 pm	**Oral Presentations II. Clinical Disorders and Seasonality**
2:00-2:20 pm	**Successful chronotherapeutics normalizes brain imaging correlates of emotional processing in bipolar depression** *F. Benedetti*
2:20-2:40 pm	**Effect of light treatment on circadian rhythms, rest-activity cycles and well-being in women with emotional instability of the borderline type** *V. Bromundt, S. Kyburz, G. Dammann, A. Wirz-Justice, C. Cajochen*
2:40-3:00 pm	**Seasonality effects of sunshine on suicide** *B. Vyssoki, G. Sonneck, N. Praschak-Rieder, S. Kasper, M. Willeit, N.D. Kapusta*
3:00-3:20 pm	**Season of birth associated with body fat at birth in Canadian children** *R.D. Levitan, J.L. Kennedy, P. Silveira, M. Steine, C. Soares, H. Gaudreau, S. Matthews, M. Meaney*
3:20-3:45 pm	Break
3:45-4:00 pm	**J. Christian Gillin Junior Investigator Research Award** **Is total sleep deprivation combined with light therapy a long-lasting treatment? Predictors and outcome in bipolar depression** *D. Delmonte, C. Gavinelli, C. Brambilla, B. Barbini, F. Benedetti, C. Colombo, E. Smeraldi*

4:00-5:00 pm SLTBR Annual Business Meeting

7:00 pm Annual Banquet at Kursalon

Saturday, July 3rd, 2010

9:00 - 11:00 am **Symposium III: Lighting and Health**
Chair: George Brainard, Thomas Jefferson University, USA

9:00 - 9:30 am **Basic physiology of phototransduction for the circadian system**
Samer Hattar, Johns Hopkins University, USA

9:30 - 10:00 am **Method for prospective analysis of the circadian efficacy of daylight**
Christopher Pechacek, Brooks Air Force Base, USA

10:00 - 10:30 am **Architecture and light: a spectrum of choices**
Phillip Mead, University of Idaho, USA

10:30-11:00 am **Lighting for manned space exploration**
George Brainard, Thomas Jefferson University, USA

11:00-11:15 am Break

11:15-12:35 pm **Oral Presentations III. Biological Effects of Light**

11:15-11:35 am **Light-controlled melatonin suppression: effects of age**
H. Piazena, L. Franke, R. Uebelhack, D. Kockott

11:35-11:55 am **Patterns of hormonal release in plasma in natural and artificial light**
M. Säter

11:55-12:15 pm **Influence of daytime light on nighttime parameters including sleep, melatonin secretion and alertness**
C. Stoll, A. Rodenbeck, C. Schierz, D. Kunz

12:15-12:35 pm **Effect of light in schools: replication of a field study in the lab**
N. Wessolowski, C. Barkmann, M. Schulte-Markwort

12:35-1:00 pm **President's Closing Remarks**
Namni Goel, University of Pennsylvania, USA

SLTBR 22ND ANNUAL MEETING

POSTER PRESENTATIONS

SEASONALITY AND MOOD DISORDERS: CLINICAL STUDIES AND FUTURE PERSPECTIVES
B. Barbini, C. Gavinelli, C. Brambilla, S. Ragni, C. Colombo

SEASONALITY, MOOD, AND SLEEP QUALITY IN COLLEGE STUDENTS IN A NORTHERN LATITUDE
J. Dada-Samuel, J.R. Prichard

FOUR MONTHS FOLLOW-UP IN BIPOLAR DEPRESSION AFTER TOTAL SLEEP DEPRIVATION WITH LIGHT THERAPY
D. Delmonte, C. Gavinelli, C. Brambilla, B. Barbini, F. Benedetti, C. Colombo, E. Smeraldi

THE ERG RESPONSES TO LIGHT STIMULUS LEVELS OF MELANOPSIN-EXPRESSING RETINAL GANGLION CELLS WITH THE RECEPTOR-SILENT SUBSTITUTION TECHNIQUE
Y. Fukuda, S. Tsujimura, S. Higuchi, A. Yasukouchi, T. Morita

SEASONALITY AND HERATABILITY IN EUTHYMIC MOOD DISORDER PATIENTS
C. Gavinelli, D. Delmonte, C. Brambilla, B. Barbini, C. Colombo

IN VIVO QUANTIFICATION OF LENS TRANSMISSION IN ELDERLY SUBJECTS BEFORE AND AFTER CATARACT SURGERY
M.C. Giménez, M.J. Kanis, D.G.M. Beersma, B.A.E. van der Pol, D. van Norren, M.C.M. Gordijn

FORMATION OF LUMIRUBIN DURING LIGHT THERAPY IN ADULTS
F. Grass, W. Wyskovsky, S. Kasper

EFFECTS OF SHORT WAVELENGTH SOLID-STATE LIGHTING ON MELATONIN SUPPRESSION AND ALERTNESS
J. Hanifin, M. Thiessen, J. Balaicuis, E. Evans, K. West, B. Warfield, K. Cecil, J. Kemp, M. Jablonski, M. Downes, M. James, B. Byrne, E. Gerner, C. Pineda, D. Sliney, J. Maida, C. Bowen, N. Goel, D. Dinges, S. Lockley, G. Brainard

SPECTRAL TRANSMITTANCE OF MODERN GLAZING SYSTEMS AND ITS IMPACT ON THE INTERNAL LIGHT ENVIRONMENT
P. Hanuliak, J. Hraška

PROMOTING ALERTNESS AND SLEEP BY DYNAMIC LIGHTS FOR CONTROL ROOM OPERATORS
A. Lowden

OCULAR PARAMETERS AS AN OBJECTIVE TOOL FOR THE ASSESSMENT OF TRUCK DRIVERS FATIGUE
Y. Morad, Y. Barkana, D. Zadok, M. Hartstein, E. Pras, Y. Bar-Dayan, Y. Bar-Dayan

EFFECTS OF NIGHT MEAL ON SECURITY GUARDS' SLEEPINESS
C. Moreno, P. Nehme, M. Ulhoa, M.A. Codarin, E. Moulatlet

LIGHTING IN CARE HOMES FOR OLDER PEOPLE
P.L. Morgan, S. Hopkins, B. Middleton, L.J.M. Schlangen, D.J. Skene

CHANGE IN SLEEP STATE OF THE ELDERLY BEFORE AND AFTER CATARACT SURGERY
T. Morita, M. Tanaka, K. Hosoe, T. Hamada

MORNING PEOPLE ARE STABLE, PSYCHOLOGICALLY AND CHRONOBIOLOGICALLY: A PRELIMINARY REPORT
G. Murray, J. Anderson, T. Cooper, J. Gooley, S. Lockley

ACUTE NON-VISUAL RESPONSES TO SIMULTANEOUS PRESENTATION OF BLUE AND RED MONOCHROMATIC LIGHT IN HUMANS
C. Papamichael, D.J. Skene, V.L. Revell

THE INFLUENCE OF DURATION AND IRRADIANCE OF LIGHT ON ACUTE NON-VISUAL RESPONSES IN HUMANS
C. Papamichael, D.J. Skene, V.L. Revell

IMPACT OF LIGHT THERAPY ON THE EASE OF LEARNING CURVE AND ACADEMIC SUCCESS RATE OF STUDENTS
J. Roby

PHASE RESPONSE CURVE TO A SINGLE 6.5-H LIGHT PULSE OF SHORT-WAVELENGTH LIGHT
M. Rüger, M. St. Hilaire, G.C. Brainard, C.A. Czeisler, S.W. Lockley

EFFECT OF BRIGHT LIGHT ON SLEEPINESS OF NIGHT WORKERS
K. Sadeghniiat, Z. Yazdi, O. Aminian, M. Abbasi

EFFICACY AND HYPNOTIC EFFECTS OF MELATONIN IN SHIFT-WORK NURSES: DOUBLE-BLIND, PLACEBO- CONTROLLED CROSSOVER TRIAL
K. Sadeghniiat, Z. Yazdi, O. Aminian, M. Abbasi

METEOROLOGICAL ANALYSIS OF SYMPTOM DATA FOR PEOPLE WITH SAD (SEASONAL AFFECTIVE DISORDER)
C.E. Sarran, P. Sachon, Y. Meesters

AN ACUTE EFFECT OF LIGHT ON REPRODUCTIVE HORMONES IN WOMEN: THE ROLE OF SPECTRUM
O.Y. Sergeeva, K.V. Danilenko

MENSTRUAL CYCLES ARE INFLUENCED BY SUNSHINE
O.Y. Sergeeva, K.V. Danilenko

MONITORING PHYSIOLOGICAL VARIABLES DURING SIMULATED NIGHT SHIFT WORK: THE INFLUENCE OF NOCTURNAL MODERATELY BRIGHT LIGHT EXPOSURE
O.Y. Sergeeva, K.V. Danilenko, V.L. Revell, D.J. Skene, V. Kolodyazhniy, A. Wirz-Justice

SEASONAL EFFECTS ON DEPRESSION RISK (EPDS>10) AND SUICIDAL SYMPTOMS IN WOMEN
D.K.Y. Sit, K.L. Wisner, H. Seltman, M. Terman

CHRONOBIOLOGICAL STUDY OF CIRCADIAN VARIABLES OF MUSCULAR FORCE OF GLASS BLOWERS WHO ARE WORKING IN ALTERNATE SHIFTS
E. Vladut

SOCIETY FOR LIGHT TREATMENT AND BIOLOGICAL RHYTHMS ABSTRACTS 2010

LIGHT DIRECTLY INFLUENCES LEARNING AND MOOD PREDOMINANTLY THROUGH MELANOPSIN CELLS

C.M. Altimus, T. LeGates, S. Hattar
Johns Hopkins University, Department of Biology, Baltimore, MD USA

Objectives: Short day length and irregular light schedules can lead to mood disorders, cognitive dysfunction, and fatigue as observed in seasonal affective disorder, shift work, and transmeridian travel. Although a common feature of these various conditions is a change in the timing or duration of light input, sleep and circadian rhythms disruptions may also contribute to these symptoms. The objective of this study is to understand the direct role of light in regulating cognitive functions and mood-related behaviors.

Methods: To gain a better understanding of how light information influences limbic functions, we administered light pulses throughout the circadian cycle in a manner that does not change sleep amounts or abolish circadian rhythmicity and then assessed learning and mood-related behaviors. In mammals, light is transduced by photoreceptors in the retina into an electrical signal that can be interpreted by the brain. To determine the cells responsible for conveying this light information to areas of the brain that control learning and mood, we used a mouse line lacking melanopsin containing intrinsically photosensitive retinal ganglion cells (ipRGCs). These ipRGCs have been shown to convey light information to modulate circadian rhythms and sleep but have not been linked to light-influenced limbic functions.

Results: We show that this irregular light schedule increases depression-like behaviors and reduces hippocampal long-term potentiation and learning. Alleviating the depression-like behaviors in mice exposed to the irregular light cycles by administering an antidepressant restores hippocampal dependent learning. In addition, ablating melanopsin cells in mice, which eliminates circadian photoentrainment but maintains image formation, shows that the disruptive effects of the irregular light cycles on learning and mood are mediated via melanopsin cells.

Conclusions: These results reveal that light information conveyed by melanopsin cells modulates cognitive functions and mood and indicate that the temporal modulation of subconscious light detection is important for proper cognitive functions including learning and mood.

Keywords: Circadian, Sleep, ipRGCs, Retina, Cognition

Funding Support: This work was supported by the David and Lucile Packard Foundation.

SEASONALITY AND MOOD DISORDERS: CLINICAL STUDIES AND FUTURE PERSPECTIVES

B. Barbini, C. Gavinelli, C. Brambilla, S. Ragni, C. Colombo
Department of Clinical Neurosciences, Mood Disorders Unit - San Raffaele Turro Hospital, Milan, Italy, University Vita Salute San Raffaele Milano

Objectives: In recent years, studies on mood disorders have progressively focused on the study of seasons and mood during depressive or manic episodes and during euthymic periods, episodes during a lifetime, or more than one episode each year (as seen in rapid cyclers). Furthermore, intra-individual variability exists because the illness sometimes shows a tendency to shorten in subsequent cycles. The recurrence pattern is also influenced by external factors, the most important of which are light and changes of in lighting exposure during the seasons. Seasonal patterns have been observed in processes involving serotonergic functioning, and it has been postulated that these processes may be influenced by photoperiod, suggesting that the seasonal patterns of incidence of several psychiatric conditions may share a common neurophysiological substrate. The typical pattern of recurrence of mood disorders follows interindividual patterns since each patient presents his own specific pattern in response to a few pharmacological treatments, which shorten in the subsequent cycle of illness, and in maintenance treatments, which decrease episode rates. Some authors have stressed the concept of seasonality, as many patients show critical months of the year when they tend to have a new recurrence independent of polarity.

Methods: The aim was to evaluate the influence of chronobiological and genetic factors in two different samples of patients who were consecutively recruited during the past year: the first one was consisted of euthymic outpatients formerly affected by Major Depressive Disorder, Bipolar Disorder and Major Depressive Disorder (Single Episode). A second group consisted of inpatients affected by Mood Disorders recruited during the acute phase of illness. Socio-demographic information, medical information, and data on seasons of onset and of previous episodes were collected though an anamnestic sheet. Patients completed a battery of questionnaires on seasonal patterns, chronotype and sleep quality. T-test analyses were performed to investigate relationships between all the clinical and sociodemographic variables, and determine differences in the various assessment scales.

Results: We found significant seasonal distributions of mood recurrences, with lower seasonality in patients affected by Major Depressive Disorder (Single Episode) than patients with a longer history of illness. Patients reporting heritability for their disorder had a significantly higher fluctuation throughout the seasons. In relation to sleep, we found differences between Unipolar and Bipolar patients and we found that high seasonality was associated with complaints in sleep adequacy and in sleep disturbance. There are other seasonal environmental factors which were potential triggers for seasonal changes in mood. One such factor, known to induce seasonal allergies in a large portion of the population, is high pollen counts. We found a higher seasonality in patients that reported feeling worse in high pollen periods.

Conclusions: Our data suggest three important considerations: the identification of a seasonal concordance can help patients become more aware of specific risk periods for developing recurrences; the presence of seasonality can be related to the patient's heritability of disease; and sleep problems are a significant characteristic of Unipolar and Bipolar patients even in euthymic periods, indicating that chronobiological disregulations persist even after the remission of an illness episode. Therefore, sleep, light and seasonality are three interconnected features that lie at the basis of chronobiology that, when altered, have an important effect both on psychopathology and on the treatment of depression.

Keywords: Seasonality, Photoperiod, Sleep

SUCCESSFUL CHRONOTHERAPEUTICS NORMALIZES BRAIN IMAGING CORRELATES OF EMOTIONAL PROCESSING IN BIPOLAR DEPRESSION

F. Benedetti
Ospedale San Raffaele, Division of Neuroscience, Milano, Italy

Objectives: There is still a high uncertainty about which biological changes are needed to recover from a major depressive episode. Changes of monoaminergic neurotransmission are often emphasized, but they are paralleled by profound changes in brain metabolism, biological rhythms, and intracellular neuronal signaling pathways regulating gene expression, neuroplasticity, and neurotrophic mechanisms. Sleep deprivation (SD) and light therapy (LT) target the biological mechanisms which are responsible of the possibility, unique to mood disorders, of rapid switching between depression, euthymia, and mania. Multiple neurobiological effects correlate with the clinical mood amelioration, suggesting a multi-target mechanism of action, and an impressive group of brain imaging studies (using positron emission tomography, single photon emission tomography, functional magnetic resonance imaging, proton spectroscopy, arterial spin labeling) showed that the clinical response is associated with metabolic changes in cortico-limbic structures. We explored the functional meaning of these changes by assessing neural responses to emotional stimuli (negative facial expression) with blood oxygen level dependent functional magnetic resonance imaging (BOLD fMRI) techniques.

Methods: We studied 35 healthy participants and 40 patients affected by a major depressive episode in the course of bipolar depression, severe, without psychotic features. Patients were treated for one week with combined repeated SD (three cycles, interspersed with recovery sleep) and morning LT. Mood changes were rated on Hamilton Depression Rating Scale (HDRS). BOLD fMRI neural responses to a face-matching paradigm (which allow exploration of implicit emotional processing) were studied at 3.0-Tesla before and after antidepressant treatment. Diagnosis and response to treatment were considered as factors, with sex and age as nuisance covariates. Results were corrected for multiple comparisons with family-wise error.

Results: Twenty-seven patients (67.5 %) showed a full antidepressant response after the one-week treatment (remission criteria: final HDRS scores <8). In the whole sample the task activated cortico-limbic structures including the amygdala, anterior cingulate cortex (ACC), and dorsolateral prefrontal cortex (PFC). In comparison to controls, patients showed higher reactivity in amygdala, and lower reactivity in ACC and PFC. Responders had higher responses in PFC than non-responders. As a result of successful treatment, responders were able to reduce amygdala reactivity, and increase ACC reactivity, thus reaching the values of healthy controls, while non-responders could not normalize neural responses in these areas.

Conclusions: Confirming previous results by our research group, one week of antidepressant chronotheraputics with combined SD+LT could induce clinical remission in the majority of patients affected by bipolar depression. Remission was paralleled by profound changes in the activity of cortico-limbic structures known to participate in the experience of emotion. Amygdala activation with bottom–up, stimulus-driven emotional processing and neural responses in amygdala correlate with the subjective experience of emotion. Conversely, PFC and ACC exert an inhibitory feedback on amygdala in response to aversive stimuli. A deficit in the inhibitory function of these latter areas in our bipolar depressed patients could provide a neural basis for their enhanced sensitivity to negative stimuli and mood-congruent distortions in the cognitive control of emotions. Successful chronotherapeutics targeted these mechanisms and restored the normal top-down filter on the limbic reactivity to aversive stimuli.

Keywords: Bipolar Disorder, Sleep Deprivation, Light Therapy, BOLD fMRI

LIGHTING FOR MANNED SPACE EXPLORATION

G. Brainard, J. Hanifin
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In the art and science of lighting building interiors, four traditional objectives have been to provide light that: 1) is optimum for visual performance; 2) is visually comfortable; 3) permits aesthetic appreciation of the space; and 4) conserves energy. Over the past 30 years, the biomedical literature has shown that light can be used to successfully treat patients with selected affective and sleep disorders as well as healthy individuals who have circadian disruption due to shift work, transcontinental jet travel, or space exploration (Lam, R.W., Seasonal Affective Disorder and Beyond: Light Treatment for SAD and Non-SAD Disorders, 1998; Dijk et al., Amer. J. Physiol. 281, 2001). In view of that published literature, the Commission Internationale de l'Eclairage (CIE), the Illuminating Engineering Society of North America (IESNA) and the Deutsches Institut fur Normung (DIN) have published monographs addressing the broad topic of how light effects human health (Commission Internationale de l'Eclairage, Ocular Lighting Effects on Human Physiology and Behaviour, Technical Report 158, 2004; Illuminating Engineering Society of North America, Light and Human Health: An Overview of the Impact of Optical Radiation on Visual, Circadian, Neuroendocrine, and Neurobehavioral Responses, IES TM-18-08, 2008; Deutsches Institut fur Normung, Optical radiation physics and illuminating engineering - Part 100: Non-visual effects of ocular light on human beings - Quantities, symbols and action spectra, DIN V 5031-100:2009-06, 2009). This emergent topic provides the basis for major changes in future architectural lighting strategies.

Space exploration vehicles and space habitats, although highly specialized, are architectural environments which still employ light for the traditional architectural purposes, but can also use light as a built-in stimulus for potentially improving circadian, neuroendocrine and neurobehavioral regulation of astronauts. Circadian disruption and sleep deficits have been identified as major risk factors during space missions (Longnecker and Molins, Bioastronautics Roadmap, 2005; NASA Human Research Program Integrated Research Plan, HRP-47065, 2009). The resulting physiological and behavioral changes from circadian disruption can threaten the success of a mission by diminishing alertness, cognitive ability, and psychomotor performance. Similar issues confront the earth based ground crews that support space flight missions. This presentation will review progress towards the development of lighting countermeasures for sleep and circadian disruption in astronauts and ground crew members. In addition, preliminary work on the potential use of solid state lighting systems onboard the International Space Station will be discussed.

