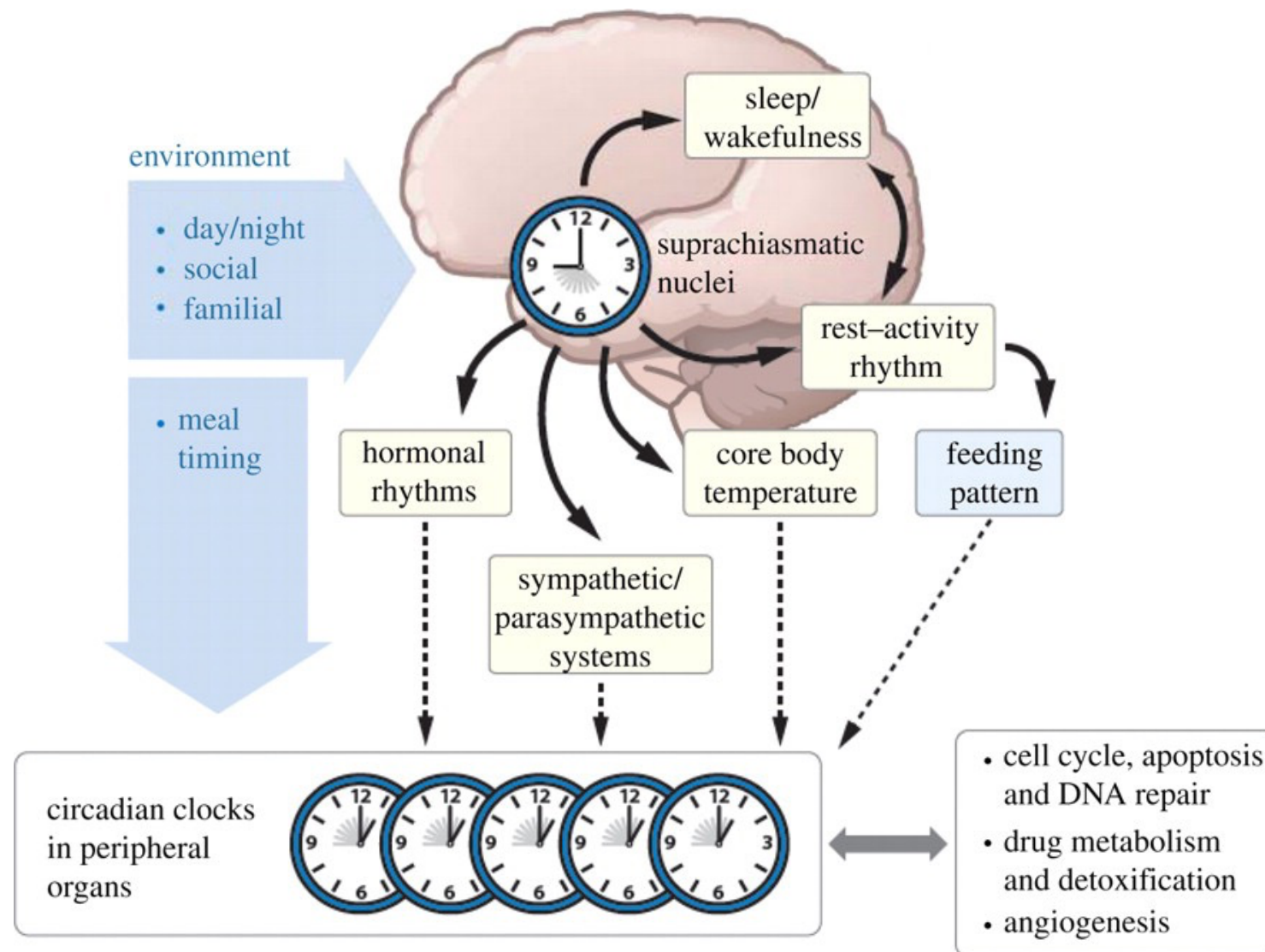


# Clinical Evaluation of Software Countermeasures to Mobile Device