Translating Research into CIRCADIAN-IMPACTFUL Solutions

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people / place / performance





Agenda

Circadian Lighting Context Circadian Science (lite-ish) Project Case Studies





Light and Health



G light and health - Google ×

C Secure https://www.google.com/search?authuser=1&biw=1693&bih=817&ei=HFXFWt2KFsiA0wKp9o_oAQ&g=light+and+health&og=light+and+health&gs_l=psy-at



About 654,000,000 results (0.58 seconds)



Light and Health | Research Programs | LRC - Lighting Research Center www.lrc.rpi.edu/programs/lightHealth/index.asp •

Researching how light can be used to promote health and wellbeing. Biological rhythms that repeat approximately every 24 hours are called circadian rhythms. Light is the main stimulus that helps the circadian clock, and thus circadian rhythms, keep a synchronized rhythm with the 24-hour day. Publications · Media · Research Projects

Light and health - Fagerhult (International)

https://www.fagerhult.com/knowledge-hub/Light-and-health/ ▼

Light gives us health. Light, or light radiation, not only affects our visual cortex but also the whole of our alertness, wellbeing and performance. Our circadian rhythm and seasonal variation are genetically fixed, but they are regulated to a certain extent by our surroundings, above all by light.

Health Impact of Light

www.healthimpactoflight.com/ -

Did you know that the type of light you're exposed to affects your circadian rhythm? Pre-sleep lights tell your body to release melatonin and get ready for a peaceful night's sleep.





Forum News Research FAQ

Ever notice how people texting at night have that eerie blue glow?

Or wake up ready to write down the Next Great Idea, and get blinded by your computer screen?

During the day, computer screens look good-they're designed to look like the sun. But, at 9PM, 10PM, or 3AM, you probably shouldn't be looking at the sun.

f.lux

f.lux fixes this: it makes the color of your computer's display adapt to the time of day, warm at night and like sunlight during the day.

It's even possible that you're staying up too late because of your computer. You could use f.lux because it makes you sleep better, or you could just use it just because it makes your computer look better.

Download f.lux

Free for Windows.

(also available for Mac, Linux, and iPhone/iPad)

By downloading, you agree to the f.lux EULA



Like 97,503 people like this. Sign Up to see what your friends like.

f.lux makes your computer screen look like the room you're in, all the time. When the sun sets, it makes your computer look like your indoor lights. In the morning, it makes things look like sunlight again.

Tell f.lux what kind of lighting you have, and where you live. Then forget about it. f.lux will do the rest, automatically.



https://justgetflux.com/ https://fluxometer.com/









CIRCADIAN LIGHTING DESIGN

Intent: To support circadian health by setting a minimum threshold for daytime light intensity.

54: Circadian lighting design	٠			
OVERVIEW			AAP 2	TECHNICAL FAQ (7)

BACKGROUND

Light is one of the main drivers of the circadian system, which starts in the brain and regulates physiological rhythms throughout the body's tissues and organs, affecting hormone levels and the sleep-wake cycle. Circadian rhythms are kept in sync by various cues, including light which the body responds to in a way facilitated by intrinsically photosensitive retinal ganglion cells (ipRGCs): the eyes' non-image- forming photoreceptors. Through ipRGCs, lights of high frequency and intensity promote alertness, while the lack of this stimulus signals the body to reduce energy expenditure and prepare for rest. The biological effects of light on humans can be measured in Equivalent Melanopic Lux (EML), a proposed alternate metric that is weighted to the ipRGCs instead of to the cones, which is the case with traditional lux. During Performance Verification, EML is measured on the vertical plane at eye level of the occupant. Tables L1 and L2 in Appendix C show how to calculate the EML of individual lamps and larger spaces.



PART 1

Melanopic Light Intensity for Work Areas

Light models or light calculations demonstrate that at least one of the following requirements is met:

- a. At 75% or more of workstations, at least 200 equivalent melanopic lux is present, measured on the vertical plane facing forward, 1.2 m [4 ft] above finished floor (to simulate the view of the occupant). This light level may incorporate daylight, and is present for at least the hours between 9:00 AM and 1:00 PM for every day of the year.
- b.¹⁷⁴For all workstations, electric lights provide maintained illuminance on the vertical plane facing forward (to simulate the view of the occupant) of 150 equivalent melanopic lux or greater.