Keywords: Circadian Phototransduction, Light, Melatonin, Pineal Gland, Space Exploration

Funding Support: This work supported by the National Space Biomedical Research Institute through NASA NCC 9-58, NASA Award #NNX09AM68G, and the Philadelphia IESNA Chapter. Philips Lighting, an NSBRI industrial partner, provided the lighting systems for some of the work discussed here.

EFFECT OF LIGHT TREATMENT ON CIRCADIAN RHYTHMS, REST-ACTIVITY CYCLES AND WELL-BEING IN WOMEN WITH EMOTIONAL INSTABILITY OF THE BORDERLINE TYPE

V. Bromundt[1], S. Kyburz[1], G. Dammann[2], A. Wirz-Justice[1], C. Cajochen[1]
[1]Centre for Chronobiology, Psychiatric Hospitals of the University of Basel, Switzerland; [2]Psychiatric Clinics Münsterlingen, Switzerland

Objectives: Patients with Borderline Personality Disorder (BPD) suffer from instable self-image and relationships interacting with problems in affect regulation and mood variability, depression, anxiety and self-injurious behavior. Disturbances in sleep and daytime fatigue are also common complaints in this patient group. Here, we investigated circadian rhythms, rest-activity cycles and well-being in women with BPD under real life situations with and without light treatment.

Methods: Fourteen medicated and unmedicated women (29.9±5.5y) diagnosed with BPD according to DSM-IV criteria and the Borderline Personality Inventory (BPI) were investigated during 3 weeks with and 3 weeks without light treatment (Sept.-March) in a cross-over design. Rest-activity cycles were measured using wrist actimetry and sleep-wake logs. Once a week, multiple saliva samples were collected over a 27-h period for the determination of diurnal melatonin and cortisol rhythms. On the same day, questionnaires concerning their present well-being, daytime alertness, anxiety and anger were filled in at wake-up, at midday, in the evening, and at bedtime. Throughout the entire study protocol, regular interviews and a range of questionnaires were used to assess clinical state (SKID interview, BSL, PSQI, SPAQ+, BDI, SIGH-ADS, STAI, STAXI, SPQ). Morning light therapy (Daylight, Uplift Technologies, Canada) was administered at home for 30-40min timed according to MEQ score and compliance was checked by the light sensor on Actiwatch. 10 healthy women (25.7±4.6y), matched by age and daily commitments (<15h working per week), followed the same protocol over 6 weeks, but without light treatment. Data gathered during week 2 and 3 of light treatment (LT) and of no light treatment (oLT) were used in the statistical analysis.

Results: BPD patients had significantly worse subjective sleep quality (PSQI, $p<0.001$), higher scores in anxiety (STAI, $p<0.001$) and anger (STAXI, $p<0.001$) compared to healthy controls. BPD also showed significantly higher depression scores and reduced daytime alertness than controls during both oLT and LT (BDI, $p<0.001$; WM, $p<0.001$). Seven of the 14 BPD fulfilled SAD, 2 Sub-SAD criteria according to SPAQ+, whereas 2 controls fulfilled Sub-SAD criteria. BPD patients had highly disturbed, normal and highly regular rest-activity cycles (relative amplitude RA: range 0.52-0.97, median=0.81) during oLT, which did not reach significance when compared to controls (RA: range 0.79-0.95, median=0.9; t-test BPD-controls: $p=0.106$). Furthermore, the diurnal profiles of salivary melatonin and cortisol did not significantly differ between BPD patients and controls. Actimetric derived sleep parameters revealed worse sleep quality in BPD during oLT compared to controls (sleep efficiency, $p=0.024$, sleep onset latency, $p=0.031$, mean wake bout time, $p=0.019$, sleep duration, $p=0.047$). Morning light treatment caused a significant phase advance of L5onset of activity ($p=0.019$), and a tendency for the M10onset ($p=0.096$) and the melatonin onset ($p=0.093$) in BPD compared to oLT. Moreover, sleep duration was significantly shortened ($p=0.023$), and daytime alertness significantly improved ($p=0.014$). Furthermore, atypical depression scores ($p=0.024$) were significantly declined in BPD during LT compared to oLT, whereas general depression scores and borderline symptoms showed no improvement.

Conclusions: Light treatment has clear beneficial effects in BPD such that it improves daytime alertness and atypical depression symptoms. Therefore, light therapy may be a useful adjunctive treatment of these patients.

Keywords: Light Treatment, Circadian Rhythms, Alertness, Borderline Personality Disorder

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SLEEP DEPRIVATION AND THE CIRCADIAN CLOCK

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Objectives: Sleep deprivation is a pervasive trend in much of modern society. However the impact of short sleep episodes on the human circadian clock has not been fully determined. In this presentation we will explore the impact of short sleep episodes on (1) the timing of the human circadian clock and (2) the responsiveness of the human circadian clock to bright light.

Methods: Five experiments addressing the following questions will be described: (1) what happens to circadian phase when bedtime is delayed by 3 hours? (2) what happens to circadian phase when wake time is delayed by 3 hours? (3) do two weeks of short sleep episodes alter phase advances to bright light? (4) do two weeks of short sleep episodes alter phase delays to bright light? Finally we will describe the effects of sleep deprivation *per se* on phase shifts to bright light. All experiments were within subjects design, counterbalanced across subjects. In all experiments the salivary dim light melatonin onset (DLMO) was used as the phase marker of the circadian clock.

Results: The results indicate that (1) delaying bedtime significantly delays the circadian clock, indicating humans are remarkably sensitive to dim evening indoor light, (2) delaying wake time ("sleeping in") leads to a large phase delay indicating the importance of morning light in determining circadian phase, (3) two weeks of short sleep episodes significantly reduce phase advances to bright light and (4) phase delays to bright light. Finally, sleep deprivation significantly reduces phase shifts to bright light.

Conclusions: These results reveal the significant impact that short sleep episodes have on the timing of the human circadian clock and its responsiveness to light. As the human circadian clock phase shifts quite slowly, these findings suggest that the treatment of circadian rhythm sleep disorders with bright light will be negatively impacted in people with a history of short sleep episodes.

Keywords: Melatonin, Light, Sleep

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SEASONALITY, MOOD, AND SLEEP QUALITY IN COLLEGE STUDENTS IN A NORTHERN LATITUDE

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Objectives: College student sleep is plagued by insufficient total sleep time and irregular sleep-wake patterns, and sleep quality is negatively influenced by stress and negative mood (Lund et al., J. Adolesc. Health 46: 124-32, 2010). It is currently unknown to what extent seasonality may be a contributing factor in poor student sleep, especially for students attending school in regions with wide seasonal variations in light and temperature. Our goals were to (1) assess the extent to which college students attending school in a northern climate show seasonality, (2) determine whether students with high seasonality scores show more problematic mood and sleep behaviors, and (3) explore whether birth latitude is a significant predictor of seasonality and sleep problems for students living in a Northern climate.

Methods: An anonymous online survey on sleep, mood, and seasonality was administered to students who were primarily recruited from the psychology department subject pool at the University of St. Thomas, Minnesota, USA (latitude 45°N). Questionnaires used to assess sleep included the Epworth Sleepiness Scale (ESS), the Horne-Ostberg Morningness Eveningness Scale (MES), and the Pittsburgh Sleep Quality Index (PSQI). Questionnaires used to assess mood included the Beck Depression Inventory (BDI), the Subjective Units of Distress Scale (SUDS), and the Profile of Mood States (POMS). To assess seasonality, the Seasonal Pattern and Assessment Questionnaire (SPAQ) was administered. Students who completed the survey (n = 195) were divided into three groups: those showing high (>10), medium (7 – 10), and low (<7) global seasonality scores on the SPAQ. These three groups were compared by ANOVA for differences in sleep quality, mood and daytime activities. In a separate pilot study to assess the influence of birth latitude on sleep patterns and mood, daily sleep diaries and actigraphy measurements of activity were used to compare daily sleep patterns of students who were born and reared in Minnesota (n = 9) with students who were born and spent at least their first five years in tropical latitudes before moving to Minnesota (n = 8) for one week in fall and one week in mid-winter.

Results: The majority of students showed seasonal patterns in sleep and activity. On average, students slept less in winter (> 7 hrs) than in summer (7-8 hrs; $t=-4.42$, $df=179$, $p<0.01$). Furthermore, many students observed seasonal changes in mood (51%), energy level (47%), social activity (41%) and weight (31%). Students with high seasonality scores slept less, had more inefficient sleep, lower sleep quality (PSQI), and greater daytime sleepiness (ESS) than those with low or medium seasonality scores (for all measures, $F_{2,181} > 3.0$, $p < .05$). High seasonality students experienced more stress (SUDS; $F_{2, 125}=5.08$, $p<0.01$) and depression (BDI; $F_{2, 125}=19.42$, $p<0.01$) than those with lower seasonality, and this effect was more pronounced in the winter. In the second study, paired t-tests showed significant differences between fall and winter in sleep latency, bed time range, and day time sleep in transplanted students, but not in Minnesota natives.

Conclusions: These results demonstrate that students with high seasonality experience more mood and sleep problems in winter than those with low and medium seasonality, and that students' birth latitude may influence their propensity for seasonal changes in sleep and daytime functioning. These findings are specifically relevant for college health professionals whose students hail from a wide range of geographic locations. Given the close relationships between sleep quality and physical and mental health, intervention programs for sleep disturbance that address seasonality should be considered.

Keywords: Sleep, Mood, Seasonality, Student, Health

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SEASONAL CHANGES IN FEMALE REPRODUCTIVE FUNCTION

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Objectives: To review studies on seasonal variations in reproductive function in women living mostly at temperate latitudes, and on environmental variables that may mediate the seasonal changes.

Methods: A literature search was done using our own database of publications and the PubMed library, with e-mail inquiries to the authors or to colleagues for additional information. Our own data were included. Analyzed indices included: menstrual cycle length (3 seasonal studies), luteinizing hormone (LH), follicle-stimulating hormone (FSH), prolactin, estradiol and/or progesterone (10 studies), ovary follicle growth (2 studies), ovulation occurrence (3 studies), and also outcomes of artificial insemination (7 studies). Only 4 studies attempted to ascertain whether the annual fluctuations in women's reproductive function are driven by light or other environmental factors.

Results: Menstrual cycles were found to be slightly shorter in summer than in winter. Seasonal changes in folliculogenesis, ovulation occurrence and artificial inseminaton outcomes, when found, similarly pointed to a more efficacious ovarian function in summer. Hormonal results were inconsistent, but some studies did show significant seasonal changes. In three seasonal studies which investigated an influence of environmental variables on women's reproductive function, anovulatory cycles (histologically diagnosed) were associated with higher air temperature but not humidity in India, *in vitro* fertilization rates directly correlated with monthly hours of sunshine but not temperature or humidity in Israel, and an attempt was made to relate seasonality in birth rates to changes in regional sunshine. Recently, we have shown that for all seasons combined, shorter menstrual cycles are associated with increased sunshine 2–3 days before the presumed ovulation day; air and perceived temperature, atmospheric pressure, moon phase and moonlight were not significant predictors [Sergeeva and Danilenko, unpublished].

Conclusions: The seasonal studies presently available provide evidence for a greater ovarian activity in summer vs. winter in women living in a continental climate at temperate latitudes. Some methodological limitations such as: homogeneity of the studied groups, parallel vs. crossover design, number/timing of blood samples for hormonal assay etc. – might influence the consistency of the results. More generally, sunshine was found to be a factor that influences menstrual cycle. This corroborated findings with artificial light that showed a shortening of the menstrual cycle following light administered around the days of presumed ovulation (6 studies), enhanced ovarian follicle growth (1 study) and ovulation (2 studies), increased secretion of hypophyseal reproductive hormones (5 studies). There are several putative mechanisms, in particular neuroendocrine and/or neurovegetative pathways, that may explain how light hitting the eyes influences women's reproductive function.

Keywords: Women, Seasonality, Menstrual Cycle, Light

FOUR MONTHS FOLLOW-UP IN BIPOLAR DEPRESSION AFTER TOTAL SLEEP DEPRIVATION WITH LIGHT THERAPY

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Objectives: The American Psychiatric Association practice guidelines for the treatment of Bipolar Depression suggest the possible usefulness of non-pharmacological treatments, because of the lower latency of action, the fewer side effects, and the reduced risk of manic switches with respect to antidepressant drug treatments. Total Sleep deprivation (TSD) is the most widely documented chronotherapeutic intervention to reduce depressive symptoms within 24–48 hours in 40%–60% of patients as largely documented. Our purpose was to study the long-lasting effects of TSD + Light Therapy (LT) in terms of relapse rate, mania switch and the recourse to a traditional pharmacological antidepressant therapy.

Methods: 128 bipolar depressed inpatients were studied: 108 patients had a Bipolar type 1 Disorder (BDI) and 20 patients Bipolar type 2 Disorder (BDII). The study was conducted at the Mood Disorder Unit, Department of Clinical Neurosciences, Scientific Institute and University Vita-Salute San Raffaele, Milan, Italy. The inclusion criteria were: Axis I diagnosis of Bipolar Disorder; a depressive episode according to DSM-IV criteria; absence of other diagnosis on Axis I, II or III. Patients previously treated with antidepressant drugs (11 patients), went through a wash out period. All patients were administered three consecutive TSD + LT cycles, and each cycle was composed of a period of 36 h awake. We evaluated the psychopathological state of our patients administering Hamilton Depressive Rating Scale (HDRS), Beck Depression Inventory (BDI) and Visual Analogue Scale (VAS) during the TSD + LT 3 cycles, at the end of the TSD + LT protocol, two weeks later, and during check-ups after 1 month and subsequently after 4 months. The data were analyzed with one-way analysis of variance for repeated measures (ANOVA) and we performed a survival analysis.

Results: Responder patients were considered those who had a HDRS score < 8 and 82 patients (65.08%) responded to the therapy. Of 82 responders 60 were discharged without any other pharmacological therapy (fully responders); 22 patients were treated with and antidepressant compound. Of 60 fully responders, 32 subjects (53.33%) remained fully responders, 11 (18.33%) did not complete the follow up, as they did not come to check-ups, 12 (20%) patients had a partial relapse after 1 month, detected by the increment of HDRS, 5 (8.33%) patients had a relapse after 4 months. We divided the sample into two groups: the fully responders and those who needed the introduction of a pharmacological therapy, even if their HDRS was < 8. Taking into consideration the scores of the self-rating scales, BDI final scores and VAS final scores are significantly different (T-test $p<0.05$ respectively): patients who needed the introduction of a pharmacological antidepressant therapy did not show a reduction in BDI and VAS final scores. Repeated measures analysis of variance among the two groups, considering the BDI scores, shows a statistically significant results, in fact we found a significant interaction between time x group, $F(4, 220)=3.9602$, $p=0.004$.

Conclusions: The results confirm that both TSD and LT sustained the acute antidepressant effect. Our rate of response was 65.08%. Only 2 patients did not complete the protocol because of a lack of compliance, 7 (5.4%) patients had a transient ipomanic switch. 12 patients relapsed 1 month after the protocol and 5 after 4 months. The rate of relapse is globally 28.33%. Those patients who needed the introduction of an antidepressant therapy had generally higher final scores both in the BDI and VAS, those differences were statistically significant. BDI and VAS are both self-report questionnaires, they reflect the patient's cognitions, with respect to the HDRS which evaluates the severity of depressive symptoms observed. Nevertheless some patients, even if considered clinical responders, continue to complain about psychological suffering, still considering themselves depressed. These patients benefit from a maintenance antidepressant pharmacological therapy after the chronobiological treatment.
In conclusion, the positive response to TSD + LT confirms the usefulness as a first-choice therapy in bipolar depressed patients; it is a safe and well tolerated therapy, with long-lasting effects, minimizing the risk of relapsing within the first 4 months after the remission.

Keywords: Total Sleep Deprivation, Chronobiology, Light Therapy, Bipolar Disorder, Biological Rhythms

LIGHTING UP THE DAYS OF NIGHT WORKERS

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In night workers, there is a misalignment between the endogenous circadian signal and the imposed rest-activity cycle. This mismatch often results in non-restorative sleep in the daytime and low vigilance levels during night work. In addition, the repeated changes in the sleep-wake cycle, as well as the associated alteration in light-dark exposure, produce a disruption of internal circadian rhythms. Chronic circadian disruption has been proposed as a main cause of increased risks of cancer and metabolic disorders in night workers.

Both simulation and field studies have demonstrated that the use of controlled light exposure during night work can adjust the internal circadian phase. As most night workers choose to delay their sleep episode until shortly after their night shift, light exposure is usually timed to delay the circadian rhythms, the aim being to push the circadian peak of sleepiness out of night work and make it happen during the daytime sleep episode. Bright light exposure during the entire night shift is not an ideal solution in real life situations. On the one hand, most workers find it rather unpleasant; on the other hand, it is often incompatible with the worker's tasks or too expensive to implement at the workplace. It is possible to increase both feasibility and efficacy of nighttime light exposure by using intermittent light exposure or by adjusting the spectral composition of the light stimulus. Altering light exposure in the daytime, especially by using sunglasses in the morning and by using very dark shades in the bedroom during daytime sleep, can also significantly increase the adjusting effects of nighttime light exposure.

While it is possible to make a perfect adjustment of the internal circadian phase to the altered sleep-wake cycle of night workers, it is rarely the best solution. With a complete adjustment, the workers complain of having sleep and vigilance problems when they return on a day-oriented schedule, during day work or free days. Most importantly, recent studies strongly suggest that on the long term, repeated phase shifts have much worse health consequences than a stable circadian misalignment. Therefore, contemporary research is now aiming at finding ways to produce partial circadian adjustments in night workers, and in testing compromise circadian phases that could be well tolerated during both night and day work while minimizing adverse effects on sleep, vigilance and mood.

In a previous study, we found that a minority (8 of 30) of night nurses showed a partial circadian adjustment after an average of 4 consecutive night shifts. This partial adjustment was associated with better subjective sleep quality in the daytime. Light exposure was continuously recorded in these nurses and we found very distinctive 24-h light exposure profiles between nurses who showed some circadian adjustment and those who did not (Dumont et al., 2001). The timing of increased light exposure was globally consistent with predictions made by phase-response curves to light in humans, but most differences in light exposure profiles occurred in the daytime. These observations suggested that increasing light exposure at night might be unnecessary to produce partial circadian adjustment in night workers and to improve their daytime sleep quality. We tested this hypothesis in a recent 6-day study of laboratory simulation of night work (Dumont et al., 2009). After 2 "day shifts", the subjects (15 M/ 23 W; 20-35 y.) worked 4 consecutive night shifts (00:00 h – 08:00 h). Light exposure was the same for all subjects during "night shifts": 50 lux on the first 3 nights, and below 20 lux on the last night. Three daytime profiles of light exposure were tested: one favoring a phase delay (Delay group), one favoring a phase advance (Advance group), and one similar to the profile previously measured in the night nurses showing no circadian adjustment (Stable group). The schedule of the 8-h daytime sleep episode was the same in the Delay and Stable groups (09:00-17:00), but later in the Advance group (14:00-22:00). Daytime light levels were always below 300 lux, except between 08:00 and 09:00 h when light exposure mimicked outdoors bright light exposure. Circadian phase was estimated with melatonin production. Both "Delay" and "Stable" profiles produced significant phase delays, larger in the Delay group (4.1 ± 1.3 h) than in the Stable group (1.7 ± 1.6 h). The "Advance" profile produced a significant phase advance (-2.3 ± 1.2 h). In these young, healthy subjects the impact on sleep, vigilance and mood was modest. The experimental daytime light exposure profiles will now have to be tested in the field, in a population of real night workers.

Keywords: Simulated Night Work, Circadian Phase, Phase Shift, Light Exposure, Circadian Dysfunction

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References: 1. Dumont et al. J Biol Rhythms, 16, 502-511, 2001; 2. Dumont et al. J Biol Rhythms, 24, 427-437, 2009.