Photoentrainment

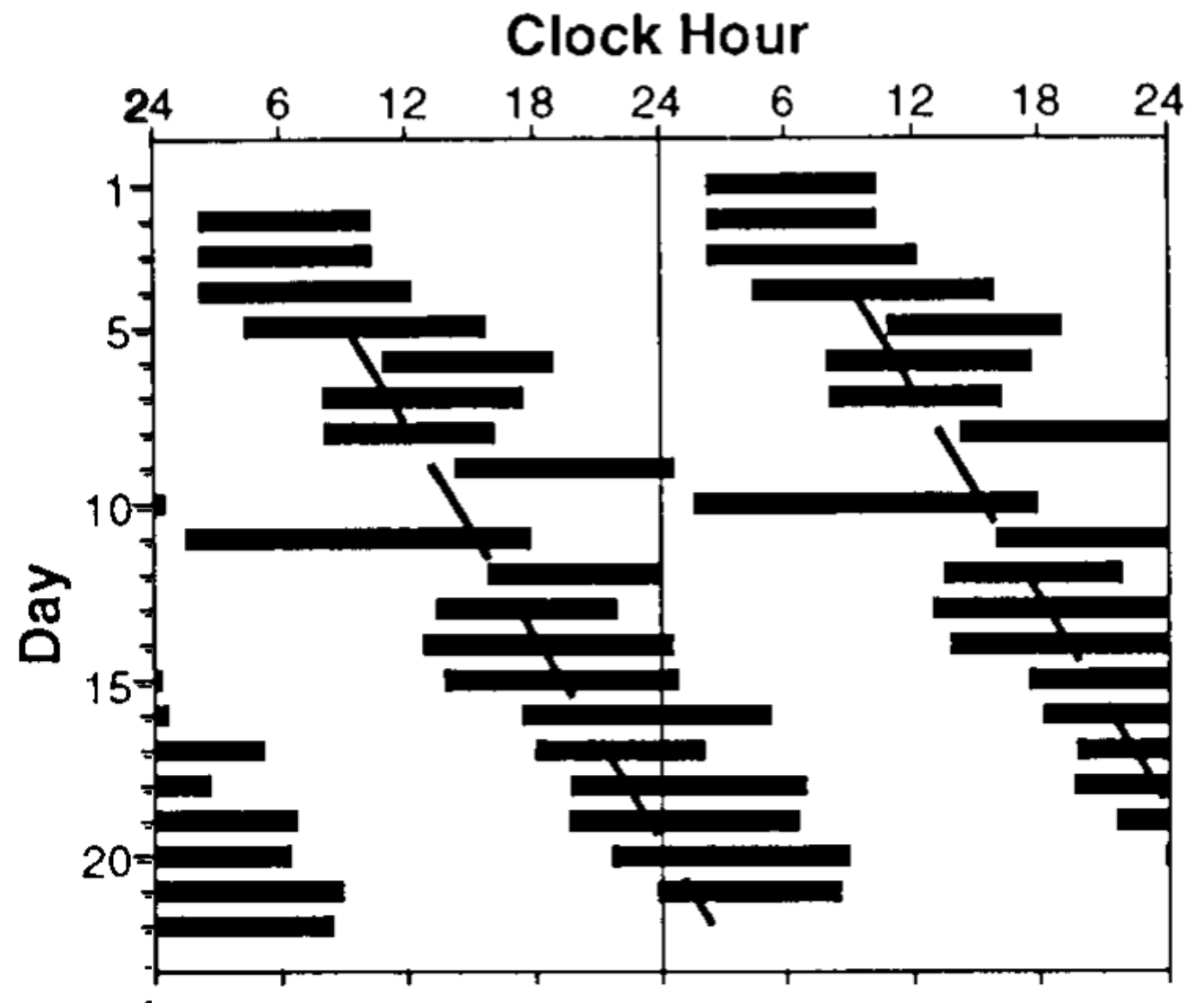
Brian Desnoyers

# The SCN



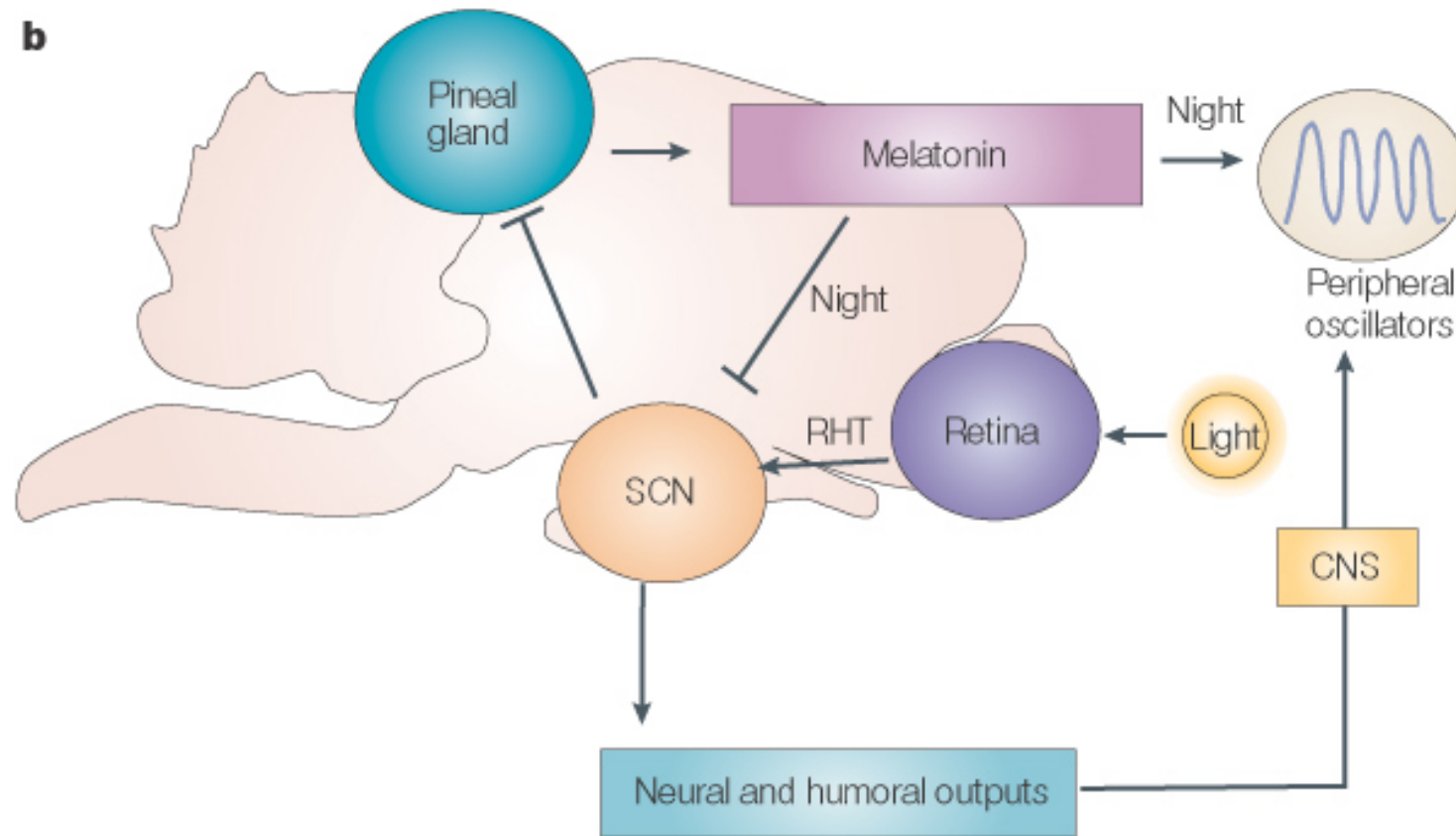
# Circadian Entrainment

- human circadian period is not exactly 24 hours, but averages around 24.18 hours