VERIFICATION

Letter of Assurance - Architect On Site - Spot Measurement



GE Lighting's Bulb/App Combination Aims to Improve Sleep Cycles



As Daylight Savings Time took effect last month, GE Lighting unveiled its C by GE line, its first connected LED light bulbs that can be controlled directly from a smartphone without a hub. Within the C by GE app, the C Sleep bulb automatically changes light settings for daytime and evening to optimize sleep cycles.

One-third of Americans don't get enough sleep, and the blue light in our smartphone and tablet screens can be one culprit. According to the National Sleep Foundation, at least 95 percent of people use some kind of electronic device within an hour of going to sleep.

The C Sleep bulb closely simulates and mimics the sun to reinforce the human body's natural rhythm and melatonin production to prepare for sleep. "For many, lighting is the gateway to a smart home that connects other devices including smart thermostats, security cameras and smoke alarms. While interoperability is key, in a crowded market with no clear platform winner, we wanted to give consumers the option for a standalone smart lighting solution." says Tom Stimac, GE Lighting's chief innovation manager.

The C by GE app is available for free in the App Store. It's currently only available on iOS but will soon be available on Android as well. The C by GE app makes it simple for users to control their C-Life and C-Sleep bulbs from their phones, getting light that's right for every moment of the day. The features include:

- A simple set up, with no hub or extra hardware needed. Just the smart bulbs and the app.
- · Instantly dim or brighten lights, with no lag or delay.
- · Build groups of lights to control them all at once (e.g. "Living Room"), or individually depending on preference (e.g. "Dresser Lamp").
- · Create and save custom lighting scenes for all the things you do at home. For example, "Movie Time," "Wake up," or "Homework Hour."
- With the C-Sleep bulb, sync your lights with your sleep cycle with the "Follow the Sun" setting, which automatically transitions through the three C-Sleep settings as the day goes on "p.m." for warm light, "a.m." for crisp light and "day" for regular light.
- · A white background display for daytime use and a dark background display for easy nighttime control.

For more information, go to www.CbyGE.com.

http://www.ies.org/LDA/E-newsletter/2016/April/newswire/2016_04-GE.cfm

IES Research Symposium 2018 Light + Human Health Symposium

At the 2018 IES Research Symposium the latest research on how light during the day and night affects our circadian, biological, and behavioral will be presented along responses with discussions on how this research might affect current and future design applications. The Symposium brings together researchers and design professionals for an open exchange of ideas that will influence future priorities for developing and adopting metrics, standards, and recommended practices.



LIGHT + HUMAN HEALTH CIRCADIAN, BIOLOGICAL + BEHAVIORAL

IES Research Symposium APRIL 8-10, 2018 | ATLANTA, GA



https://cdn2.vox-cdn.com/thumbor/RMdD`Uc9u0ZFinMJEalP1BcTiGFw=/0x72:1800x1085/1310x737/cdn0.vox-cdn.com/uploads/chorus_image/image/49199973/eatersea0316_safeco_field_official.0.0.jpg

http://humancentriclighting.org/seattle-mariners-pilot-project/

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http://humancentriclighting.org/seattle-mariners-pilot-project/





Brainard, Thomas Jefferson University



Circadian Lighting in the International Space Station



2017 NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE



This year's Nobel Prize in medicine has been <u>awarded to three scientists</u> who discovered the genes that control the circadian rhythm, or the body's natural day-night cycle.