HELPING NIGHT SHIFT WORKERS: RHYTHMS VS. REAL LIFE

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Over the last 20 years we have conducted simulated night shift studies (e.g., 1, 2) and have been able to completely phase shift circadian rhythms to align with night work and day sleep using bright light from light boxes, dark sunglasses for the commute home and dark daytime sleep episodes. However, if real night shift workers were completely physiologically adapted to night shifts, then they would be out of synch with the real world on days off and would have trouble sleeping and staying awake at conventional times.

Therefore, we have devised and tested a compromise system for permanent night work in which circadian rhythms are partially aligned with night work and day sleep so that the sleepiest time of day is delayed out of night work and into the first part of day sleep. A late sleep schedule is maintained on days off, about half way between that of the non-shift-work world and the daytime sleep schedule that workers are forced to adopt after night shifts. The goal is to have the sleepiest time of day fall near the end of, but within, days-off sleep. We tested a 35 day schedule including blocks of night shifts alternating with 2 days off and took a snapshot of circadian phase at baseline and at 4 successive days throughout the schedule to see if the target compromise circadian phase position was reached and maintained (3-6). We used intermittent bright light during night shifts (4-5, 15 min exposures from light boxes usually sold for SAD) dark sunglasses for the commute home (safe for driving, meet traffic signal color requirements), scheduled sleep episodes at home in very dark bedrooms after night shifts and on days off, and afternoon outdoor light exposure ("light brake") to keep the rhythms from delaying too far.

These interventions reset the circadian rhythms of almost all experimental subjects to the target phase after about a week (which consisted of 3 night shifts, 2 days off and more night shifts). Control subjects had the same sequence of night shifts and days off, but were free to sleep whenever they chose, remained in ordinary room light during the night shifts and wore lighter sunglasses on the way home. A few control subjects chose to sleep very late on days off (later than experimental subjects) and had circadian rhythms that shifted to the target phase position. But most control subjects had sleep patterns that resembled those of most real night shift workers and had their sleepiest time of day remain within the night shift.

When the circadian clocks of subjects delayed and became close to the target compromise phase position, the subjects had improved alertness, performance, and mood during night shifts (7). In many subjects performance levels returned to daytime baseline levels, which is a vast improvement that cannot be matched even by the use of stimulants during the night shift.

Implementing these techniques in the workplace will take the cooperation of employers (to provide light boxes and appropriate work schedules with no morning commitments) and would require workers to make some life style changes (such as giving up morning activities even on days off and making their bedrooms very dark). These techniques could also be modified for very slowly rotating shift schedules, but there are no circadian solutions for rapidly rotating shift work.

Keywords: Shift Work, Bright Light, Phase Shifting, Night Work, Circadian Rhythms

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THE ERG RESPONSES TO LIGHT STIMULUS LEVELS OF MELANOPSIN-EXPRESSING RETINAL GANGLION CELLS WITH THE RECEPTOR-SILENT SUBSTITUTION TECHNIQUE

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Objectives: The mechanisms by which melanopsin-expressing retinal ganglion cells (mRGCs) regulate circadian rhythms in humans have not been established. To understand mRGC characteristics and their role, mRGC responses should be induced or measured independent of cone and rod responses. Researchers in the fields of medicine, architecture and illumination engineering try to clarify standards for environmental light and to promote light therapy for the regulation of human circadian rhythms. However, it is important to note that the light stimuli used in these studies also affected the other photoreceptors, the rods and cones, as well as the mRGCs. The purpose of this study is to investigate the mRGC characteristics with the receptor-silent substitution technique which induces only the mRGC change in responses measured by the electroretinogram (ERG).

Methods: The illumination system has been purpose-built with a receptor-silent substitution technique. It consisted of an optical diffuser and an integrating sphere. Four different kinds of light-emitting diodes (LEDs) (Opto Supply Limited, Hong Kong) were used as internal light sources in the integrating sphere. The peak wavelengths of the four LEDs were 633, 593, 507 and 468 nm with half-height bandwidths 15, 14, 33 and 22 nm, respectively. Stimulus excitation (stimulus level) of L, M and S cones and mRGCs was calculated by multiplying spectral radiance of the light stimuli and relative luminous efficiency of L, M and S cones and mRGCs (Tsujimura, in press). The mRGC excitation of the light from the integrating sphere was modulated to a sinusoidal wave, whereas the excitation to each cone was the same throughout the light exposure. The light exposure consisted of 30 repetitions of 3-sec exposure to the sinusoidal wave and 2-sec constant (base) light irradiation. For each 3-sec exposure, we were able to choose contrast (amplitude of the sinusoidal stimuli to the base light) changes of 10, 20, 30, 40 and 50% at 5.0 Hz with analogue pulse-width modulation unit. The ERG signals from photoreceptors were continuously digitized during the experiment at a sampling rate of 5 kHz by a data input system. Ten healthy subjects (5 females, 5 males; mean ± SD age, 24.3 ± 3.4 years; range 21-31 years; Japanese) were studied in an artificial climatic chamber. All subjects had ocular health and normal color vision according to the Ishihara color blindness test. After a mydriatic agent was dropped into the subject's left eye for pupil's dilation, subjects with an ERG electrode rested their head in a chin rest, and gazed at the fixation at the center of stimulus circle (100 mm in diameter) on the diffuser in front of them. The diffuser was at a distance of 300 mm from a subject whose visual angle to the circle was 18.9 degree. The study was approved by the Ethics Committee at Fukuoka Women's University and subjects gave written informed consent prior to study.

Results: Power and phase spectra of mRGC responses were calculated by using Fast Fourier Transformation (FFT). The power indicates degree of the mRGC response and the phase expresses latency in the mRGC response to light stimuli. The response appears to elevate linearly from 10% to 50% contrast. As the test of homogeneity of variances indicated that the data of the mRGC were not homoscedastic, a nonparametric test was applied for these results. Spearman's rank correlation coefficient between the mRGC response and the contrasts showed high statistical significance (r_s=0.66, p<0.01). One-way ANOVA showed that the phase did not differ significantly between the contrasts. This means that we could collect data on mRGC responses according to the contrasts.

Conclusions: The results in this study demonstrate that the test stimuli affected only mRGC responses and that the response could be successfully detected by using the ERG. The mRGCs responded linearly to contrast changes of the light stimuli and this result provides the first knowledge of mRGC characteristics independent of effects due to the rods and cones in humans.

Keywords: Melanopsin-Expressing Retinal Ganglion Cells, Circadian Rhythms, Receptor-Silent Substitution Technique, Electroretinogram

SEASONALITY AND HERATABILITY IN EUTHYMIC MOOD DISORDER PATIENTS

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Objectives: The periodic pattern of recurrence is a biological feature of mood disorders, and the recovery from the first episode of illness is followed by a subsequent recurrence in about 90% of affected patients during their lifetime. The typical pattern of recurrence of mood disorders follows interindividual rules since each patient presents his own specific pattern with a few episodes during his life, or more than one episode each year: this pattern of variability underlies biological, chronobiological, environmental and drug-related features. Some authors have stressed the concept of seasonality, as many patients show critical months of the year when they tend to have a new recurrence independently of the polarity. It has been postulated that biological processes may be influenced by photoperiod, suggesting that the seasonal patterns of incidence of several psychiatric conditions may share a common neurophysiological substrate. This perspective underlies the aim of our study.

Methods: The aim of the present study was to evaluate the influence of chronobiological factors in a sample of 113 euthymic outpatients affected by Major Depressive Disorder and Bipolar Disorder and to specifically: study the season of concordance of depressive and manic episodes, assess their seasonality during a period of euthymia, identify a seasonality profile and detect possible relationships between circadian oscillations during an illness episode and seasonal variations in the euthymic period. These patterns were detected administering an anamnestic sheet for sociodemographic and medical informations and data on seasons of onset and of previous episodes, and by using the following questionnaires: Seasonal Pattern Assesment Questionnaire (SPAQ+) to assess seasonality evaluating the Global Seasonality Score (GSS), Morningness-Eveningness Questionnaire (MEQ) to determine the patient's chronotype and Medical Outcomes Study (MOS) Sleep Scale to evaluate sleep quality. T-test analyses were performed to investigate relationships between all the clinical and sociodemographic variables, and between differences in the assessment scales.

Results: We found a significant seasonal distribution of mood recurrences, with a 38% clustering of depressive episodes in fall for both unipolar and bipolar subjects. Unipolar patients have a concordance for a specific season in 70% of cases. Bipolar patients have a concordance for a specific season in 54% of cases for depressive episodes and 39% for manic episodes. T-test analysis between patients that reported heritability for mood disorders showed significant differences in the following variables: GSS, age of onset, duration of illness, number of depressive episodes, total number of episodes. In our study, one of the questions concerns the period with high pollen counts and the patient is asked to indicate whether he/she feels well or unwell during this time of the year. A t-test analysis, performed dividing patients according to diagnosis, showed that Unipolar patients feel significantly worse in this period of the year, with a significant difference for the GSS score revealing that patients that feel unwell have a higher seasonality score. Given these results, a T-test analysis was performed considering only patients with heritability: we found significant differences between seasonal (GSS>8) and nonseasonal subjects in duration of maintenance therapy with lithium, sleep disturbances, sleep adequacy and pollen count; similar results were obtained when subjects were also divided according to diagnoses.

Conclusions: We can hypothesize that there may be a genetic component in seasonality as patients with a positive heritability have higher GSS scores. High pollen counts can contribute to other seasonal environmental factors as potential triggers for seasonal changes in mood. Our results are in line with those found by Guzman et al. who suggested an association between self-reported mood worsening during periods of high pollen counts and a greater pattern of seasonality. This could be one of the possible explanations of the high peaks of depression concordances in spring both in Unipolar and Bipolar patients.

Keywords: Seasonality, SPAQ, Heritability

IN VIVO QUANTIFICATION OF LENS TRANSMISSION IN ELDERLY SUBJECTS BEFORE AND AFTER CATARACT SURGERY

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Objectives: Light is the key environmental signal involved in the entrainment of the biological clock in humans and light treatment is used as a therapy to treat (winter) depression. It has recently been shown that light of short wavelengths play an important role in the non-visual responses of the biological clock and alertness to light. With aging one of the most conspicuous changes occurring in the eye is the development of a yellow pigmentation in the central part of the crystalline lens (nuclear sclerosis, nuclear cataract) that reduces light transmission in particular in the short wavelengths. In the present study we describe a procedure that uses reflectometers to measure, objectively and quickly, the spectral composition of the light reaching the retina in vivo in elderly people suffering from cataract and in the same people after cataract surgery.

Methods: For the in vivo measurements of retinal reflectance before and after cataract surgery two different spot reflectometers were used; the foveal reflection analyzer (FRA) and the macular pigment reflectometer (MPR). Both devices are capable of measuring the spectral composition of the reflected light in the living human eye, and can thus be used in this study. The differences in the spectral composition of the reflected light, measured with this technique due to lens absorption, have already been validated in different age groups (Zagers et al., 2002). Measurements were conducted before and after cataract surgery on both eyes for every subject (n=14, 5m:9f, average age 77.9 ± 5.2y). The other eye was operated on within maximally 2 months. The measurements after cataract surgery were performed at least one month after the second eye was operated on.

Results: In elderly subjects with cataract light input is especially reduced in the short wavelength range compared to light input through a bright artificial lens after cataract surgery. After cataract surgery, the lens transmittance of the short wavelengths (in the range between 420 and 500 nm) improved on average by a factor of 4 (Giménez et al., 2010).

Conclusions: The technique of using spot reflectometers to measure lens transmittance holds great promises for the chronobiological field because it allows for quantification of the spectral composition and light levels reaching the retina in vivo. It is an objective, quick and easy method. It might effectively be used to increase chronobiological knowledge regarding light intensity levels and the spectral composition at which a response can be triggered. Such knowledge is critical for developing lighting conditions and light therapy treatments both in young and in elderly people.

Keywords: Circadian Rhythms, Aging, Lens Transmittance, Short Wavelength Light

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T3111C POLYMORPHISM OF THE CIRCADIAN CORE GENE, *CLOCK,* PREDICTS INTERINDIVIDUAL DIFFERENCES IN AFFECT, SLEEPINESS, FATIGUE AND EXECUTIVE FUNCTIONING DURING BASELINE AND CHRONIC PARTIAL SLEEP DEPRIVATION IN HEALTHY ADULTS

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Objectives: The T3111C polymorphism of the circadian core gene *CLOCK* (Circadian Locomotor Output Cycles Kaput) has been associated with morningness-eveningness (diurnal preference), sleepiness and sleep changes in healthy adults, with insomnia in bipolar disorder and major depressive disorder, and with recurrence of bipolar disorder. We evaluated whether the *CLOCK* T3111C polymorphism was a novel marker of inter-individual differences in mood, cognitive, sleepiness and sleep homeostatic responses at baseline and during chronic partial sleep deprivation (PSD)—the latter is commonly experienced by millions of people on a daily and persistent basis and is associated with serious health consequences.

Methods: 6 *C/C*, 45 *C/T* and 78 *T/T* healthy adults (29.9±6.9y; 63 females) completed 2 baseline 10h time in bed nights, followed by 5 PSD nights at 4h time in bed in a controlled laboratory experiment assessing neurobehavioral measures (mood, cognitive performance and executive function tests, subjective sleepiness and fatigue, Maintenance of Wakefulness Test) and physiological sleep responses. Because of the small number of subjects with the *C/C* genotype and the absence of differences between the *C/C* and *C/T* groups, these groups were combined; thus, comparisons were made between *C* allele carriers (*C/C* + *C/T*; N=51) and the *T/T* genotype. *T/T* genotypic and *T* allelic frequencies were significantly higher in African Americans than Caucasians, as has been reported previously; thus, analyses statistically controlled for ethnicity.

Results: At baseline, *C* allele carriers had significantly greater total mood disturbance—a global estimate of affective state—and significantly greater confusion. During sleep deprivation, *C* allele carriers showed significantly greater total mood disturbance, subjective sleepiness and fatigue, and poorer performance on various measures of the Tower of London, an executive function test that assesses planning and problem solving abilities. The groups did not differ significantly at baseline in circadian phase (morningness-eveningness or sleep midpoint), habitual sleep, demographic characteristics, physiological sleep structure, physiological sleepiness, subjective sleepiness, or various aspects of cognitive performance. Both groups demonstrated comparable cumulative decreases in cognitive performance (PVT, Digit Span) with increasing daily inter-subject variability, and increases in slow-wave energy (SWE) and subjective and physiological sleepiness (Karolinska Sleepiness Scale, Maintenance of Wakefulness Test) in response to chronic partial sleep deprivation.

Conclusions: The *CLOCK* T3111C polymorphism in a healthy adult population may represent a continuum of higher level executive functioning, mood, sleepiness and energy features frequently observed in patients with mood disorders. However, the *CLOCK* T3111C did not relate to sleep homeostatic or polysomnographic measures at baseline or during chronic partial sleep deprivation. Thus, the *CLOCK* T3111C polymorphism may be a genetic biomarker for a mood-cognition diathesis, but not a sleep homeostatic-circadian diathesis.

Keywords: *CLOCK* Circadian Gene, Affect, Individual Differences, Executive Functioning, Sleep Deprivation

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FORMATION OF LUMIRUBIN DURING LIGHT THERAPY IN ADULTS

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Objectives: The conversion of bilirubin to the water soluble isomer lumirubin (cyclobilirubin) has been described in infants and in a 15 year old girl with Crigler Najjar syndrome, and in an earlier study we have shown that lumirubin is also formed during light therapy in adults. Here we present a small study comparing illumination of the eyes to illumination of the body.

Methods: Five healthy individuals aged 37-74 years were randomly assigned to four conditions (dark control, body illumination 5000 lux, illumination of the eyes 5000 lux and 10000 lux combined illumination) and all probands underwent all four conditions. After a dark period of one hour the first urine sample was taken. Then the persons wearing a rissole were exposed to the light therapy lamp of 5000 lux with goggles or with a mask leaving the eyes open but shielding the body, and then respectively to 10000 lux just wearing a rissole. The control condition was under dark chamber illumination of 20 lux. Urine specimens were taken after one hour dark adaption (baseline), after 30 min and 60 min of light therapy or under 30 min and 60 min of dark chamber illumination. Urine specimens were analysed by Fluorescence Spectroscopy. In accordance with Bacci M, J Photochem Photobiol B. 3(3); 419-27 1989 we used the excitation wavelength of 315nm and recorded the emission from 380 to 480nm. The typical fluorescence peak around 415nm (410-420nm) was used for evaluation. The results are presented in relative fluorescence units (RFI) against time.

Results: There was a constant decrease of Lumirubin excretion in the dark conditon and under 5000 lux with shielded eyes and a constant increase of lumirubin excretion under eye illumination of 5000 lux and under combined eye and body illumination of 10000 lux. The difference between eye and body illumination was significant (t-test; p=0.05).

Conclusions: This study provides evidence of urinary excretion of Lumirubin duringlLight therapy in adults and is first evidence of a more efficient Bilirubin conversion in the eye than in the skin. This would be in accordance with the concept of humoral phototransduction as proposed by Oren (The Neuroscientist 2: 207-10).

EFFECTS OF SHORT WAVELENGTH SOLID-STATE LIGHTING ON MELATONIN SUPPRESSION AND ALERTNESS

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Objectives: Disturbed circadian rhythms and altered sleep-wake patterns pose significant risks to astronaut and ground crew health and safety during space exploration missions (NASA Human Research Program Integrated Research Plan, HRP-47065, 2009). As a result of these disturbances, space program personnel may experience impaired alertness, loss of concentration, and diminished performance. Monochromatic wavelength comparisons have indicated that photic circadian phase-shifting, melatonin suppression, and acute alerting responses are strongest in the blue portion of the spectrum (Brainard and Hanifin, J. Biol. Rhythms 20: 314-325, 2005). Our aim was to verify that narrow bandwidth blue solid-state lighting could evoke multiple acute physiological and neurobehavioral changes relevant to these concerns.

Methods: Eighteen healthy young subjects (mean age 25.4 ± 0.6 years, n=9 females) completed an ongoing three-day study in a laboratory free of time cues at Thomas Jefferson University. Subjects were restricted to 4h time in bed on the night prior to admission as well as Night 1, timed to end at their habitual wake time. On Night 2, subjects either remained in dim white light (<4 lux) (n=9), or they viewed a blue solid-state light exposure system (122 cm^2 blue LED array, λmax=475 nm, 29 nm half-peak bandwidth) at 30 cm for 4h beginning at their habitual sleep time to achieve a full visual field corneal exposure of 75 $\mu W/cm^2$ (n=9). Subjects rated their subjective sleepiness, performed 10-minute auditory psychomotor vigilance tasks, and completed modified neurobehavioral test batteries at regular intervals throughout the study. Polysomnography was initiated on Night 1, and Karolinska Drowsiness Tests were performed throughout the remaining wake periods. On Day 2, blood was drawn through IV catheters every 20-30 minutes and quantified for melatonin. Melatonin suppression was calculated from levels at the time of "lights on" compared to levels 2h and 4h after "lights on."

Results: Preliminary analysis showed no difference in plasma melatonin values between the two groups at the time just prior to "lights on" ($p=0.56$). There was a significant suppression of plasma melatonin, however, at 2h and 4h ($p<0.0001$ and $p<0.005$, respectively) for the blue light exposure group versus dim exposure. Other data will be presented at the meeting.

Conclusions: These data will help characterize the photoreceptor system(s) that mediate the circadian, neuroendocrine, and neurobehavioral responses to polychromatic light stimuli. Ultimately, such data may lead to the development of a flight-worthy, non-pharmacological countermeasure for acutely enhancing astronaut alertness during space missions.

Keywords: Circadian Phototransduction, Light, Melatonin, Space Exploration, Solid-State Lighting

Funding Support: This work is supported by National Space Biomedical Research Institute through NASA NCC 9-58. Philips Home Healthcare Solutions provided the lighting system used in this project.