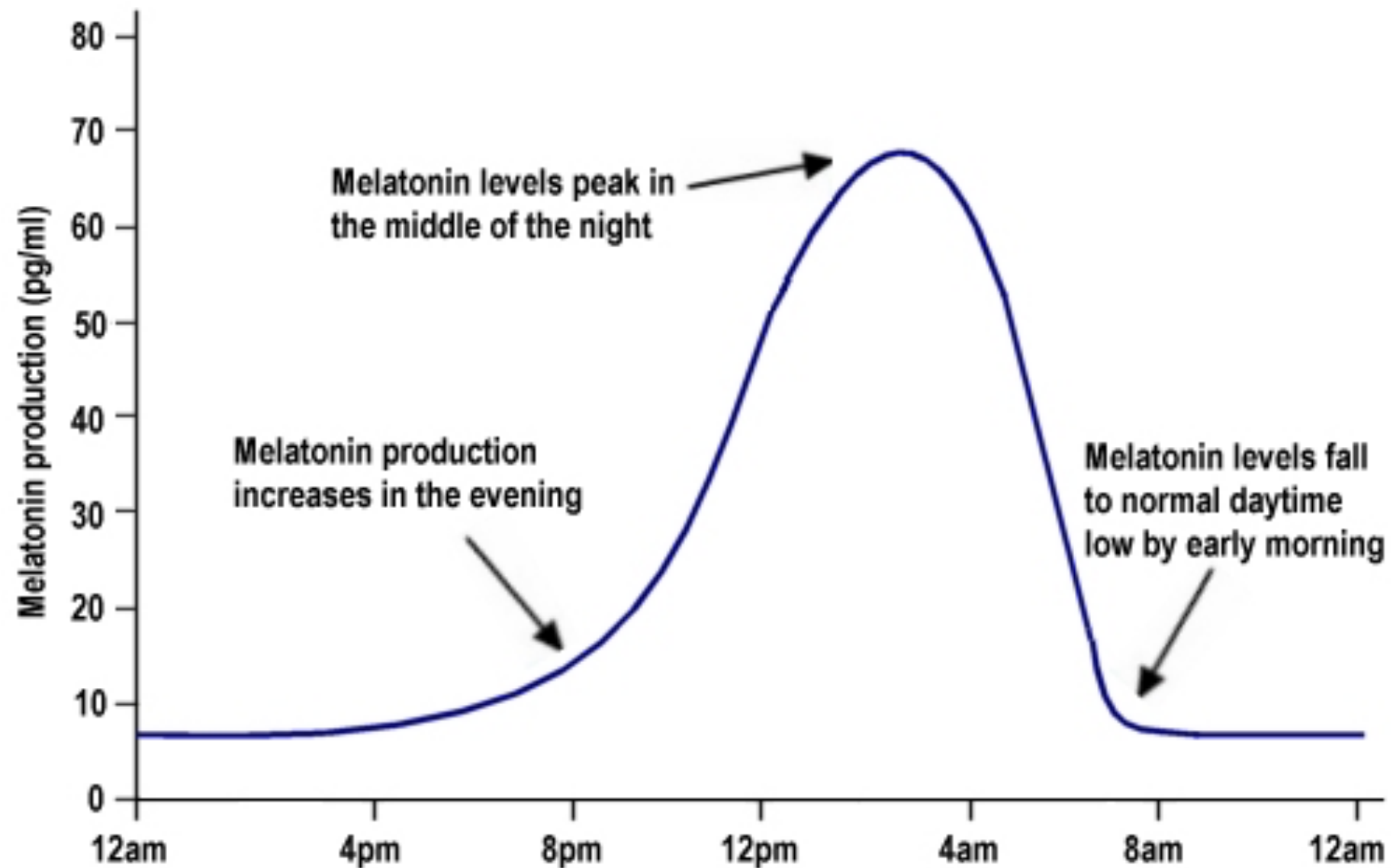
Czeisler, C. A., Duffy, J. F., Shanahan, T. L., Brown, E. N., Mitchell, J. F., Rimmer, D. W., Ronda, J. M., Silva, E. J., Allan, J. S., and Emens, J. S. (1999) Stability, precision, and near-24-hour period of the human circadian pacemaker, *Science* 284, 2177-2181.