Circadian Disruption and Health Concerns

- Poor sleep and higher stress
 - Eismann et al., 2010
- Increased anxiety and depression
 - Du-Quiton et al., 2009
- Increased smoking
 - Kageyama et al., 2005
- Cardiovascular disease
 - Young et al., 2007; Maemura et al., 2007
- Type 2 diabetes
 - Kreier et al., 2007
- Higher incidence of breast cancer
 - Schernhammer et al., 2001, Hansen, 2006

Mariana Figueiro, Lighting Research Center, Rensselaer Polytechnic

US Sleep Statistics

Average time slept on work nights 6h 31m

Average sleep needed to function best 7h 13m

Less sleep than needed on a weekday 56%

Schedule/Routine allows for adequate sleep 72%

It's all about the People!



The Value is in the People...



...Who Are Your Greatest Assets







Relative Value of "Best Places to Work" Portfolios vs. S&P 500



Does Company Culture Pay Off?, Chamberlain, 2015

Economic Cost of Insufficient Sleep



Why sleep matters, The economic cost of insufficient sleep, A cross-county comparative analysis, Hafner et al.

Biophilia and the Love of Nature



Physiological Change is MUCH SLOWER

than Environmental Change

We Live in Evolutionary Novel Environments



Americans Spend Up to 95% of Their Time Indoors

Spengler: Indoor Air Pollution, A public Health Perspective

Approximately 90,000 hrs at Work Over a Lifetime

Ancestral vs Modern Light Exposure



Location and Climate

The "Dark Days" of the Pacific Northwest



Location and Climate



Location and Climate

Yearly Sun Graph for Seattle

Rise/Set Times Day/Night Length



Poor Exposure and Climatic Deficiencies







Seasonal Affective Disorder – Winter Blues protected by the Americans with Disabilities Act

Circadian Science (lite-ish)



Circadian Rhythm

Maintaining normal entrainment is a dynamic process that depends on regular adjustments of the circadian pacemaker through exposure to a routine light/dark cycle

http://parentsforhealth.org/wp-content/uploads/2011/07/Child_playing_on_swing-.jpg

Visual and Non-Visual Systems



Eye Anatomy



Spectral Response Variation of Receptors



Melatonin and a Healthy Sleep-Wake Cycle



Phase Shifting - Alertness



Light and Chronobiology: Implications for health and disease, Munch, 2012



...Temporal Coherence







Diseases and Relative Recommended Drugs According to Actual Chronopharmacology Knowledge



The Influence of Circadian Rhythms on the Kinetics of Drugs in Humans, Beraldo, 2008

Blue-enriched white light in the workplace improves selfreported alertness, performance and sleep quality

N=94 workers on 2 floors with (\blacksquare) and without (\Box) 17000K lamps for 4 weeks each

Monthly assessment

Weekly assessment



Blue-enriched white light in the workplace improves selfreported alertness, performance and sleep quality

N=94 workers on 2 floors with (■) and without (□ 17000K) amps for 4 weeks each

Monthly assessment

Weekly assessment



Daylighting: Sky Color Temperatures



Lighting affects students' concentration positively: Findings from three Dutch studies



Dynamic lighting system Philips T5 fluorescent lamps 'Energy':12000K, 650 lux 'Focus': 6500K, 1000 lux 'Calm': 2900K, 300 lux

Standard lighting 3000 - 4000K, 300 lux

Standard concentration task (9-10am) before and then 4-5 weeks after installation School 1 – Dynamic lighting system (n=98) School 2 – Focus setting only (n=44)

The school-based studies showed that younger pupils (Grade 4) working under the Focus light setting had significantly better concentration and fewer errors as compared to the control groups. Older children (Grade 6) did not differ between conditions.

Similar results reported in Barkmann et al., *Physiol Behav* 2012; Mott et al., *Sage Open*, 2012

Sleegers et al 2012

Influence of blue-enriched classroom lighting (LED) on students' cognitive performance



LED lighting system Osram 4000K and 14000K lamps to average 5500K, ~300 lux (vertical)

Standard lighting T8/T5 fluorescent 3000K and 4000K to average ~300 lux

Significant improvement in performance with blueenriched light

Light intervention improves measures of sleep, depression, and agitation in persons with dementia living in long-term care facilities

Intervention (n=14 (9F), 86.9 ± 4.4 yrs)

- 66 ± 130 lux of standard light
 324 ± 190 lux of blue-enriched
 (9300K) light
- 4 weeks, from wake time until 6pm