SPECTRAL TRANSMITTANCE OF MODERN GLAZING SYSTEMS AND ITS IMPACT ON THE INTERNAL LIGHT ENVIRONMENT

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Objectives: Our modern style of life makes us spend more and more time indoors, and statistically more than 80% of our time is spent in the internal environment of the buildings. But the indoor environment is different in many ways compared to the outdoors. As the number of buildings tagged with "sick building syndrome" rises, a question about other factors affecting the healthy living is being raised. Lighting has been often neglected from the main design targets, aiming simply to cover basic needs for vision tasks represented solely by the illumination limits. But humans have evolved in conditions of daylight, a source of light that is rich in intensity along the whole visible spectrum and with its dynamics varying throughout the day. We believe that these properties should be also maintained in an internal environment, while taking limitations such as glare into consideration. Current international standards in illumination are specified solely on the photopic sensitivity of the human eye, so recent discoveries in the chronobiology give us new clues as to how to provide better lighting. If we want to provide healthy lighting and wellbeing in buildings, we have to adapt it as much as possible to the properties of outdoor daylight, namely we have to consider not only its quantity but also its quality – the spectral composition. Since photosensitive ganglion cells providing input to the brain's circadian pacemaker have been discovered with its action spectrum mostly sensitive to shorter wavelengths, which is different from the photopic system, the question of spectral composition of a light becomes more important. Therefore, we focused on the spectral properties of commonly used glazing systems and films for solar protection. These materials change the spectrum of daylight directly by its penetration into a building.

Methods: A set of 15 samples of glazing systems and 39 samples of foil was prepared for a spectral transmittance examination. Using a digital spectroradiometer and a stabilized source of full spectrum light, we obtained values of spectral transmittance rates in the whole visible light region of wavelengths. These values were further processed into the calculation for total light transmittance in the photopic system ($\lambda 1$= 380 nm, $\lambda 2$ = 780 nm, λmax = 555 nm) also as light transmittance using the action spectrum of a novel photoreceptor ($\lambda 1$ = 380 nm, $\lambda 2$ = 580 nm, λmax = 460 nm). After comparison, two samples with close photopic transmittance but with different transmittance in shorter wavelength region were chosen to be placed in a model of two identical office rooms. The samples of glazing systems were placed over a side opening, enabling only daylight penetration. For daylong measurements we installed the Daysimeter devices in a position imitating the eyes of a sitting person. Daysimeter is a two-sensory device providing data of photopic illuminances along the values of the circadian stimulus described by Rea et al. [1].

Results: The spectral transmittance analysis of glazing and film samples showed a typical nonlinearity, caused by the usage of different coating materials. According to these results, a samples of Antelio® and Planibel blue® were chosen for model tests. During a typical day the recorded difference in photopic illumination was 1.59 %, but the difference in circadian stimulus levels was 27.54%.

Conclusions: Only the light transmittance value typically represents the transmissivity properties of glazing products, which does not give us an overview of a performance in other wavelengths regions that are preferred by the photopic system. Results of measurements showed that an interior can differ almost 28% regarding light inputs in a shorter wavelength region compared to a photopic identically illuminated room even for commonly used glazing types. A choice of glazing type in addition to orientation, size, and position can potentially have an influence over the circadian system, which can be significant and managed by an appropriate design.

Keywords: Architecture, Daylight, Light Environment, Circadian System, Spectral Transmittance

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Reference: Rea MS et al. 2005. A model of phototransduction by the human circadian system. Brain Res Reviews 50: 213-228.

SEASONAL CHANGES IN SEROTONIN TRANSPORTER BINDING AS A 5-HTTLPR ENDOPHENOTYPE

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This talk focuses on seasonal variations in the cerebral serotonin system, reflected by fluctuations in serotonin concentrations and serotonin transporter binding, as a possible endophenotype of a well-known genetic variation in the promoter region of the serotonin transporter gene (5-HTTLPR). Being a carrier of the short 5-HTTLPR allele has been linked to vulnerability to seasonal affective disorder. This is of particular interest since the 5-HTTLPR does not seem to be directly linked to personality traits and depressive symptoms but to an increased reaction of the organism to environmental changes, in particular stressful events. Seasonal changes in serotonin transporter binding may therefore provide a powerful paradigm to test for 5-HTTLPR*environment interaction effects.

I will discuss some evidence from imaging and population studies together with our own material, in particular our recently published data (Kalbitzer et al., Biol Psychiatry. 2010 Jun 1;67(11):1033-9) on 5-HTTLPR*daylight interaction effects in a sample of 57 healthy Scandinavians. The data were collected at the Rigshospitalet, Copenhagen University Clinic over 2.5 years. In this study, where we used the radioligand [11C]DASB and positron emission tomography to measure serotonin transporter binding, we observed that only carriers of the short 5-HTTLPR allele show significant seasonal fluctuations in serotonin transporter binding with a peak in winter and a nadir in summer. The interaction effect between radioligand binding and daylight reached significance in one (putamen) of the four (caudate, putamen, thalamus, midbrain) high-binding regions we analyzed.

I will argue that seasonal fluctuations in serotonin transporter binding reflect a more or less stable homeostasis of the cerebral serotonin system which is heritable. I will conclude that the stability of this homeostasis may predict sensitivity to environmental stimuli in general and how a more or less stable homeostasis might advantageous or disadvantageous depending on the specific context.

Keywords: Serotonin Transporter, 5-HTTLPR, Endophenotype

SEASON OF BIRTH ASSOCIATED WITH BODY FAT AT BIRTH IN CANADIAN CHILDREN

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Objectives: High birth weights and body fat can contribute to obesity risk over the lifespan. This study examines whether season-of-birth influences body fat at birth in a Canadian sample.

Methods: Basic weight and length measures were collected in 86 consecutive children taking part in a longitudinal study of maternal adversity, vulnerability and neurodevelopment (MAVAN). Ponderal indices to assess body fat (calculated as weight/length^3) were calculated at birth and at 36 months of age. General linear models were used to study whether season-of-birth was associated with ponderal index at birth and/or change in ponderal index over the first three years of life.

Results: Spring births were associated with a higher ponderal index (PI) than were births at other times of the year (28.5 +/- 3.4 kg/m^3 vs 25.8 +/- 3.7 kg/m^3 respectively; F=5.02; df 1,84; p=.028). Season of birth was also a significant predictor of change in ponderal index over the first three years of life, i.e. children with a spring birth had a much greater drop in PI over the first three years of life than did other children (12.2 +/- 4.7 kg/m^3 vs. 8.6 kg/m^3 respectively; F=9.10, 1,84, p=.003). As a result, no further difference in PI at 36 months of age, based on birth season, was detected. These findings appeared to be much stronger in girls than in boys.

Conclusions: Babies born in the spring, and girls in particular, had more body fat at birth than did other children, though lost this extra fat by 36 months of age. This birth difference might reflect an effect of season on maternal diet in pregnancy, further moderated by fetal sex. These children will continue to be followed over time to assess the long term implications of this finding for seasonal and non-seasonal eating patterns and obesity risk.

Keywords: Season-of-Birth, Seasonal Thrifty Hypothesis, Obesity Risk

Funding Support: This work was supported by the Canadian Institutes of Health Research (CIHR)

Reference: Levitan RD, Masellis M, Lam RW, Kaplan AS, Davis C, Tharmalingam S, Mackenzie B, Basile VS, Kennedy JL. A Season of Birth/Dopamine-4 Receptor Gene Interaction Associated with Weight Gain and Obesity in Women with Seasonal Affective Disorder: a *Seasonal Thrifty Phenotype Hypothesis*. Neuropsychopharmacology 2006; 31:2498-2503.

PROMOTING ALERTNESS AND SLEEP BY DYNAMIC LIGHTS FOR CONTROL ROOM OPERATORS

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Objectives: To improve alertness, sleep and adaptation to rotating shiftwork, a new dynamic light regimen adjusted to current work hours was tested.

Methods: The illumination level in a control room at a nuclear power station was about 200lux at straight horizontal gaze. In a small part of the control room above the positions of the reactor operators new lightning equipment was installed. The new lights were in major part shielded from other operators also working in the same room. The new lights were designed to give three different light exposures: 1. White strong light, 1050lux at 90o horisontal gaze, 6000K; 2. Weak yellow light, 650lux, 3000K; 3. Yellow moderate light, 700lux, 4000K. The fitting consisted of five Savio™ armatures including Philips lightning (AktiViva Natural, 54W, 16mm and TL5, 827, 54W, 16mm). In a cross-over design the old and new light exposures were given in connection to a sequence of three night shifts, two free days and two morning shifts (NNN++MM) and with 7 weeks in-between sessions. The operators consisted of two groups, 7 reactor operators from seven work teams were at one time exposed to the new equipment and 16 other operators were used as controls. The study was conducted during winter months with no opportunities to receive day light exposure after night work or before morning work. Operators were given actigraphs, filled in a sleep/wake diary and melatonin saliva samples were collected at work. The exposure group had a mean age of 50.2 ranging from 42-57 yrs, the control group had a mean age of 46 yrs ranging from 30-62 yrs. ANOVAs were calculated in connection to night work, free days and morning work using the factors group (exposed reactor operators/non-exposed other operators) and light (new/old exposure).

Results: Wake/sleep diary data showed that the new light treatment increased alertness in connection to night work at 02:00h and at 04:00h (interaction group x light, $p<0.05$). During free days after night work, sleep length increased with 0.7 hours to 7.42 hours with the new lights (interaction group x light, $p<0.05$) and these days were rated as being better (interaction group x light, $p<0.05$).

Conclusions: It seems that appropriate dynamic light in windowless rooms during the dark Nordic season may promote alertness, sleep and better adaptation to quickly rotating shiftwork.

Keywords: Shiftwork, Sleepiness, Light Treatment, Sleep, Actigraph

ARHITECTURE AND LIGHT: A SPECTRUM OF CHOICES

P. Mead
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This paper addresses many of the questions that Anna Wirz-Justice and Colin Fournier raised in their recent article "Light, Health and Wellbeing: Implications from chronobiology for architectural design" in the January 2010 edition of the *World Health Design* journal. The objective of this paper is to further stimulate research and dialog between architects, bright light manufacturers and chronobiologists that can strengthen the implementation of chronobiologically informed building designs, building guidelines, and if possible, building codes.

Planning codes and standards have certainly prolonged life and provided a higher quality of living since the Industrial Revolution. Early codes countered clearly defined health hazards in the 1800s such as the rapid spread of disease from open sewage, or rickets and tuberculosis from a lack of sun light, fresh air and crowded living conditions. More recent codes in the 1990's have addressed quality of life issues such as accessibility and ventilation. These later codes met initial resistance due to higher energy consumption and substantially increased costs associated with larger room sizes and new hardware. Similarly, if lighting levels are codified in a ubiquitous manner (like the incorporation of fluoride in many city water supplies), there could be stiff resistance from energy conservationists, building project managers and those sensitive to the glare that often accompanies indoor bright light. However, if a more flexible strategy is implemented that utilizes appropriate doses of lighting that are strategically incorporated into an existing vocabulary of building components at appropriate times; in places and times of the occupant's choosing without bothering those nearby who may not welcome the same light levels, then the resistance could be mitigated.

For this implementation, chronobiologists and architects are natural allies because light has been aesthetically celebrated for over 2500 years in religious and artistically inspired buildings. Additionally architects are vaguely aware of the benefits of daylight for energy efficiency and biological reasons. However, what is lacking in their education is a sufficient understanding of chronobiology and an awareness of existing design options that can economically create brightly lit, glare reduced areas that are near 1000 lux. Currently, there is a sizable array of historical design precedents that can harvest higher than normal levels of daylight as well as room programs and lighting layouts that can economically focus high levels of artificial light where it can be delivered at the appropriate time with minimized glare pollution. These examples provide fertile ground from which architects, bright light designers and chronobiologists can research and assess for health effectiveness, economy, usability and comfort.

Conclusions: To convince the building industry and public whether chronobiologically sensitive lighting levels need to be instituted in codes or disseminated in standards or guidelines depends on a number of variables. If the evidence is clear that a sizable segment of the population needs higher lighting levels to prolong their lifespan and quality of life, then chronobiologically inspired design may make its way into the codes. Just as current accessibility building codes which are part of the Americans with Disabilities Act (ADA) address a sizable and influential segment of the population, lighting codes could also be folded into these codes and address a sizable and perhaps influential segment that suffer from light deficiency.

OCULAR PARAMETERS AS AN OBJECTIVE TOOL FOR THE ASSESSMENT OF TRUCK DRIVERS FATIGUE

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Objectives: Ocular parameters are influenced by sleep derivation and the use of chemical substances which are two major causes for traffic accidents. We assessed the use of these parameters as an objective screening tool for a driver's fitness for duty.

Methods: Pupillary diameter, pupil reaction to light and saccadic velocity were measured in 29 army truck drivers every morning for two months and compared to baseline measurements taken while the subjects were alert. An index which expressed the difference between study and baseline measurements was calculated, and drivers with significant deviation from baseline were disqualified and interviewed. Non-disqualified drivers served as controls.

Results: Twenty-nine percent of disqualified drivers reported sleeping less than the minimum of 7h required by army regulations compared with 8% of control drivers ($p=0.01$). Disqualified drivers had worse sleep quality the night before the test (Groningen Sleep Quality Scale, $p=0.03$) and incurred more accidents per driving day during their service (0.023 vs. 0.015 accidents/day, $p=0.03$). Two disqualified drivers admitted to using alcohol or sleeping pills.

Conclusions: Thus, these ocular parameters may serve as a screening tool for drivers that are at high risk for driving. Drivers who were disqualified even once tend to be involved in more motor vehicle accidents than their peers.

Keywords: Ocular Parameters, Assessment, Truck Drivers, Fatigue

EFFECTS OF NIGHT MEAL ON SECURITY GUARDS' SLEEPINESS

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Objectives: A few studies have been performed to evaluate the effects of different diets contents on sleepiness. It has been suggested that there is an increase in sleepiness with a high-carbohydrate diet. This is particularly relevant for night workers who need to remain alert during work. This study aims to compare the effects of different night meal contents on sleepiness among night security guards.

Methods: Twenty-four night security male guards who work from 22:00 to 06:00h (Monday to Friday) volunteered to participate in this study. The guards' average age was 30.8 yo (SD= 5.5 yo); body mass index was 28.7 kg/m2 (SD= 4.0 kg/m2) and waist was 106.2 cm (SD= 10.4 cm). They wore an actigraph for three weeks, five days a week (Monday to Friday), to estimate their sleep-wake cycle, which was confirmed by a daily sleep log. The Karolinska Sleepiness Scale (KSS) was used to self-record sleepiness every three hours from waking up to going to bed. The first week was considered the baseline and the workers had the night meal they used to eat at work. In the second week the night meal was exchanged for a high-carbohydrate diet and in the third week the content of the night meal was high-protein. The workers did not know about the contents of the meals. Two analyses of variance were performed. The first one considered time of day as the repeated measurement and condition (baseline, high-carbohydrate diet, and high-protein diet) as a factor. The second ANOVA considered time of day as the repeated measurement, and body mass index as a factor (higher than 30 kg/m2 and lower than 30 kg/m2) for each experimental condition. Post-hoc tests were calculated whenever necessary.

Results: The first ANOVA did not reveal any significant effect among the three conditions. The other analysis found a time of day effect for the baseline week ($p<0.05$); a time of day effect ($p<0.05$) and an interaction effect between time of day and body mass index higher than 30 kg/m2 for the week with a high-carbohydrate meal ($p<0.05$). There were no significant effects observed on the condition with a high protein night meal.

Conclusions: The results suggest an effect from the contents of the night meal on night workers' sleepiness modulated by weight.

Keywords: Night Work, Nutrition, Sleepiness

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LIGHTING IN CARE HOMES FOR OLDER PEOPLE

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Objectives: The light dark cycle is a major time cue that entrains human physiology to the 24 hour day. Photic information is perceived by specialized cells in the retina and transmitted to the suprachiasmatic nuclei (SCN), the central circadian oscillator. Circadian phase shifting is most sensitive to short wavelength blue light, ~ 460 nm. With advancing age, alterations in the eye, the circadian timing system and the homeostatic regulation of the sleep-wake cycle occur which may partly explain the increased prevalence of sleep problems in older people. For the population of elderly people living in care home facilities there may be the added disadvantages of decreased independent mobility and poor quality indoor lighting. The aim of the study was to investigate the effect of a novel lighting condition (blue-enriched white light; 17000 K, 1000 lux) compared to a control white light (4000 K, 200 lux) on sleep quality, daytime alertness and performance in care home residents. Presented here are the room lighting levels and the participants' light exposure throughout the study with the hypothesis that the room lighting and an individual's light exposure will be increased in the 17000 K light condition compared to the control 4000 K light condition.

Methods: The 12-week study was a randomized crossover design conducted in four care homes (CH1, 2, 5 and 6) from September to December (2008 and 2009). After a baseline week of original care home lighting, each light intervention period (4000 K or 17000 K) lasted 4 weeks, with a 3-week washout period in between (original care home lighting). The experimental lights were installed in selected communal areas regularly used by the participants. The environmental light conditions in the communal areas were monitored daily using continuously recording lux meters (Hobos, Tempcon instrumentation Ltd, UK). The spectral composition and intensity of the test lights were also measured during each light condition. To determine individual light exposure levels, residents (n= 31, 4 males 27 females; 84 ± 7.5 years, mean ± SD) continuously wore Actiwatch activity and light monitors (Cambridge Neurotechnology Ltd) on their wrists. Using Actiwatch sleep analysis 5 software the time spent per day above a 500 lux threshold was determined for each subject in each light condition and compared using repeated measures 1 way ANOVA followed by a post hoc Bonferroni multiple comparison test.

Results: Evening room lighting levels in the care homes were consistent from week to week. As expected lighting levels increased with the 17000 K lights, (mean lux ± SD) as shown in the preliminary data (CH1 990 ± 176 lux, CH2 916 ± 155 lux, CH5 807 ± 209 lux, CH6 752 ± 206 lux) compared to the 4000 K lights (CH1 160 ± 33 lux, CH2 195 ± 36 lux, CH5 219 ± 67 lux, CH6 186 ± 60). The test lighting was evenly distributed across each room whereas the original care home lighting showed much greater variation (CH1 40 ± 23 lux, CH2 52 ± 76 lux, CH5 30 ± 15 lux, CH6 26 ± 19 lux). In 3 of the 4 care homes (CH2 n=5; CH5 n=12; CH6 n=9) the mean time per day (min ± SEM) spent by residents in light levels >500 lux was significantly greater during the 17000 K light condition (CH2 137±50 mins, $P<0.05$; CH5 64±15 mins, $P<0.0001$; CH6 29±5 mins $P<0.0001$) compared to the 4000 K lights (CH2 12±6 mins, CH5 7±2 mins, CH6 8±4 mins) and the washout period (CH2 15±5 mins, CH5 8±3 mins, CH6 4±2 mins). In CH1 (n=5) the difference between the 17000 K light condition (25±20 mins) and the 4000 K lights (23±9 mins) and the washout period (5±3 mins) did not reach statistical significance. Overall the 17000 K lights increased the time spent above 500 lux compared to the 4000 K lights and washout by 48±12 and 52 ±12 mins, respectively.

Conclusions: The findings indicate that through increasing the light in selected communal areas the amount of time that care home residents spend under brighter light conditions (>500 lux) can be greatly increased.

Keywords: Light, Aging, Sleep Disorders

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CHANGE IN SLEEP STATE OF THE ELDERLY BEFORE AND AFTER CATARACT SURGERY

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Objectives: Aging is associated with changes to the transparency of the cornea and lens, these structures becoming more opaque. The amount of deterioration depends on the wavelength of the light and transmission of short wavelengths in particular falls in the aged people compared to younger controls. In the pathological condition known as a cataract, this reduction in transmission can be very marked. Light of short wavelengths is important in the control of melatonin secretion and the sleep-wake rhythm. The cataract patients, whose optical systems transmit light poorly, especially the shorter wavelengths, would be expected to have poor sleep as a consequence of the inadequacies of light transmission in the daytime. Moreover, cataract surgery should improve not only their sight but also the quality of their sleep. The present study has investigated melatonin secretion profiles and sleep patterns before and after cataract surgery. Accepting that surgery will increase the amount of light entering the eye, particularly light of short wavelengths, it is predicted that the operation will result in increases in melatonin secretion and an improvement in sleep.