# Photoentrainment

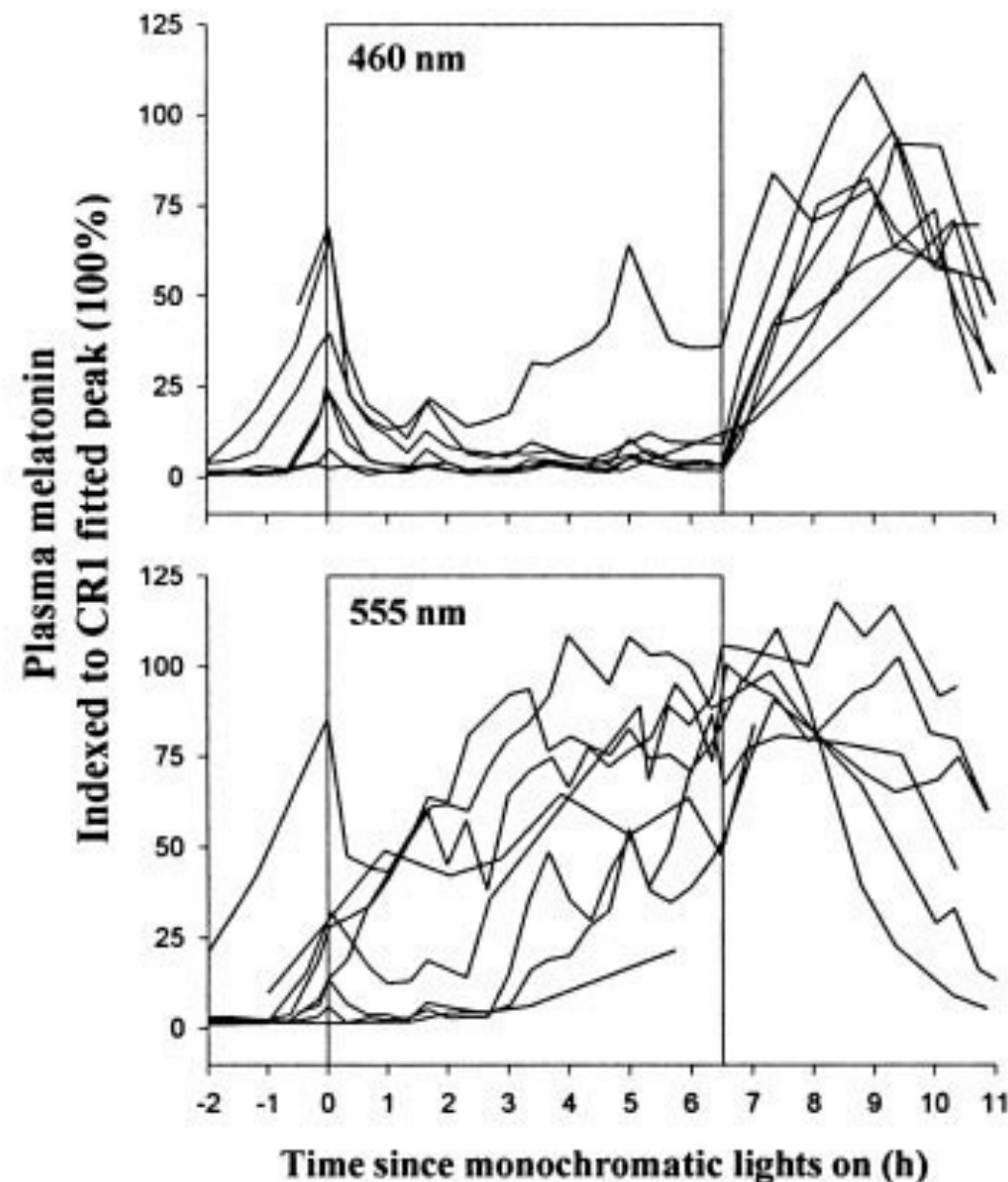


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# Melatonin Rhythm