Cohen-Mansfield Agitation Inventory



Score

Figueiro et al, 2014

Project Case Studies



Enhanced Care Environments

Improved Staff Happiness / Wellness / Productivity Improved Patient Care / Improved Rates of Healing

Improved Patient / Family Satisfaction

Success for Patients / Family / Institutions

Ecosystem Concepts



Behavioral Health Unit (Seattle)





Lessons Learned: Behavioral Health Unit (Seattle)

- Limited buy-in from lighting designer created challenges
- Micro-managing may be necessary to ensure design intent is met
- Less detailed Sequence of Operations (SoO) leads to ambiguity and can result in less than ideal decisions in the field
- Tying the lighting solution to the overall design strategy is key for a unified design
- Working with the interior designer to optimize materials and the light source improves the final solution
- Be specific with fade times; institute multiple way points between set point if controls are limited

• DON'T GIVE UP!

Lessons Learned: Behavioral Health Unit (Seattle)

- 41% savings as compared to a non-tunable system with the same number of luminaires
- 19% increase in energy use compared to meeting only visual tasks needs
- 74% of annual lighting energy is consumed by the 6 hours dedicated to increased illumination levels for circadian regulation.
- Manual control can increase savings as users reduce lighting levels. A second round of Cx can also trim consumption as users become more familiar with their discrete needs.

Children's Behavioral Medical Unit

Children's Behavioral Medical Unit



Safety and Security Level





Patient Focused Circadian Solutions

Goal: Circadian Rhythm Entrainment

Combination of Dimming with Color Shifting Fixtures

Example Schedule (Actual Schedule to Be Determined) 8 am - 12 pm - Cool CCT with High Illumination Levels 12 pm - 3 pm - Neutral CCT with Medium Illumination Levels 3 pm - 8 pm - Warm CCT with Medium Low Illumination Levels

Staff Focused Circadian Solutions

Goal: Circadian Rhythm Entrainment Alerting Effect

Combination of Dimming with Color Shifting Fixtures

Example Schedule (Actual Schedule to Be Determined) 8 am - 12 pm - Cool CCT with High Illumination Levels 12 pm - 3 pm - Neutral CCT with Medium Illumination Levels 3 pm - 8 pm - Warm CCT with Medium Low Illumination Levels

This schedule should be adjusted to best fit staff shifts. The impact of behavior upon circadian entrainment should also be discussed with staff, especially those who work the night shift as well as rotating shift work.

Lessons Learned: Children's Behavioral Health Unit

- Work with decision makers
- Diagram measurement points
 - include height and direction of view
- A very detailed SoO still left unanswered questions especially in regards to overrides
- If resources fall short, set CCT and vary illumination for visual consistency
- Materials matter
 - Wood finishes resulted in ~ 2000 CCT decrease at the eye level.
- Consult users...and then consult again, user interface changed multiple times

Lessons Learned: Children's Behavioral Health Unit

- Validate which fixtures will be in the control system
 - Eg. exam lights were held out and were the greatest opportunity for circadian light
- Jettison a package if the suppliers aren't playing ball
 - Don't be afraid to ask the replacement manufacturer, particularly if they can shorten lead time
- Luminaires for behavioral health are limited especially those with color tuning capabilities
- Built-in color tuning curves simplify the controls and can greatly reduce programming time (DMX helps reduce this burden)
- Innovation is not easy, but an awesome client and dedicated team make it simpler and more fun

• DON'T GIVE UP! – Keep Chewing

ZGF Design Office (Vancouver)



Lessons Learned:

ZGF Design Office (Vancouver)

- Fully Proprietary System simplified controls but reduced choice
- Partnership started with manufacturer leadership and research staff
- Worked closely with interior designers to meet their aesthetic goals and lighting system performance
- Occupants who understand the "why" are more forgiving to hiccups in the Cx process
- Daylight dimming can be integrated
- User interface is key
 - What amount of control is needed?
 - What information is displayed at the switch?

Questions?



Thank you.

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