Methods: Fifteen cataract patients (9 males and 6 females, mean age = 70.5y, SD = 7.2) participated. These subjects were identified as suffering from acquired tritanopia (based on the desaturated 15-hue test, Lanthony, France). UV-cutting intra-ocular lenses (IOLs) were used, not blue light-cutting IOLs, for patients after surgery. Each subject was studied for 3 consecutive weekdays before, and one month after, their cataract surgery. Each subject wore a portable illuminance and activity monitor (Actiwatch-L) on the wrist of their non-dominant arm throughout the study days (including when sleeping). The data were summed for illuminance and activity during two periods: "daytime", from wake-up time to 18:00 h and "nighttime" from 18:00 h to retiring time. The average values from the first two days of study were used for analysis of the amounts of light exposure and activity, and the sleep parameters. The sleep efficiency and sleep latency, based on the activity record during sleep time, were calculated by the Actiware-Sleep software. From 10:00 h in the morning of the third day to 6:00 h in the morning of the fourth day, saliva was collected every four hours with Salivette. The concentration of saliva melatonin was analyzed by the ELISA method (EK-DSM, Buhlmann). To obtain the total amount of melatonin secreted, the 4-h concentrations of melatonin were summed. The maximum amount of melatonin secreted and the time of maximum secretion were calculated by using spline interpolation.

Results: The analyses were performed on only the 12 subjects who provided complete data. No statistically significant differences between before and after surgery were observed in the amount of light received, activity, and the times of wake-up and retiring; there were no significant changes in their life style during experimental period. However, individual subjects responded differently; some showed increased melatonin secretion and improved sleep parameters whereas others showed deteriorations in these variables. This difference might be because morning or daytime exposure to light, especially light of short wavelength, promotes melatonin secretion and nocturnal sleep but exposure at night has an opposite effect. That is, an earlier wake-up time means that the effect of morning daylight predominates whereas a later retiring time accentuates the opposite effect of light at night. For the relationship between retiring time and sleep efficiency, a strong negative correlation ($r=-0.75$; $p=0.017$) was observed after surgery and, for the relationship between wake-up time and sleep efficiency, there was a negative tendency ($r=-0.58$; $p=0.067$) after surgery. No significant correlations were present between sleep efficiency and retiring and wake-up time before surgery, and between melatonin secretion and retiring and wake-up time either before or after surgery.

Conclusions: The subjects showed a negative correlation between wake-up or retiring times and sleep efficiency after surgery. The subjects' eyes received more light of short wavelengths and this affected sleep efficiency. The amount of light obtained during daytime as a result of the surgery works to improve sleep (if the retiring time is early), but the light received during the nighttime affects sleep negatively (with later retiring times). As a result of the surgery, the subjects responded not only positively to morning and daytime light but also negatively to light in the nighttime.

Keywords: Cataract, Short Wavelength Light, Sleep Efficiency, Elderly

MORNING PEOPLE ARE STABLE, PSYCHOLOGICALLY AND CHRONOBIOLOGICALLY: A PRELIMINARY REPORT

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Objectives: The endogenous circadian timing system is implicated in maintenance of mental health, but this association is not well-understood. Self-reported diurnal preference may be an important bridging concept, as 'morningness' has been shown by some investigators to correlate with (i) advanced circadian phase, and by others with (ii) psychological stability as measured in low Negative Emotionality (NE) and high Conscientiousness (C). Circadian amplitude, indexing robustness of suprachiasmatic nucleus (SCN) oscillation, may be a circadian substrate for psychological stability [e.g., 1], but has received little research attention. The aim of this research was to integrate personality trait and circadian assessments of healthy adults in order to test a number of predictions, including; (i) Morningness will be negatively associated with NE and positively associated with C, (ii) Morningness will be associated with earlier circadian phase, and (iii) Morningness will be associated with higher circadian amplitude.

Methods: Data were drawn from several inpatient laboratory studies conducted in a time-free environment at the Brigham & Women's Hospital, which included a baseline ≥ 30-hour constant routine (CR) protocol in <3 lux following three standard baseline days (16 h wake: 8 h sleep), as detailed elsewhere [2]. Subjects maintained a fixed sleep-wake schedule for 3 weeks prior to admission, validated by telephone call-ins and wrist actigraphy, which determined the in-patient sleep-wake times. Data from 92 young adults (age 18-30 years, n = 35 female) were analyzed from two different studies (n=55 and n=37, respectively). Morningness was measured using the Horne-Ostberg Morningness-Eveningness Questionnaire. The Psy-5 scales of the Minnesota Multiphasic Personality Inventory (MMPI-2) were used to measure NE and C (negative Disconstraint). Circadian phase and amplitude were estimated from the plasma or salivary melatonin rhythm (collected every 30-60 minutes during the CR procedure) using a three-harmonic model.

Results: Initial analyses found no differences between participants drawn from the various studies, permitting groups to be collapsed for hypothesis testing. Morningness scores were approximately normally distributed (M = 50.9, SD = 8.7, range: 30 – 72). Morningness was associated with older age (r = .32, p < .005) and an earlier sleep/wake schedule in the week preceding the laboratory protocol (bedtime: r = .37, waketime r = .38, p < .001 in both cases).

Table 1. Relationship between diurnal type, two facets of psychological stability and two circadian parameters

	NE	C	Circadian phase	Circadian amplitude
Morningness	-.26*	.21*	-.38**	.22*

Note: NE = negative emotionality, C = conscientiousness. * p < .05, ** p < .001

As shown in Table 1, hypotheses were supported with small-moderate effect sizes: stronger Morning-type preference was associated with decreased NE, increased C, earlier circadian phase and increased circadian amplitude. Earlier circadian phase was also significantly associated with higher circadian amplitude (r = -.27, p < .05). Exploratory investigations of the remaining Psy-5 traits from the MMPI-2 found no associations with Morningness or circadian parameters.

Conclusions: The majority of research into individual differences in circadian rhythm function has focused on the trait of diurnal type, and the circadian parameter of phase. This association was replicated here using rigorous chronobiological techniques, and extended by demonstrating that Morningness was associated with psychological stability (-NE and C) in the same sample. The novel hypothesis that Morningness would be associated with higher circadian amplitude was also supported. The findings underscore Morningness as one link between circadian biology and general personality traits. Restricted range of personality traits (particularly NE) was a limitation, and more complete analysis awaits investigation of larger, more representative samples.

Keywords: Circadian, Personality, Lark/Owl, Dim Light Melatonin Onset

References: 1. Vitaterna, M.H., et al., Proc Natl Acad Sci U S A, 2006. 103(24): 9327-32; 2.Lockley, S.W., et al., Sleep, 2006. 29(2): 161-168.

SUICIDE SEASONALITY: OVERVIEW AND CURRENT EVIDENCE

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Seasonality of suicides is a long-known and well-established phenomenon. It has already been observed in medieval chronicles, and investigations about seasonal patterns in occurrence of suicides have been published as early as 1825. Although it is commonly believed that most suicides happen in winter, research draws a very different picture: it is an established fact that suicide incidence is highest in spring (and lowest in autumn). In the northern hemisphere, this corresponds to the period between March and June, whilst in the southern hemisphere, the pattern is reversed: spring (and also the peak of suicide incidence) is in the time span between September and December. When suicide seasonality is explored in more detail, seasonal patterns are mostly driven by violent suicide methods (especially hanging, drowning, and jumping from high places). Moreover, women show an additional biannual cycle, with a second, smaller peak located in autumn.

The opposite patterns of seasonality in the northern vs. southern hemispheres suggest seasonality in suicide incidence to be related to climatic influences. Indeed, this is one of the suspected causes, as higher suicide rates have been found to be associated with increased sunshine hours (and also lower levels of relative humidity). Furthermore, suicide seasonality has been found to be linked to seasonal variation in psychiatric disorders (especially mood disorders). These facts may well have neurobiological underpinnings, as both sunshine and mood disorders are associated with altered serotonergic function. Moreover, low levels of the serotonin metabolite 5-hydroxyindoleacetic acid have been found in the cerebrospinal fluid of suicide attempters. Other suspected causes of suicide seasonality pertain to annual changes in social life and interactions, which explanation has already been proposed by Durkheim one century ago.

Seasonality of suicides was first reported to diminish in 1981 in Britain. More recently, seasonality of suicides was reported to decrease in other countries as well (e.g., Finland, Denmark, Switzerland). However, still other studies found no decrease (Italy) or even increases in suicide seasonality (e.g., Australia, USA). In this context, it has been suggested that the strength of suicide seasonality might be associated with suicide prevalence.

The present study analyzed suicides in Austria (1970-2008, $N = 67{,}741$) with complex demodulation, which is a "local" (point-in-time-specific) version of harmonic analysis. This method allows continuous modeling of seasonality by estimating the amplitude and the location (phase) of the yearly peak of suicide occurrence as a function of time. Hence, arbitrary sectioning of the time series analyzed (as was commonly done in prior related research) is avoided and possible associations of the amplitude of suicide seasonality with absolute numbers of suicide cases can be assessed. Results show that seasonality in Austria has been stable from 1970 onwards when associations of the amplitude of suicide seasonality with absolute suicide numbers are taken into account. Minor, albeit nominally significant, decreases in suicide seasonality are merely found in two subgroup analyses by sex and method (drowning among men and hanging among women), which however did not noteworthy contribute to overall seasonality, which, in turn, is preponderantly driven by hanging among men.

In summary, seasonality of suicides seems to be stable in contemporary Austria. It seems likely that patterns of increasing and decreasing seasonality in other countries correspond to the respective associations of suicide incidence with the strength of seasonality. Incorporating these data-analytic aspects and insights in future related research will serve our understanding of seasonal patterns in suicidal behavior and possible changes therein.

Keywords: Suicide, Seasonal Variation, Biologic Factors, Serotonin, Time Trends, Complex Demodulation, Austria

ACUTE NON-VISUAL RESPONSES TO SIMULTANEOUS PRESENTATION OF BLUE AND RED MONOCHROMATIC LIGHT IN HUMANS

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Objectives: Non-visual responses in humans are primarily blue light (λ_{max} ~ 480 nm) sensitive and this is mediated via the melanopsin-expressing intrinsically photosensitive retinal ganglion cells (ipRGCs) in the inner retina. Melanopsin appears to be a bistable photopigment that can form stable associations with both the *11-cis* and *all-trans* isoforms of retinaldehyde and utilise light to transition between these states. Both *in vivo* and *in vitro* work have demonstrated that prior exposure to long wavelength (red) light can enhance responses to subsequent short wavelength (blue) light exposure, presumably via this bistable function by increasing the proportion of the *11-cis* isoform available for photic stimulation. In the real-world, broadband polychromatic white lighting is used that contains wavelengths between 400 and 700 nm; thus, if the bistability of melanopsin is to be exploited in the optimisation of lighting it would more likely be via concurrent, rather than consecutive administration of red and blue light. Thus, the aim of the current study was to assess whether simultaneous presentation of red and blue monochromatic light could enhance human responses to blue light alone, and to investigate the irradiance dependency of these responses.

Methods: Healthy males (n = 16) aged 18-35 years (22.7 ± 3.9 years; mean ± SD) were studied in 6 or 8 overnight highly controlled (posture, food intake, light environment) laboratory sessions in a randomised, cross-over within-subject design. Prior to and during the overnight sessions the sleep/wake cycle (23:00 – 07:00 h), caffeine, alcohol and medication intake were controlled. The laboratory sessions included a 30 minute light stimulus individually timed to occur on the rising phase of the melatonin profile. The first night was a baseline, no-light condition and for the remaining nights blue (λ_{max} 479 nm) and red (λ_{max} 627 nm) monochromatic light at varying intensities (479 nm $2.5 \times 10^{13} – 1 \times 10^{14}$ photons/cm^2/sec; 627 nm $2.5 \times 10^{13} – 3.2 \times 10^{14}$ photons/cm^2/sec) were presented either alone or in combination. Light was administered via a sphere to ensure uniform illumination of the retina and the participants were pupil dilated and had fixed, monitored gaze. Subjective mood and alertness and plasma melatonin levels were assessed at regular intervals before, during and after the light pulse; heart rate was assessed throughout each overnight session.

Results: To date for all irradiances (2.5×10^{13}, 5×10^{13} and 1×10^{14} photons/cm^2/sec) of 627 nm light alone tested minimal melatonin suppression was observed that did not significantly differ from the changes in melatonin levels observed under the baseline (no light) condition. For both the 479 nm alone and 479 + 627 nm light conditions a significant effect ($p < 0.0001$) of irradiance was observed. The addition of 627 nm light did not significantly alter the melatonin suppression response to 479 nm blue light alone. Heart rate and mood and alertness data are currently being analyzed.

Conclusions: The blue light sensitivity and irradiance dependency of melatonin suppression concurs with previous studies in humans. However, the absence of response potentiation with simultaneous presentation of blue and red light suggests that the dynamics between the melanopsin isoforms are more complex than was originally speculated and require further investigation. If melanopsin bistability can be targeted using polychromatic light sources, the results of the current study will be relevant for optimizing lights in home, clinical and industrial settings.

Keywords: Light, Humans, Melanopsin-Bistability, Melatonin, Non-Visual Responses

Funding Support: 6th Framework Project EUCLOCK (018471), Philips Lighting (Eindhoven, The Netherlands) provided the light sources and cables.

THE INFLUENCE OF DURATION AND IRRADIANCE OF LIGHT ON ACUTE NON-VISUAL RESPONSES IN HUMANS

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Objectives: Melanospin containing intrinsically photosensitive retinal ganglion cells (ipRGCs) are sensitive to blue light (λ_{max} ~ 480 nm) and mediate an array of non-visual responses in humans. Acute light-induced responses in humans are irradiance-dependent but the impact of the duration of a light stimulus on the magnitude of these responses is less well understood. The relationship between duration and response magnitude is not linear and work in hamsters has suggested that there is a critical integration period during which photons are absorbed and beyond this additional light has no further effect. The aim of the current study was to assess the dependency of the magnitude and dynamics of human nocturnal non-visual responses on light irradiance, total photon content and light duration.

Methods: Healthy males (n = 9) aged 18-35 years (24.7 ± 5.3 years; mean ± SD) were studied in 6 overnight highly controlled (posture, food intake, light environment) laboratory sessions in a randomised, cross-over within-subject design. Prior to and during the overnight sessions the sleep/wake cycle (23:00 – 07:00 h), caffeine, alcohol and medication intake were controlled. Overnight sessions included a monochromatic (λ_{max} 479 nm) light stimulus individually timed to occur on the rising phase of the melatonin profile. The first night was a baseline, no-light condition and for the remaining nights blue (λ_{max} 479 nm) monochromatic light was administered at varying intensities and durations (10, 20 or 30 minutes). Light irradiance was adjusted either to provide the same photon flux (3×10^{13} photons/cm^2/sec) for 10, 20 and 30 min or to administer the same total number of photons (5.4×10^{13} photons) in 10, 20 and 30 min light pulses. Light was administered via a sphere to ensure uniform illumination of the retina and the participants were pupil dilated and had fixed, monitored gaze. Heart rate (Actiheart, Cambridge Neurotechnology, UK) was monitored throughout each overnight session. Subjective mood and alertness were verbally rated and blood samples were taken for measurement of plasma melatonin levels at 10 min intervals before, during and after the light stimulus. The maximum melatonin suppression attained as well as the suppression at +10, +20 and +30 min from the start of the light stimulus was calculated for each light condition.

Results: Significantly lower melatonin suppression was observed with the 10 min light stimulus compared to the 20 and 30 min photon flux-matched light stimuli (3×10^{13} photons/cm^2/sec). Melatonin suppression did not significantly differ between the three total photon-matched stimuli (5.4×10^{13} photons) when given for 10, 20 or 30 mins. Assessment of the time course of the melatonin response revealed that the most sustained melatonin suppression occurred with the 30 min light stimulus. Heart rate and mood and alertness data are currently being analyzed.

Conclusions: These preliminary findings suggest that the magnitude of the acute melatonin suppression response to light in humans is dynamic and is highly dependent upon an interaction between the duration and irradiance of a light stimulus. Identifying the critical irradiance and minimum integration period required to drive a range of non-visual responses will help to optimize the duration and light intensity needed for light treatments.

Keywords: Light, Duration, Human, Irradiance, Melatonin

Funding Support: 6th Framework Project EUCLOCK (018471), Philips Lighting (Eindhoven, The Netherlands) provided the light sources and cables.

PRELIMINARY METHOD FOR PROSPECTIVE ANALYSIS OF THE CIRCADIAN EFFICACY OF (DAY)LIGHT WITH APPLICATIONS TO HEALTHCARE ARCHITECTURE

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Objectives: The objective of this paper is to describe the characteristics of (day)light that may promote human health by providing lighting for the appropriate synchronization of circadian rhythms, and to use these findings to make specific (day)lighting recommendations, grounded in biological findings. Insufficient or inappropriate light exposure can disrupt normal circadian rhythms which may result in adverse consequences for human performance, health, and safety. An inpatient hospital room was simulated utilizing state of the art software to estimate achievement of lighting goals.

Methods: Four models were constructed for the purpose of calculations and experiments which follow (1) a photometric model which converts illuminance into a circadian weighted-value using Microsoft EXCEL (2) a DAYSIM simulation model of the subject room for annual daylight estimation (3) a RELUX simulation model of the subject room for artificial interior illumination estimation and (4) a RADIANCE simulation model of the subject room for measuring the relative effects of interior paint color on light spectra as received at specific points in a subject room. Using calculations from the first model, (day) lighting intensity, spectrum, and timing goals were set for the next two models. The fourth model was used to estimate the relative decay in major spectral components (Red, Green, Blue) of daylight due to differing paint colors for interior wall surfaces.

Results: These model predictions remain to be tested experimentally and therefore remain a work-in-progress as additional information is accrued. These initial findings demonstrate that room with a window is no guarantee of adequate circadian illumination. Artificial lighting, in its most common forms, cannot substitute for circadian illumination in most building applications. Other design decisions such as interior paint color may also impact the adequacy of circadian illumination.

Conclusions: This paper has successfully demonstrated that simulation software may be utilized to predict how architectural design affects the circadian efficacy of light as received by the human eye. While a specific scenario was envisioned, some general conclusions such as the design of, and distance from, a building's façade impact daylight's circadian cues (Pechacek et al, LEUKOS 5, 2008).

Keywords: Circadian, Daylight, Evidence-Based Design, Melatonin

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LIGHT-CONTROLLED MELATONIN SUPPRESSION CONSIDERING PERSON'S AGE

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Objectives: The discovery of retinal photoreceptors responsible for melatonin suppression and of their spectral sensitivity by Brainard et al. (2001) and Thapan et al. (2001) allows to develop both effective and energy-efficient light sources to stimulate the individual circadian rhythms based on age-depend spectral sensitivity of the eyes, on time of the day, on the needs to fulfil visual functions as well as on the needs for health protection. The circadian efficacy of light sources is sufficiently described by the spectrum, the irradiance, the geometry of exposure and the radiance.

Methods: We exposed healthy volunteers of different ages and with free pupil adaptation to polychromatic (white) light sources of different spectra and determined the individual effective (circadian weighted) threshold irradiance responsible for melatonin suppression. In addition, we analyzed the effects of both different solid angles of exposure and of radiance.

Results and Conclusions: In case of exposure in 2π geometry, the effective (circadian weighted) threshold irradiance for getting saturation of melatonin suppression ranged between $E_{cm} \approx (0.3 \pm 0.1)$ W m^{-2} for young adults and $E_{cm} \approx (0.6 \pm 0.2)$ W m^{-2} for seniors. Assuming a value of threshold luminance concerning glare $L_{vG} = 500$ cd m^{-2} as defined in DIN 5035-1, the relative circadian effectiveness ($k_{cv} = E_c/E_v$) – or equivalently the Correlated Colour Temperature (CCT) – of white light sources has to exceed values k_{cv} of about 0.13 W m^{-2} klx^{-1} (or equivalently CCT ≥ 1450 K) for young adults and of about 0.25 W m^{-2} klx^{-1} (or equivalently CCT ≥ 1700 K) for seniors for getting sufficient melatonin suppression below the threshold value of glare (E_c - effective (weighted) circadian irradiance, E_v – illuminance). In cases of light exposures using threshold irradiance E_{cm} but with reduced solid angles (Ω) and adequately increased radiances, melatonin suppression decreased significantly in the range $0.1 \text{ sr} \leq \Omega \leq 0.5$ sr due to a significant reduction in the number of exposed receptors on the retina whereas melatonin concentration increased for solid angles below about 0.1 sr. Moreover, increase of radiance was limited by glare. Thus, the criterion $k_{cv} \cdot \Omega > E_{cm}/L_{vG}$ had to be met in order to get sufficient melatonin suppression without glare.