# Effect of Light Wavelength on Photoentrainment

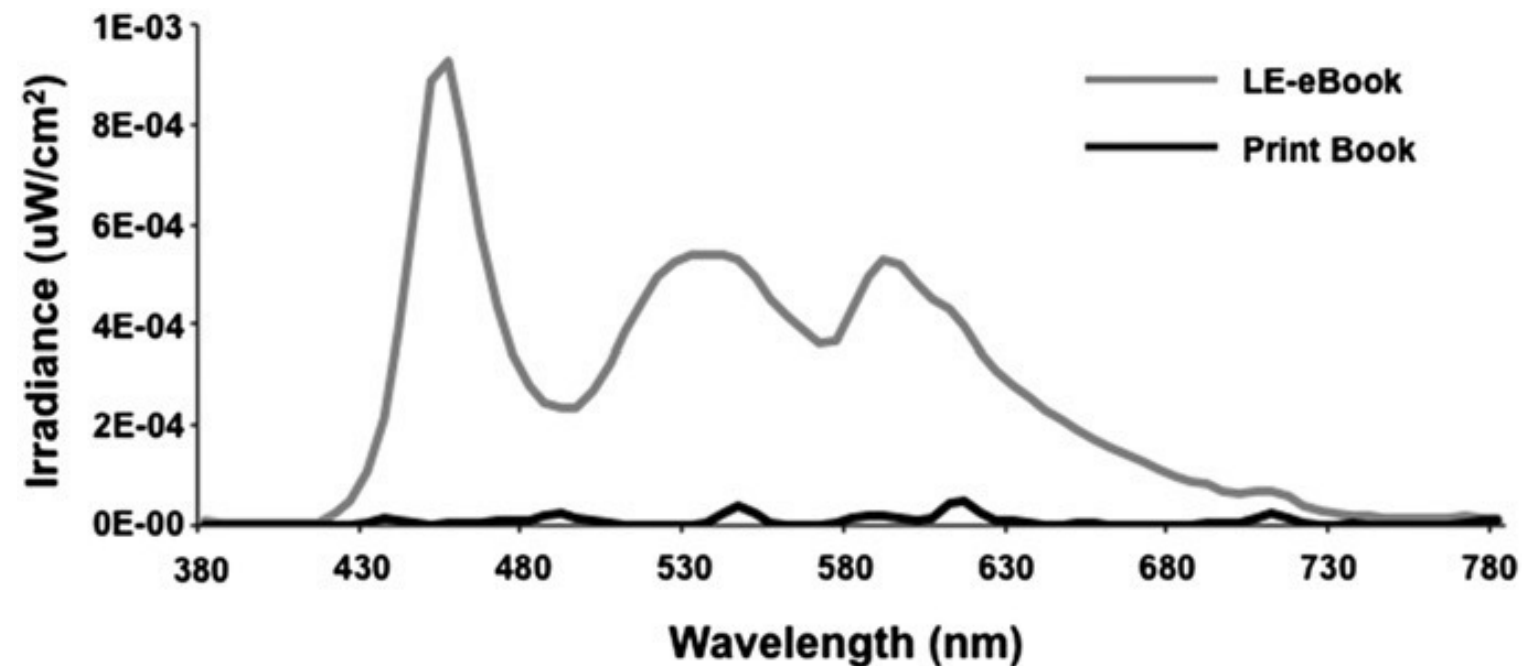
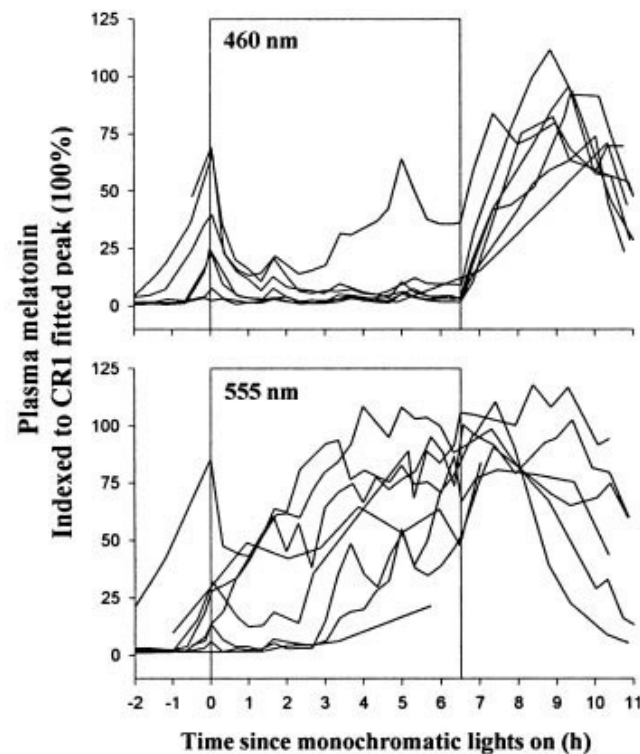