Keywords: Melatonin Suppression, Circadian Rhythms, Threshold Values, Glare

COGNTIVE PERFORMANCE UNDER ROTATING SHIFT WORK – IS THE MORNING SHIFT A RISK FACTOR?

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Objectives: Endogenous circadian clock influences the cognitive processing within a 24-h day. Shift work causes environmental disturbances of the clock with consequences to sleep, attention and cognitive processing. Trends in the risk of accidents and injuries in the industrial situations suggest differences in cognitive performance between the individual work shifts. We investigated if the cognitive performance and the susceptibility for lapses varied between morning shift, late shift and night shift and what role chronotype plays for diurnal variation of performance.

Methods: An explorative field study was conducted. Seventeen nurses (seven male, age between 22 and 52) participated on the experimental test protocol. Chronotype, mental health and sleep quality was evaluated in standardized questionnaires. Six early chronotypes (mid sleep on free days corrected for sleep deficit, msf_sc = 2.56, SE .28), five normal chronotypes (msf_sc = 4.21, SE .05) and six late chronotypes (msf_sc = 6.14, .27) were identified according to the Munich Chronotype Questionnaire (Roenneberg et al., 2003). The sleep-wake behavior was verified by wrist actigraphy and sleep diaries. An auditory discrimination task was used for evaluation of cognitive performance. Performance, vigilance and sleepiness were measured in the morning shift, afternoon shift and night shift on three following days. Test sessions took place at the beginning, in the middle and at the end of each shift. Diurnal variation of performance within the work shift was analyzed using median-based by ANOVA for repeated measures. Temporal fluctuation of performance between the works shifts was analyzed by ANOVA for repeated measures based on the mean value of all three test sessions of each shift.

Results: Cognitive performance varied significantly between and within the work shifts. The poorest performance and vigilance was observed in the morning shift, whereas performance did not differ considerable between the afternoon and night shift. The deterioration of auditory performance was especially visible at the beginning of the morning shift and after the melatonin onset during the night shift. No increase of lapse rates was observed during the night. The mean melatonin onset occurred in the late evening, between 20:00 hours and 1:00 hours. When onsets were determined individually for chronotypes, the mean melatonin onset took place for early types at 20:50 p.m. (SE 37 min), for normal types at 23:40 p.m. (SE 24 min) and for late chronotypes at 0:25 a.m. (SE 47 min). Sleep duration was related to the kind of work shift. The nurses slept significantly shorter in the night before the morning shift [mean 5:04 hours (SE 17 min)] than in the night before the afternoon shift [mean 7:40 hours (SE 27 min)]. The sleep-wake behavior varied between chronotypes. Late chronotypes slept shorter before the morning shift and longer before the late shift than early and normal chronotypes. Diurnal course of performance and vigilance did not vary significantly between chronotypes, though a trend was visible in that early and normal chronotypes showed the best vigilance level and the best performance in the afternoon shift, whereas late chronotypes had a peak in vigilance and performance in the night shift. The analysis of questionnaires showed a trend for a decrease of sleep quality, prolongation of sleep time and an increase for risk of depression with progressive years in shift work.

Conclusions: These results suggest that the highest risk for accidents and injuries was visible in the morning shift which has important consequences for the health and safety protection at the workplace. The environmental disturbances of the clock which has consequences for sleep, attention and cognitive processing indicates a decrease of the flexibility of the circadian system under shift work conditions.

Keywords: Cognitive Performance, Shift Work, Risk of Accidents and Injuries, Mental Health

Reference: Roenneberg, T., Wirz-Justice, A., Merrow, M (2003). Life between clocks: daily temporal patterns of human chronotypes. *Journal of Biological Rhythms*, 18, 80-90.

LIGHT AND MELATONIN PHASE RESPONSE CURVES (PRCS)

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Light and melatonin are able to shift the timing of the circadian clock with the direction and magnitude of this phase shift being dependent upon the time at which the stimulus is administered. This relationship can be described as a phase response curve (PRC). This ability of light and melatonin can be exploited to treat situations of circadian misalignment where the circadian clock is inappropriately aligned with the desired sleep/wake schedule such as occurs in night shift work and jet lag. The optimal stimulus administration time may depend on the dose (melatonin) or spectral power (light). Thus, we have generated PRCs to two different doses of melatonin as well as both blue and white light using the same protocol which will allow the phase shifting effects of melatonin and light to be directly compared and determine the influence of dose/spectra on the shape of the PRC.

The protocol is designed to administer a light/melatonin stimulus to subjects free-running through an ultradian light/dark cycle. Each subject contributes one point to a PRC. After maintaining a regular sleep/wake schedule at home for a week the subjects complete a 5-day laboratory session which consists of a baseline phase assessment to determine their dim light melatonin onset (DLMO), 3 days on an ultradian light (< 150 lux): dark (0 lux) cycle (LD 2.5:1.5) and concluding with a final phase assessment. Subsequently, the subjects return to their fixed home sleep/wake schedule for another week before returning to the laboratory for a second session. On one session the subjects are exposed to the stimulus (light pulse/melatonin pill) at the same clock time on each of the 3 days whilst in the ultradian LD cycle and during the other session they receive room light/placebo pill (counterbalanced; double blind for melatonin conditions). An individual's phase shift to the stimulus is calculated by subtracting the phase shift to the free-run from the phase shift to the stimulus. The PRCs are plotted relative to DLMO but also to each individual's home sleep midpoint. In real-life conditions the DLMO may not be known and so it is essential to be able to predict the phase shifting efficacy of light and/or melatonin relative to a known parameter (sleep times) to treat situations of circadian misalignment. Two different doses of melatonin (0.5 and 3.0 mg) and two different light stimuli (blue and white) have been used. The blue light is an intermittent pattern of three 30 min pulses separated by 15 min of room lighting of ~ 185 lux and produced by narrow bandwidth LEDs (λ_{max} 467 nm; goLITE, Philips) and the white light is a 2 h pulse of fluorescent light ~ 3500 lux.

PRCs to 0.5 and 3.0 mg melatonin have been completed (Burgess et al., 2008; Burgess et al., 2010). These PRCs have revealed that the optimal time of administration for both advances and delays is later for the lower dose. However, the maximum phase shift observed does not differ between doses when they are given at their respective optimal administration times. To date, partial PRCs to white light and blue light have been constructed and these are currently being completed.

Keywords: PRC, Light, Spectra, Melatonin, Dose

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THE RELATIONSHIP BETWEEN THE SPRING PEAK OF SUICIDES AND DEPRESSION

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The well-known seasonal variation of suicide (spring/early summer peak, winter low) also corresponds to the annual fluctuation of some indicies of central serotonergic metabolism, including brain serotonin transporter binding capacity, indicating significantly lower brain serotonergic activity in spring and summer and it is also demonstrates that low central serotonin metabolism is a strong biological correlate of some pathological behaviours, such as depression, impulsivity and violent suicidal acts.

Based on the early findings suggesting that seasonality of suicides might be the consequence of the seasonal incidence of depression–related suicides, previously we found that decreasing seasonality of suicides might be a good marker of lowering rate of depressive suicides in the population. In our most recent study we analyzed the relationship between increasing antidepressant utilization and national suicide rate of Hungary between 1998 and 2006, with particular regard to seasonal patterns and gender differences. Time trend analysis (ARIMA) had been applied to investigate the correlation between the trend of antidepressant prescription and both of suicide rates and seasonality index. During the 9 years of the study period there was a significant ($p<0.001$) correlation between the steadily increasing antidepressant prescription (113%) and continuous decline in total national suicide rate (23%) as well as both in females and males (21% and 23%, respectively), but this relationship was 8-fold stronger in males. Increasing antidepressant utilization was associated with significantly decreased seasonality of suicides only among males. As national suicide rates are affected by many known (unemployment, divorce rate, alcohol consumption, living standard etc) and unknown factors the isolation of the result of better treatment of depression in declining suicide rates is not easy. Our present results suggest that decreasing seasonality of suicides could be a good marker of lowering rate of depression-related suicides in the population particularly among males.

IMPACT OF LIGHT THERAPY ON THE EASE OF LEARNING CURVE AND ACADEMIC SUCCESS RATE OF STUDENTS

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Objectives: This study has 4 objectives: 1. Study the impact of light therapy on energy, mood and sleep of college students (average age: 18 years) during their academic semester. 2. Assess the possible link between light therapy, academic achievement and ease of learning of the students. 3. Establish a link between the intrusive light in the environment of the students and their sleep/awakening and general health. 4. Stimulate learning and concentration of students while promoting science.

Methods: Two groups of 32 students each have participated in the study (identified by group A and group B). These students come from the Natural Sciences program at CEGEP de Sherbrooke (Québec, Canada). Students' schedule was planned so that they had their chemistry class every morning at 8h30, while having their light therapy under the supervision of the teacher. During that period, the students followed their classes and, at the same time, they received their daily light dose (30 minutes). The study was performed over two periods of five weeks, from November 9th until December 11th, 2009 and from January 19th until February 20th, 2010. During the fall semester 2009, the group A acted as the active group and the group B as the control group. During the winter semester 2010, the roles of both groups were interchanged (group A was the control group and group B, the active group). The light therapy was performed using Litebook Elite™ device (new generation of light therapy lamp using the technology of light-emitting diodes, from Litebook Company, Alberta, Canada). To monitor the study, each student signed a form of consent and completed a logbook. The content of the logbook was as follows: 1. A questionnaire to establish their chronotype profile; 2. A preliminary questionnaire describing their general profile: color of eyes, general health, extra curriculum work, type of lamps used in their environment, smoker or not, etc.; 3. A daily questionnaire describing their way of life: hours of sleep, mood, energy, diseases, time spent in front of television and computer, hours of activity outside and inside, etc.; 4. A summary questionnaire.

Results: For autumn 2009, 58% of the students fully completed the study. Another 22% completed most of the study, while failing to report 3 to 5 days of results (logbook and/or light exposure). Finally, 20% of the students failed to report 6 to 14 days of results (logbook data and/or light exposure). In the active group (group A), some students reported that the light therapy helped them to be more focused during the class, produced more energy and improved sleeping. One student had strong SAD symptoms before the study, and with the light therapy project, the symptoms disappeared. For the winter 2010, 90% of the students fully completed the study. Another 10% completed most of it, while failing to report 2 to 5 days of results (logbook and/or light exposure). In the active group (group B), students reported that the light therapy helped them to be more focused during the class, produced more energy and improved sleeping.

Conclusions: The analysis and the compilation of the logbook data as well as the analysis of the students' academic profile (current and past academic achievements) are in progress. This data are used to assess a possible link between the light therapy, the ease of learning and the success at school. This paper presents and discusses the compilation of these results. This paper also presents the planned work for next fall. Groups A and B will be followed through their academic success. The light therapy protocol will be reconducted by following two new groups. A follow-up on the profile of the circadian rhythms of these students is also planned by the dosage of the melatonin in their saliva or their urine.

Keywords: Light Therapy, Ease of Learning, Chronotype, Circadian Rhythm, Teenage Sleep

Funding Support: CEGEP de Sherbrooke, Québec, Canada and Litebook Company Ltd, Alberta, Canada

PHASE RESPONSE CURVE TO A SINGLE 6.5-H LIGHT PULSE OF SHORT-WAVELENGTH LIGHT

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Objectives: The resetting response of the human circadian pacemaker to light depends on the circadian timing of exposure and is described by a Phase Response Curve (PRC). Previous PRCs in humans have been carried out for bright white light. Given that the circadian photoreception system is most sensitive to shorter-wavelength visible light, the aim of the current study was to assess whether the PRC to a 6.5-hour exposure to monochromatic blue light (480 nm) differed substantially from the PRCs to white light constructed using the same protocol.

Methods: Eighteen young (18-30 years), healthy male and female subjects were studied for 9-10 days in a time-free environment. Following three baseline days (16:8 h wake:sleep), subjects underwent an initial ~30-52-hour Constant Routine (CR) in <3 lux and, after an 8-hour sleep, were exposed to monochromatic 480 nm light (11.8 $\mu W/cm^2$) for 6.5 hours in a modified Ganzfeld dome centered in the 16-hour wake episode. The subjects' pupils were dilated 15 minutes prior to light exposure. The light timing for each subject was randomized to one of 18 circadian phases separated by 20^o intervals according to habitual wake-time. After an 8-hour sleep, subjects began a second CR (~32-55 h) followed by a recovery sleep and discharge. Core Body Temperature (CBT) was measured every minute via a rectal thermistor. Data were visually inspected and non-physiological values due to probe slips and removals were excluded. The phase of CBT minimum was determined for CR1 and CR2 separately. Phase shifts were calculated for the difference in CBT-min between CR1 and CR2, plotted according to conventional criteria, and fit with a single harmonic function.

Results: The PRC derived from the CBT data of 16 subjects shows a peak-to-trough amplitude of 2.3 h, with maximal delays of -1.4 h and maximal advances of 0.9 h, respectively.

Conclusions: Exposure to a 6.5 h pulse of 480 nm monochromatic light resets the circadian pacemaker according to a conventional Type 1 PRC.

Keywords: Short-Wavelength Light, Phase Response Curve, Core Body Temperature

Funding Support: This work was supported by National Institute of Mental Health Grant 5R01MH45130-19.

EFFECT OF BRIGHT LIGHT ON SLEEPINESS OF NIGHT WORKERS

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Objectives: Many critical aspects of modern life, including medical care, power generation, the military, law enforcement, and public transportation, depend on shift workers. About 20% of workers in industrialized countries are shift workers and more than of half of them work on night or rotating shifts. Shift work is associated with numerous negative effects, the most prominent of which is disturbed sleep. Most night workers complain of sleepiness due to lack of adjustment of circadian rhythms. In simulated night-work experiments scheduled exposure to bright light has been shown to reduce these complaints. Our study assessed the effects of bright light exposure on sleepiness during night work in an industrial setting.

Methods: In a crossover design, 94 workers at a ceramic factory were exposed to either bright light (2500 lux) or normal light (300 lux) during breaks on two consecutive nights. All subjects worked two 12-hour day shifts (0600 h to 1800 h) followed by two days off work, and two 12-hour night shifts (1800 h to 0600 h). This schedule was then repeated after a four-day washout period. Twenty minute breaks were initiated between 2400 h and 0200 h. Two break rooms were set up which were similar (e.g., with respect to temperature, décor and general ambience) apart from lighting conditions. One of the break rooms was modified for bright light (BL). Workers were instructed to go to the bright light room for all breaks during night work. During the normal light condition, workers went to the room with normal illumination (300 lux). Sleepiness ratings were determined using the Stanford Sleepiness Scale (SSS) at 2200 h, 2400 h, 0200 h and 0400 h. The SSS is a seven-point verbally anchored scale.

Results: All participants were male, and the mean age was 33 years (range 21 – 45 years). In both conditions the workers took two breaks at work. The first break had a mean length of 22.0 ± 0.2 min and the second break lasted 21.2 ± 0.4 min. The timing of breaks or their frequency did not significantly differ between conditions. Sleepiness was most significant at 0400 h and at 0200 h. A significant reduction in sleepiness was noted in the group exposed to bright light, particularly on the second night between 0200 h and 0400 h.

Conclusions: This study demonstrates the effectiveness of exposure to bright light (BL) on decreasing the level of sleepiness in shift workers during their breaks. Despite the short duration of exposure to bright light (two 20 minute breaks), significant effects were observed. Exposure to bright light may be effective in reducing sleepiness in night workers. Further research is necessary to determine the persistence of this effect and to assess the effects in terms of worker safety and productivity.

Keywords: Circadian Rhythm, Shift Work, Sleepiness, Bright Light, Night Work

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EFFICACY AND HYPNOTIC EFFECTS OF MELATONIN IN SHIFT-WORK NURSES: DOUBLE-BLIND, PLACEBO-CONTROLLED CROSSOVER TRIAL

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Objectives: Night work is associated with disturbed sleep and wakefulness, particularly in relation to the night shift. Circadian rhythm sleep disorders are characterized by complaints of insomnia and excessive daytime sleepiness that are primarily due to alterations in the internal circadian timing system or a misalignment between the timing of sleep and the 24-h social and physical environment. The pineal hormone melatonin regulates a variety of physiological processes. However, it is the hypnotic effects of melatonin that are considered an integral component of its physiological role in sleep modulation. Administration of melatonin can also produce phase shifts in circadian rhythms, and has been used to treat the symptoms of circadian maladaptation associated with shift work.

Methods: We evaluated the effect of oral intake of 5 mg melatonin taken 30 minutes before nighttime sleep on insomnia parameters as well as subjective sleep onset latency, number of awakenings, and duration of sleep. A double-blind, randomized, placebo-controlled crossover study with periods of 1 night and washouts of 4 days comparing melatonin with placebo tablets was conducted. The treatment phase of each sequence consisted of taking a 5 mg tablet of melatonin about 30 minutes before habitual nighttime sleep. The placebo phase consisted of taking an identical looking placebo on the same schedule. Both melatonin and placebo were taken on the first night after night work. We tried to improve nighttime sleep during recovery from night work. Participants were 86 shift-worker nurses aged 24 to 46 years. Each participant completed a questionnaire immediately after awakening.

Results: Sleep onset latency was significantly reduced while subjects were taking melatonin as compared with both placebo and baseline. There was no evidence that melatonin altered total sleep time (as compared with baseline total sleep time). Although melatonin treatment did not significantly alter other insomnia variables compared with baseline values, there was a significant improvement in sleep quality with melatonin treatment. No adverse effects of melatonin were noted during the treatment period.

Conclusions: Melatonin may be an effective treatment for shift workers with difficulty falling asleep. Regarding the high prevalence of insomnia in shift workers, more studies about melatonin effect on different kinds of insomnia parameters (difficulty falling asleep, difficulty staying asleep, problem waking up too early, and sleep quality) causing by shift working is recommended.

Keywords: Melatonin, Shift Work, Insomnia, Nurse, Sleep

References: 1. Sveinsdottir H et al. Self-assessed quality of sleep, occupational health, working environment, illness experience and job satisfaction of female nurses working different combination of shifts. Scan j caring sci 2006;20: 229-237; 2. Montes A et al. Treatment of primary insomnia with melatonin: a double-blind, placebo-controlled, crossover study. J Psychiatry Neurosci 2003;28: 191-196.

THE PUPILLARY REFLEX DURING SHORT-TERM LIGHT EXPOSURE IN VIVO: IS MELANOPSIN BISTABILITY DETECTABLE?

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Objectives: Intrinsic photosensitive ganglion cells (ipRCG) are sensitive to blue light. Regeneration of the melanopsin chromophore in ipRGC's differs from that of rods and cones and may include stimulation with another wavelength, in particular red light (termed bistability). This study was designed to evaluate if melanopsin bistability is present during short-tem exposure. Light response was evaluated by the pupillary light reflex (PLR).

Methods: Nine healthy subjects were examined with chromatic pupillometry using blue or red light, 470 and 660 nm, 300 cd/m^2. The baseline pupil size was measured during 10 seconds in the dark before each experiment and the PLR during the experiment was expressed normalized to the baseline pupil. The subjects were exposed to either a sequence of blue light stimulations (blue-blue-blue), or a sequence where the middle stimulation was changed to red light (blue-red-blue). All exposures were 30 seconds and separated by dark intervals. As a summary parameter, the pupil size during each 30 second light exposure was summed (Area Under the Curve, AUC). To analyze the presence of bistability, the response to blue light was analyzed as the percentage difference between the first (reference) blue exposure and the last blue exposure (test).

Results: The AUC was significantly larger during blue exposure compared to red light ($p<0.001$) and during exposure to blue light the pupil contraction was nearly constant, in contrast to a slow re-dilation during exposure to red light. The analysis of bistability (comparing the percentage difference with either blue or red interweaving light) did not show a significant difference ($p>0.2$). Similar results were found after an initial dark-adaptation of 30 minutes.

Conclusions: The PLR during blue light was significantly larger than for red light, indicating that ipRGC cells were stimulated. The present study did not indicate the presence of bistability of melanopsin as the response to blue light was not significantly affected by an interweaving 30 seconds exposure to red light. The molecular mechanism in regeneration of human melanopsin has not yet been elucidated and previous studies in vitro and in vivo are not consistent regarding bistability. A possible explanation of the lack of bistability in the present study may be due to the relative short light exposure.

Keywords: Pupillary Light Reflex, Melanopsin, Bistability, Chromatic Pupillometry

Funding Support: The Velux Foundation.

METEOROLOGICAL ANALYSIS OF SYMPTOM DATA FOR PEOPLE WITH SAD (SEASONAL AFFECTIVE DISORDER)

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Objectives: Variation in natural light levels is known to affect people with SAD. Several meteorological factors related to luminance can be forecast but little is known about which factors are most indicative of worsening of SAD symptoms. The aim of the meteorological analysis is to determine which factors are linked to SAD symptoms.

Methods: The symptoms of 292 individuals with SAD in Groningen and the surrounding area were evaluated by weekly questionnaire over the period 2003 to 2009. Meteorological factors linked to periods of low natural light wre obtained from hourly measurements from 36 weather observation stations from KNMI (Koninklijk Nederlands Meteorologisch Institut). The observed weather variables include sunshine duration, global radiation and cloud cover. Interpolated values were linked to the location of patient residence. Regressions of the SAD symptoms against each weather variable individually are carried out adjusting for weeks of light treatment administered. The weekly rate of change of each weather parameter is also examined to determine possible relationships with symptom change.

Results: Weekly sunshine duration, global radiation and horizontal visibility are anti-correlated with SAD symptoms; cloud cover and mist probability are positively correlated. Rate of symptom change is linked to sunshine duration and cloud cover as well as the rate of change of these and the rate of change of global radiation. The mean weekly change in SAD symptom score $S_{BDI\text{-}II}$ for weeks with no light treatment is 0.026 of $\ln(S_{BDI\text{-}II} + 1)$ per week (95% Confidence Interval CI [0.014;0.039]), and -0.45 (95% CI [-0.51;-0.39]) for light treatment weeks. The results suggest that light treatment is mainly effective in weeks of low sunshine duration, low global radiation and greater cloud cover.

Conclusions: The meteorological variables sunshine duration, global radiation, horizontal visibility, cloud cover and probability of mist are linked to SAD symptoms. Furthermore, week-on-week change in sunshine duration, global radiation and cloud cover may be used to predict worsening of symptoms. Light treatment is an effective means of countering the lack of natural daylight and may be even more effective if used at times when worsening of symptoms are forecast by meteorology.

Keywords: Seasonal Affective Disorder, Meteorology, Light Treatment

BLOCKING SHORT WAVELENGTHS OF LIGHT DOES NOT IMPACT ALERTNESS LEVEL IN THE MIDDLE OR END OF A SLEEP DEPRIVED NIGHT

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Objectives: It has been suggested that blocking the stimulating effect of blue light in the morning, could yield, in shift workers, a period of high sleepiness while driving (Lockley SW. J Pineal Res, 42: 210-1, 2007). We investigated if blue blockers would impact the possible alerting effect of a blue-enriched white light in the middle or the end of a sleep deprived night, when people are most tired.

Methods: 20 participants (9M, 11F) were maintained awake in dim light through two consecutive nights during which vigilance was assessed subjectively with a visual analogue scale (VAS) and objectively with the Conners' continuous performance test 2 (CPT-II) at 23:30 h, 1:30 h, 3:30 h and 5:30 h. The first night served as baseline evaluation and the second as the experimental night. Group 1 (n=10, 4M) was exposed first to 500 $\mu W/cm^2/s$ of blue-enriched white light (provided by two Litebook Élites) at 3:00 h and then to 1500 $\mu W/cm^2/s$ from the same light device at 5:00 h while wearing blue-blockers (500 $\mu W/cm^2/s$ behind the glasses). Group 2 (n=10, 5M) performed the same conditions in a different order.

Results: Groups were analyzed separately due to an unfortunate difference in mean age ($p = 0.001$) and bedtime habits ($p = 0.039$). In group 1 ([age ±SD; time in bed ±SD] 27.4 ±1.8 years old; 8:30 ±0:51), VAS was higher than baseline after both the 3h30 and 5h30 light exposures. In group 2 (24.5 ±1.5 years old; 7:43 ±0:43) no subjective effect of light was observed. Besides in both groups, no difference could be detected with the CPT-II.

Conclusions: Prior to the study, one group was receiving about 45 minutes more sleep per day. It was this group only who appeared to benefit most from bright light at night in terms of subjective vigilance. Wearing blue blockers did not hinder this effect.

Keywords: Blue-Enriched Light, Vigilance, Sleep, Blue-Blockers

PATTERNS IN HORMONAL RELEASE IN PLASMA WHEN STAYING IN NATURAL AND ARTIFICIAL LIGHT

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Objectives: The aim of the study was to investigate the subjects' psychological, physiological and visual response to lighting design/electromagnetic radiation.

Methods: The study was carried out at Jonkoping University in three rooms that looked the same but differed in the quantity and quality of electromagnetic radiation. 20 persons, 12 women and 8 men with an average age of 24.6 years attended the study. In order to gather data about the physiological responses to the three lighting environments, saliva and blood specimens were collected from the test subjects in order to measure the levels of cortisol, melatonin, adrenaline, noradrenalin and oxytocin. The specimens were collected by a biomedical analyst from the Ryhov County Hospital (*Länssjukhuset Ryhov*). The analyses were carried out by Ingegerd Thudén and Carina Tengham as described below. The test tubes were transported daily to the Clinical Chemistry Department in carrying cases equipped with freezer clamps. Ice cubes and freezer clamps were available each day. Leftover material, centrifuge and waste were transported away at the end of the study. In the oxytocin test, the test tubes were frozen at -70 ºC. In the test for cathecholamines, the tubes were frozen at -70 ºC. Cortisol tests were treated as routine tests and the backup test tubes were frozen at -20 ºC. Gunilla Burell's Personality Test was used to measure the emotional response to room and lighting design. The test, "How people feel", developed at the Department of Environmental Psychology in Lund was also used. Semantic environmental description was used to record the room experience (Küller 1991).

Results: When hormonal release in plasma among 20 subjects is investigated when staying in daylight and artificial light during a day, differences in mean for level of hormones can be seen. Each subject's hormonal release in artificial light is analysed with the subject's hormonal levels released in daylight as a reference.

Table 1. Mean for visual support, cognitive performance, hormones and the experience of wakefulness.

Room Time	Vis.s	Cogn perf.	Kortisol nmol/L	Adrenalin nmol/L	Nadrena nmol/L	Melatonin pg/ml	Oxytocin pmol/L	Awake
1 12.00	5.8	83.8	Highest	Mid	Middle	Middle	Middle	3
2 12.00	5.3	82.5	Middle	Highest	Lowest	Lowest	Highest	2.8
3 12.00	4.3	79.5	Lowest	Lowest	Highest	Highest	Lowest	2.8
1 16.00	5.1	73.2	Middle	Middle	Lowest	Highest	Middle	2.9
2 16.00	4.8	67.5	Highest	Highest	Middle	Lowest	Highest	2.5
3 16.00	5.6	63.5	Lowest	Lowest	Highest	Middle	Lowest	3.2

Conclusions: The results from the study suggest that **t**he means in hormonal level of cortisol, adrenalin, noradrenalin, melatonin and oxytocin among the subjects measured in daylight is, when compared to those obtained when the subjects stay in artificial light, the most natural. From the deviation in general patterns during the day, differences can be seen from the subject's increase and decrease in hormonal levels when staying in natural and artificial light. When the changes in hormonal level are analyzed and compared to the general patterns that can be seen during the day, the subject's that show the most increase in hormonal levels, do so in the most decreasing level of light. More knowledge about the impact from electromagnetic radiation on hormonal release has the potential to guide the design of lighting applications and the future development of new light sources, such as LEDs, in a way that provides natural and human illuminated environments with limited negative physiological impact.

Keywords: Lighting Design, User Responses, Patterns, Hormonal Release

AN ACUTE EFFECT OF LIGHT ON REPRODUCTIVE HORMONES IN WOMEN: THE ROLE OF SPECTRUM

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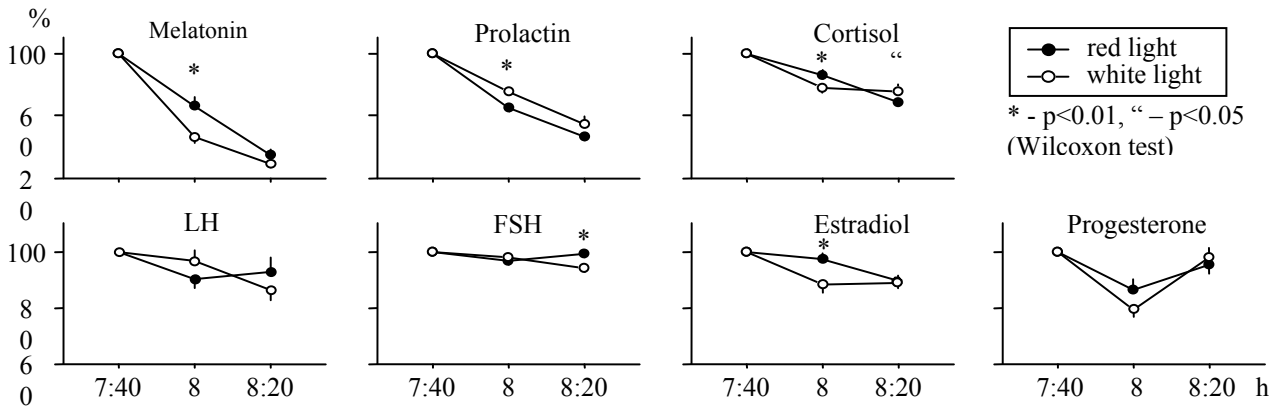
Objectives: Light is known to stimulate reproductive function in women. However, little is known about the immediate specific effect of light on female reproductive hormones. Studying small groups of women, Miyauchi and colleagues found that light raised serum levels of follicle-stimulating hormone (FSH), luteinizing hormone (LH) and prolactin. The effect on prolactin has been extensively investigated, but the results are contradictory; estradiol levels were not immediately changed by bright light (summarized in [1]). We here investigated the acute impact of light on reproductive hormones in women, addressing the role of blue-sensitive (~480 nm) melanopsin-based photoreception mediating the non-visual effects of light. Melatonin and cortisol were also measured as recognized indicators of the specific spectral action of light (control).

Methods: In April-May 2009, 16 healthy women (age 20-44 y) came to the laboratory twice in 1-3 days (median = 2 days) during the follicular phase of their menstrual cycle. They arrived ~07:30 shortly after waking and wore sunglasses (<10 lux) during the 5-10 minute walk from their home to the laboratory. During one session, a broad-spectrum white-appearing light with a superimposed peak at 469 nm was presented; during the other session, short-spectrum red light with a peak at 651 nm was used (crossover, counter-balanced order). The study used light-emitting diode units matched for irradiance levels (~7.0 W/m^2 at a distance of 50 and 45 cm, respectively). In photopic units, the lights were 1300 vs. 1100 lux presented against 5-10 lux background. Venous blood was taken prior to and following 20 and 45 minutes of light to measure concentrations of FSH, LH, prolactin, estradiol, progesterone, melatonin and cortisol.

Results: The levels of all hormones decreased during the first 20 min of light exposure (see figure). In the case of melatonin and prolactin, this may reflect the natural morning decay (circadian-dependent); data on cortisol levels (which usually increase in the morning) and the remaining hormones (which have no distinct circadian variations) point to the possibility of a confounding effect of activity (a transition from standing to sedentary position) on hormone blood concentration. Compared to red light, white light decreased melatonin and increased prolactin levels at 20 min. Unpredictably, estradiol levels were decreased during the first 20 min by white light. Results on LH and FSH should be interpreted with caution as both hormones (especially LH) are secreted in a pulsatile fashion. There was no change in progesterone levels by white light; the data on cortisol is conflicting.



Conclusions: Moderately bright blue-enhanced white light stimulates prolactin and decreases estradiol secretion compared to matched-by-irradiance red light; the effect is transient and lasts for ~20 minutes. No conclusive results were found for LH, FSH and progesterone. The involvement of melanopsin photoreception in the effects of light on reproductive homones in women merits further investigation.

Keywords: Women, Light, Reproductive Hormones

Funding Support: The study was sponsored by Lumie®. The work of the group was supported by Velux foundation. OYS is paid by grant EUCLOCK (the EU 6th Framework Project No. 018741).

Reference: Danilenko KV, Samoilova EA. PLoS Clin Trials 2007, Feb 9;2: e7.

MENSTRUAL CYCLES ARE INFLUENCED BY SUNSHINE

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Objectives: Previous studies have shown that artificial light can influence the menstrual cycle. Light exposure before the presumed day of ovulation shortens the menstrual cycle in women with long menstrual cycles or women with winter depression (summarized in [1]). We investigated whether natural light has a similar effect.

Methods: 129 women (age 18–40 y) living in the continental climate of Novosibirsk, Russia (55° N) provided menstruation onset dates for over a year between 1999-2008. Cycles were of normal length (21-36 days), regular (e.g. uninterrupted by abortion) and intact (e.g. not compromised by hormonal contraceptives). These data were matched by years to a database of meteorological indices that included daily hours of sunshine, mean daytime (9:00, 12:00, 15:00 and 18:00) values of cloud cover, humidity, atmospheric pressure, air temperature and perceived temperature. The latter was calculated using the UTCI index and reflected the actual temperature perceived by the human body when humidity, wind speed and solar radiation are taken into account [www.utci.org]. Additionally, data on moon phase (values represented sinusoidal dynamics) and moonlight (moon phase corrected for nighttime cloud cover) were introduced. For statistical analyses, meteorologic indices were standardized using 29-days moving z-transformation to remove seasonal dynamics in their mean and variance values. Individual menstrual cycle lengths were also z-transformed. The menstrual and meteorological databases were merged in a file in which the presumed date of ovulation was aligned with the meteorologic indices on that date ± 12 days. The presumed ovulation day for each subject was calculated from their mean menstrual cycle length using a regression formula obtained from raw data provided by Dr. René Ecochard from his daily ultrasound study [2]. The presumed ovulation day varied between days 12-17 of the menstrual cycle. As a seasonal component cannot be removed from menstrual cycle variations without confounding the results (the cycles were almost one-day shorter in summer), analysis of covariance (ANCOVA) was used. It explored (1) menstrual cycle length (standardized) as dependent continuous variable, (2) month during which the cycle started as independent nominal variable, and (3) meteorologic index (standardized) as independent continuous variable (or covariate). Due to the large number of ANCOVA computations (200), each including a high number of cases (up to 1681 menstrual cycles), the covariate regression coefficient was considered to be significant at a probability level, $p<0.001$.

Results: The ANCOVA's regression coefficient was significant only for sunshine ($p=0.0006$) and cloud cover ($p=0.0004$) at day -2 before the presumed day of ovulation: the more sunshine (or less cloud cover) on this day, the shorter the menstrual cycle. The next most significant predictors were sunshine again at day -3 ($p=0.0029$) and humidity at day -3 (positive association, $p=0.0044$). Air and perceived temperature, atmospheric pressure, moon phase and moonlight did not appear to exert a significant influence ($p>0.017$). The analysis repeated for each season separately did not reveal new significant results. When we investigated raw sunshine data at days -2 and -3 before the presumed day of ovulation vs. previous 4 days (mean values), ANCOVA confirmed the significance of the covariate 'sunshine' for the menstrual cycle length (days) in the model ($p=0.0003$). A simple linear regression analysis yielded a coefficient of -0.032, i.e. increased sunshine, such as 12 hours at days -2 and -3 before the presumed day of ovulation compared to the previous four days, results in a menstrual cycle shorter by almost 0.4 days on average.

Conclusions: Even though the actual light exposure each woman received was unknown, evidence suggests a relationship between hours of sunshine and menstrual cycle length: the more sunshine 2-3 days before the presumed day of ovulation, the shorter the menstrual cycle. Air /perceived temperature, atmospheric pressure and moonlight /phase were not found to be significant predictors. The influence of day-to-day change in sunshine on cycle length is undoubtedly related to the change in ovulation time and, as a consequence, follicular phase duration.

Keywords: Menstrual Cycle, Sunshine, Meteorologic Indices, Moon Phase

Funding Support: The study was sponsored by Lumie®. The work of the group was supported by Velux foundation. OYS is paid by grant EUCLOCK (the EU 6th Framework Project No. 018741).

References: 1. Danilenko KV, Samoilova EA. PLoS Clin Trials 2007, Feb 9;2: e7.; 2. Ecochard R et al. BJOG 2001, 108: 822-829.

MONITORING PHYSIOLOGICAL VARIABLES DURING SIMULATED NIGHT SHIFT WORK: THE INFLUENCE OF NOCTURNAL MODERATELY BRIGHT LIGHT EXPOSURE

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Objectives: The development of an optimal strategy to promote adaptation to night shift work is one of the problems of modern society. The idea of a compromise phase position has been proposed by Eastman and Martin [1] whereby the circadian clock is sufficiently delayed such that on night shifts the workers are alert and perform well, and in the daytime they get good sleep, but not so far delayed such that on intervening days off the workers are asleep all day and cannot socialize. A series of studies by the Eastman group have investigated the capacity of intermittent bright light treatment to shift the circadian clock to this compromise phase position. They demonstrated that this light exposure pattern across 3 nights shifts (5 or 6 pulses of 15–20 min at 4100 lux once an hour starting shortly before 01:00 h; <50 lux for the remainder of the night) combined with a fixed daytime sleep/dark period resulted in a phase delay of ~4 h on average in the melatonin rhythm [2]. In these studies the only marker of the circadian clock was the melatonin rhythm. Part of the EUCLOCK project has involved the development of the ClockWatcher and LightWatcher devices which can measure rectal and skin temperature, respiratory rate, ECG, 3-D movements, and intensity and spectral composition of light at eye level, respectively, in field situations. These devices allow a variety of circadian rhythms to be tracked across several days which will be very useful in monitoring rates of adaptation to a shifted sleep/wake schedule. Therefore, the aim of the current study was to adapt the protocol of the Eastman group to assess the rate of adaptation of circadian rhythms in melatonin and other indices during a simulated night shift protocol with nocturnal bright light pulses timed to phase delay.

Methods: This simulated shift work "field" study was performed in Novosibirsk (55º N) between November 2009 and January 2010. Nine healthy subjects (2M:7F, mean age ± standard deviation 27.1 ± 3.9 y, range 23–33 y) completed a 10-day protocol (in groups of 3). This comprised five baseline days with bedtimes and wake times within ± 30 min of a self-selected target time (based on the preceding 1-week sleep logs), 4 days of night shift from 23:00–07:00 h with a recovery sleep at home that had to end by 15:00 h at the latest after the first 3 nights, followed by 1.5 days of post-shift free regimen. During the sedentary activity of the first 3 night shifts, the subjects were exposed intermittently to bright light 1000 lux (for 20 min every hour from 00:00 to 05:00 h) and a well lit room background (100–200 lux) for the remainder of the time. Subjects' activity and ambient light exposure were monitored throughout the protocol using ClockWatcher and LightWatcher. Saliva samples, for radioimmunoassay of melatonin levels (Bühlmann Laboratories), were obtained every 30–60 min from 19:00 to 07:00 h on all 4 night shifts. For the 5 h before the first night shift (19:00–00:00 h) and the entire fourth night shift the subjects remained in ≤8 lux to allow assessment of the dim light melatonin onset (DLMO) which was the primary phase marker. DLMO was determined as the time that melatonin levels crossed and remained above an individually calculated threshold value (mean ± 2 standard deviations of the 5 lowest values).

Results: After three days of night shift with the intermittent moderately bright light the DLMO had delayed by 4 h 30 min ± 74 min (range 2 h 22 min – 6 h 31 min) from 21:41 h ± 41 min (21:01–23:05 h) to 02:11 h ± 30 min (23:30–03:53 h). The phase delay was quite consistent across subjects (p=0.27, one-group variance test). There was no significant correlation between the magnitude of the phase delay and the subject's initial circadian phase (p=0.50). Melatonin levels appear to be suppressed during the night shifts with the bright light; however, the extent of the suppression varied between individuals and requires further analysis.

Conclusions: The moderately bright intermittent light (1000 lux: 20 min /150 lux: 40 min for 5 hours) during the night shift effectively delayed the salivary melatonin rhythm towards the compromise phase position (4.5 h after 3 night shifts). Analyses of sleep, light exposure, alertness and additional physiological circadian data are yet to be completed.

Keywords: Human, Shift Work, Bright Light, Circadian Rhythms, Melatonin

Funding Support: Supported by grant EUCLOCK (the EU 6th Framework Project No. 018741). Light boxes used were from Lumie®.

References: 1. Eastman CI and Martin SK. Ann Med 1999, 31: 87-98.; 2. Smith MR et al. Physiol Behav 2008, 95: 449-456.

SEASONAL EFFECTS ON DEPRESSION RISK (EPDS>10) AND SUICIDAL SYMPTOMS IN WOMEN

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Objectives: We examined the effects of seasonal variation on depression risk and risk for suicidal ideation in postpartum women. We hypothesized that the Spring and Fall months will be associated with an increased frequency of depression risk and suicidal symptoms compared to other times of the year.

Methods: From 2006-2010, the investigators screened women 4-6 weeks after delivery for postpartum depression (PPD) with the Edinburgh Postnatal Depression Scale (EPDS). The outcome variables of interest were: EPDS > 10 which suggests increased depression risk and EPDS item 10>1 which suggests suicidality. The explanatory variable included the calendar months of the year.

Results: The investigators telephone-screened 9339 women; 1316 (14%) women had scores on the EPDS>10 which suggested possible risk for PPD. Suicide risk (EPDS item 10 >1) was identified in 294 women (3%). The risk for suicidal symptoms peaked in September (Figure 1). Depression risk decreases between May to August (Figure 2). Analysis of variance and spectral analysis will be used to explore seasonal variations in risk for suicidal symptoms and depression.

Conclusions: Postpartum depressed patients may have reduced activation of the serotonergic pathways. The effects of seasonal light on the serotonin pathways may contribute to heightened risk for suicidal and depressive symptoms in certain patients. After delivery, suicidal symptoms may be compounded by maternal state and the classic seasonal effect.

Keywords: Seasonal, Suicidality, Depression Risk, Postpartum

Funding Support: NIMH K23 MH082114 – K23 Career Development Award (D. Sit, PI) and NIMH R01 MH071825 - Identification and Therapy of Postpartum Depression (KL Wisner, PI).

Figure 1.

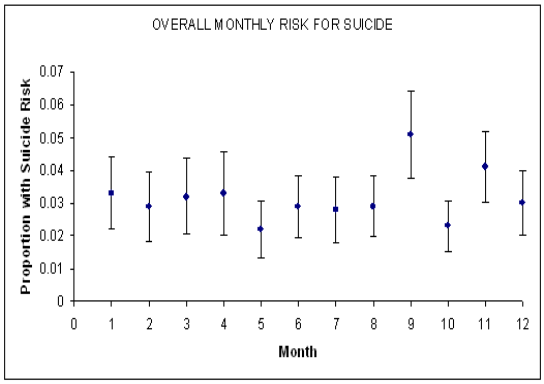
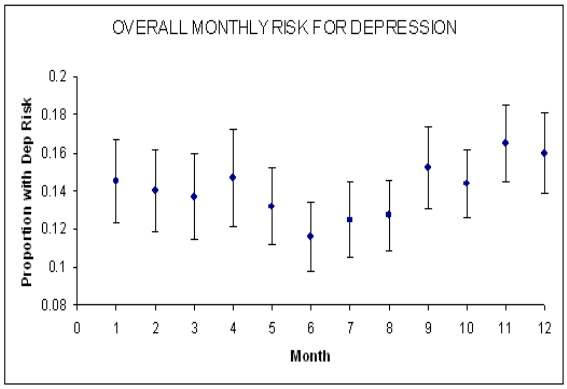


Figure 2.



POSITRON EMISSION TOMOGRAPHY IMAGING OF SEASONAL CHANGES IN BRAIN SEROTONIN TRANSMISSION

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Objectives: Climate, in particular sunshine, is known to influence mood and energy levels, creating an upswing on bright, sunny days and a downswing in cold, dark winter seasons. In recent studies higher serotonin transporter availability in healthy human subjects was shown in times of less light exposure and lower serotonin levels have been reported in winter in an Australian study. Furthermore, seasonal alterations of serotonin-1A receptor expression have been recently suggested by an animal research study.

Methods: In our retrospective study we examined light-dependent variations in serotonin-1A receptor binding in cortical and subcortical limbic regions in 36 healthy human subjects. The receptor binding was quantified by positron emission tomography and the highly specific radioligand [*carbonyl*-^{11}C]WAY-100635. Additionally, binding potential values were correlated with individual exposure to global radiation and sunshine. In a next step, subjects were divided into two groups depending on their exposure to global radiation and differences between the two groups were calculated.

Results: Partial correlation analysis controlling for age and gender revealed highly significant positive correlations between regional serotonin-1A receptor binding and the 5 day accumulation of global radiation (r=.37 to .48, p=.030 to .004). Additionally, highly significant differences in the serotonin receptor binding were found between the two groups (low and the high exposure to global radiation) (T=-2.63 to -3.77, p .013 to .001).

Conclusions: Together with recently reported seasonal fluctuations in serotonin turnover and transporter availability, these results show the influence of seasonal factors on the regulation of human brain serotonin transmission and might help to fully identify the pathogenesis of seasonal affective disorder.

Keywords: Serotonin-1A Receptor, PET, Seasonality

INFLUENCE OF DAYTIME LIGHT ON NIGHTTIME PARAMETERS LIKE SLEEP, MELATONIN SECRETION AND ALERTNESS

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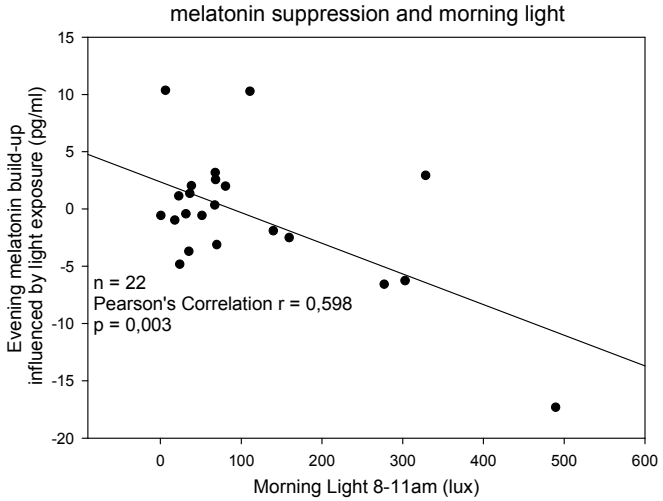
Objectives: Light exposure is known to have long-term therapeutic effects in chronobiologically related disorders like seasonal affective disorder (Lewy et al., 1998), shift work syndrome and even nighttime confusion in Alzheimer's disease. However, the influence of daytime light exposure in the healthy population living in a natural environment is widely unknown. The aim of the current study was to investigate the effects of light exposure during habitual daytime activities on evening alertness and light induced melatonin suppression as well as nighttime sleep in 11 healthy participants (no extreme chronotypes).

Methods: Participants were instructed to maintain their habitual sleep/wake behavior, controlled by actigraphy. They were instructed to wear *Luxblick* spectacles recording illumination and blue light (lux) on five consecutive days. Each evening participants came to the laboratory, staying in dim light conditions for three hours starting at 7 pm. At 10 pm participants were exposed to light of different intensities and spectra until 10:30 pm and went to bed at 11 pm. Each night sleep was polysomnographically recorded in the lab. Saliva samples to determine melatonin secretion were collected every 30 minutes (every 10 minutes during light exposure) until bedtime. Subjective alertness was determined every 30 minutes until bedtime using a visual analogue scale (Bond & Lader, 1974).

Results: The illumination levels participants were exposed to from 8 to 11 am was significantly associated with melatonin suppression by bright polychromatic blue light in the evening ($r = 0.598$; $p = 0.003$), with Sleep Period Time ($r = 0.329$; $p = 0.05$) as well as Time in Bed ($r = 0.412$; $p = 0.012$). There was a trend towards significance in the correlation between light in the morning and the total amount of REM sleep ($r = 0.28$; $p = 0.096$).

Conclusions: Data show that the amount of morning light is related to subsequent nighttime sleep. Future studies have to show whether daytime light may have an effect on disorders like primary insomnia as well.



Keywords: Polychromatic Light, Light History, Melatonin, Polysomnography

Funding Support: German Ministry of Education and Research FKZ: 13N8973, German Institute of Standardization

CHRONOBIOLOGICAL STUDY OF CIRCADIAN VARIABLES OF MUSCULAR FORCE OF GLASS BLOWERS WHO ARE WORKING IN ALTERNATE SHIFTS

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Objectives: The aim of the study was to investigate the circadian parameters (the amplitude, mesor, acrophase, period) of the hands muscular force (HMF) rhythm of a shift working glass blower batch (4X6, weekly shifts 5/2), compared with the clinical syndrome of alternating shift work intolerance (e.g., chronofatigue syndrome, dyssomnias, digestive disorders).

Methods: Based on an original chronobiological methodology (CoSiNor Method), according to individual clinic tolerance of working in shifts, the circadian rhythms of the HMF of a batch of 75 glass blowers working in shifts, mean age 34.9 years, ranging between 19 and 48 years and 16.2 average age were compared with the circadian rhythms of HMF of a control group of 28 glass blowers, mean age 33.2 years, raging between 19 and 50 years, average age 12.9, working in one shift (in the morning). HMF was determined with a dynamometer, in standardized conditions, in orthostatisms, before and after working, through three consecutive measurements, recording in an individual series of temporary variables, the higher values. Statistical processing of individual temporary series of HMF focused on: conventional statistical methods such as correlation coefficient –r, Student test –t, $\chi 2$ test, and also on the original program of chronobiology COSMEDMILUMAT. The circadian rhythms of HMF were significant when the average circadian amplitude was different from 0 (95%, $p< 0.05$).

Results: Using $\chi 2$ test no significant differences of the circadian rhytms of HFM in relation with shift work tolerance were found (right HMF $\chi 2=0.414$, $p< 0.05$, left HMF $\chi 2=0.583$, $P< 0.05$). The average circadian amplitudes of HMF of the subjects from alternating shifts were significantly lower compared with average circadian amplitudes of HMF of the glass blowers from the control group. The circadian amplitude of right hand muscular force of the shift workers (dominant hand) correlated significantly with the average circadian amplitude of left hand muscular force (non-dominant) ($r=0.3916$, $t=3.6366$, $p<0.05$), and the latter correlated significantly with the Pieron qualitative index. In the polar diagrams, there was a significant circadian phase delay ($t=5.28$, $p<0.05$) of 7 hours (ДФ=-7 h) for circadian acrophases of right dominant HMF, and 5 hours (ДФ=-5 h) for circadian acrophases of left nondominant HMF compared with the circadian acrophases of the subjects from control batch (group). HMF Circadian period (τ) of the shift glass blowers differed significantly ($t=5.360$, $p<0.05$) from HMF circadian period of the glass blower controls, but this did not show internal desynchronization (RH $\chi 2= 1.897$, $p< 0.05$; LH $\chi 2= 1.014$, $P<0.05$). The circadian period of right dominant HMF significantly correlated with the circadian period of left nondominant HMF ($r=0.3703$, $t=3.4059$, $p<0.05$), with the maximum peak expiratory flow ($r=0.2923$, $t=2.6117$, $p<0.05$), with the critical frequency of optical fusion ($r=0.2712$, $t=2.4073$, $p<0.05$) and with the Pieron quantitative index ($r=0.3129$, $t=2.8146$, $p<0.05$). The circadian mesor of HMF, although within normal values for glass blowers, was significantly lower compared with the circadian mesor of HMF glass blower controls; this directly correlated with the circadian mesor of respiratory variables (maximum expiratory flow per second, MEFS; Vital Capacity, VC; Maximum expiratory volume per second, Vm; and Maximum Ventilation, MV).

Conclusions: There was a direct correlation of the circadian rhythm (CR) of HMF with the CR of respiratory variables in glass blowers who work in alternating shifts. The absence of internal desychronization of the CR of HMF, the timing of circadian period of right dominant HMF with the left non-dominant hand, and also the timing of circadian periods of specific neuropsychological stimulation indicators (e.g., the optical frequency fusion and Pieron quantative index) highlights the existence of circadian oscillators, with cortical localization possibly coupling all these circadian rhythms.

Keywords: Hands Muscular Force, Circadian Variables, Shift Work

SEASONALITY EFFECTS OF SUNSHINE ON SUICIDE

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Objectives: Many studies have shown that the incidence of suicide follows a seasonal pattern with a peak in spring. More recent evidence suggests that this peak may be associated with the increase in the duration of sunshine in spring. The spring peak in suicide rates seems to be mainly the consequence of an increase in depression-related suicides. During depressive episodes, light, possibly through interaction with melatonin, norepinephrine and serotonin, may improve motivation and drive first, while mood improves at a later point in time. Thereby, a rapid increase in sunshine in spring might increase suicidal tendencies. We investigated the effect of number of sunshine hours per month on suicide rates in Austria between 1996 and 2006.

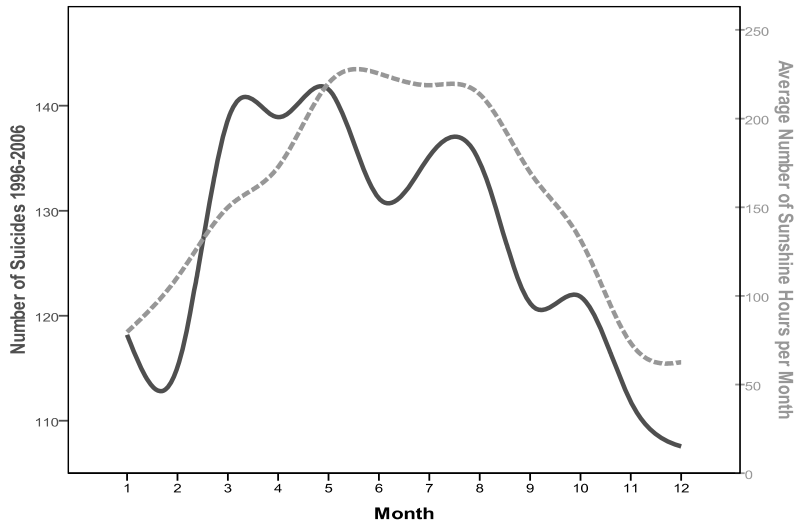
Methods: Suicide data, differentiated by month of suicide, gender, and method of suicide, were provided by Statistics Austria. Suicide methods were further classified as violent (hanging, drowning, shooting and jumping) or nonviolent methods (poisoning). Data on the average number of sunshine hours per month from 39 representative meteorological stations (provided by the Austrian Central Institute for Meteorology and Geodynamics) were used to calculate the average number of sunshine hours per month between 1996 and 2006. To examine the distribution of the average number of suicides per month and average sunshine hours per month we used ANOVA tests. The statistical analysis of the association of both metric variables, sunshine hours and suicides per month, was performed using Pearson correlation tests.

Results: A total of 16.673 suicides with a median of 126±19.8 suicides per month occurred in the examined time period. A clear seasonal pattern was observed, with suicide frequencies being highest between March and May, and lowest between November and January (df=11, F=5.2, p<.0001) for men (df=11, F=4.9, p<.0001) and women (df=11, F=2.4, p=.008). The average number of sunshine hours was highest from March to August (df=11, F=48.5, p<.0001). The average number of sunshine hours per month was significantly correlated with the number of suicides among both genders, r=.43 (p<.0001), males, r=.41 (p<.0001), and females, r=.32 (p=.0002). Regarding suicide methods, a significant correlation could be observed for violent methods (r=.48; p<.0001) but not for nonviolent methods (r= .03; p=.707).

Conclusions: These results support the hypothesis that suicidal behavior during depression is influenced by the amount of sunshine. However, we cannot rule out significant effects of other climatic or astronomical variables on suicide frequency at this point. Our data show that seasonal effects specifically account for variations in the number of violent suicides. Sunshine, via interactions with serotoninergic neurotransmission, may trigger increased impulsivity in vulnerable subjects, who might then be more prone to enact on suicidal thoughts when compared to periods of lesser light. Findings of this study could help improving therapeutic strategies aimed at preventing suicide, such as the initiation of public suicide awareness campaigns shortly before and during months with increased suicide risk.

Keywords: Suicide, Sunshine Hours, Seasonality

Figure 1. Number of suicides and average number of sunshine hours in Austria, 1996-2006



EFFECT OF LIGHT IN SCHOOLS: REPLICATION OF THE FIELD STUDY IN LAB

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Objectives: In a field study with 116 pupils, the use of Schoolvision in school classes resulted in a significant increase of attention/concentration and reading speed as well as a significant decrease of restlessness (Wessolowski et. al., 2009). Schoolvision by Philips has preset lighting programs differing in brightness and color temperature. The aim of this study was to replicate these findings in a standardized laboratory setting.

Methods: In a randomized two-group cross-sectional experiment a sample of n=95 healthy adults received either optimized light programs (Schoolvision) or control conditions (500 lx / 3200 K). Optimized light conditions for the treatment group were bright daylight (1300 lx / 5600 K) to induce attention and less bright warm-white light (600 lx / 3000 K) to reduce restlessness. Attention was measured with the d2-test of Brickenkamp and the reading test of Schneider et al. To determine restlessness an optical measurement method named "Childmove" was used, which detects changes in pixel values within a video. Childmove was developed for the measurement of whole school classes (Koenig et al., i.P.) but it can also be used in other settings.

Results: The results of the attention/concentration testing showed a significant advantage of 25% from using Schoolvision in the treatment group in terms of the d2 test error rate compared to the control group with standard light ($F=2.839$, $df=1$, $p=.048$, $\eta^2=.031$). This is comparable to the effect described by the school study. In addition, the results for the working speed of the d2 test also showed a significant advantage of 11% for the treatment group ($F=3.803$, $df=1$, $p=.028$, $\eta^2=.065$). The effect outranged the result of working speed in the school study. In contrast to the results of the d2 test, the results of the reading test could not be replicated in lab. The results concerning motoric agitation (restlessness) showed a faster decrease by using Schoolvision (after 5 min: $F=2.897$, $df=1$, $p=.0.046$, $\eta2=.031$) as reported in the school study. However, unlike the findings of the school study, a decrease in restlessness was not affected.

Conclusions: In sum, the results of the school study could be replicated: The results in the lab showed an increase of attention by using Schoolvision: The experimental group made fewer errors and had a higher working speed in the d2 test. The results of the reading test cannot be replicated, assumedly because the participating college students (59%) are very practiced in reading long texts under inconvenient environmental conditions so that the reading test was not sensitive enough for this sample. There is also a faster decrease of motoric agitation by adults detected in the lab but in contrast to the school study no relevant total decrease was found. An analysis of the z-transformed school and lab values showed that the baseline scores of the pupils in the schools were more than four times higher than those of adults in the lab. On closer inspection of the low baseline scores it was possible to find a faster decrease for the experimental group but not a higher decrease over a longer time, because both groups already almost reached the minimum right after the beginning. In sum, the results argue for the effectiveness of Schoolvision. Schoolvision appeared to have a direct and immediate effect in lab as well as in school. Schoolvision optimized the conditions for improvement of performance and health promotion independent of the sample and the setting.

Keywords: Schoolvision, Dynamic Light, Concentration, Attention, Motoric Agitation

AUTHOR INDEX