← range where LCD screen light is concentrated

← higher wavelength light

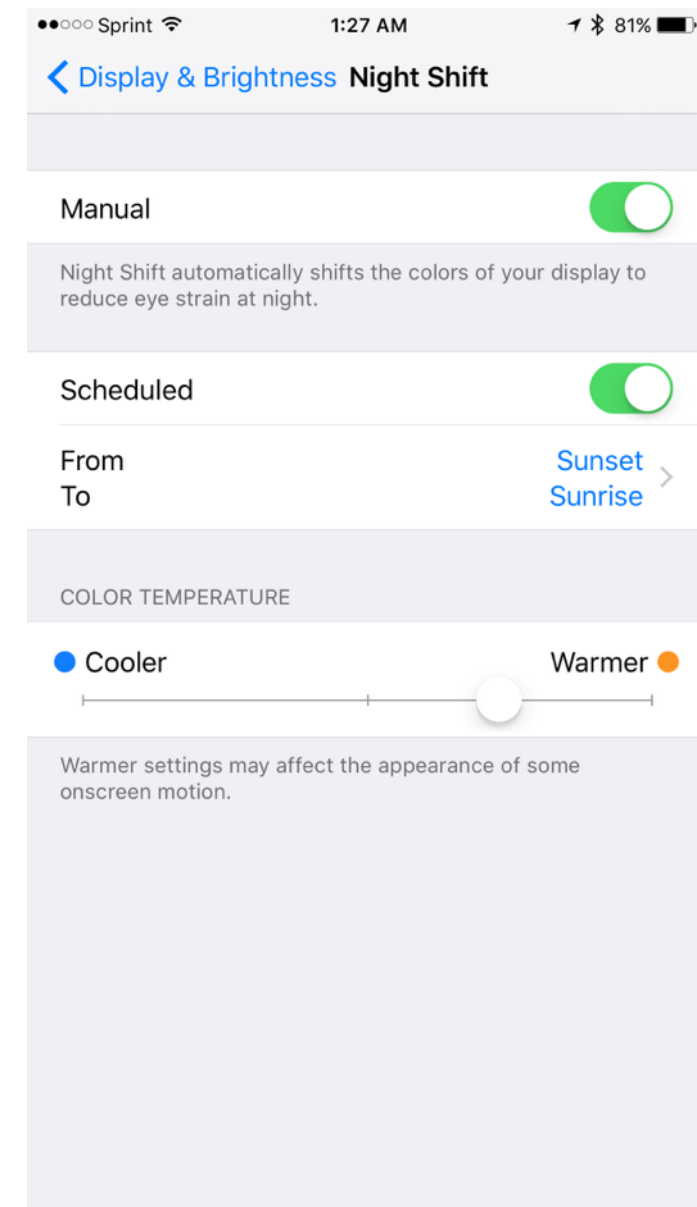
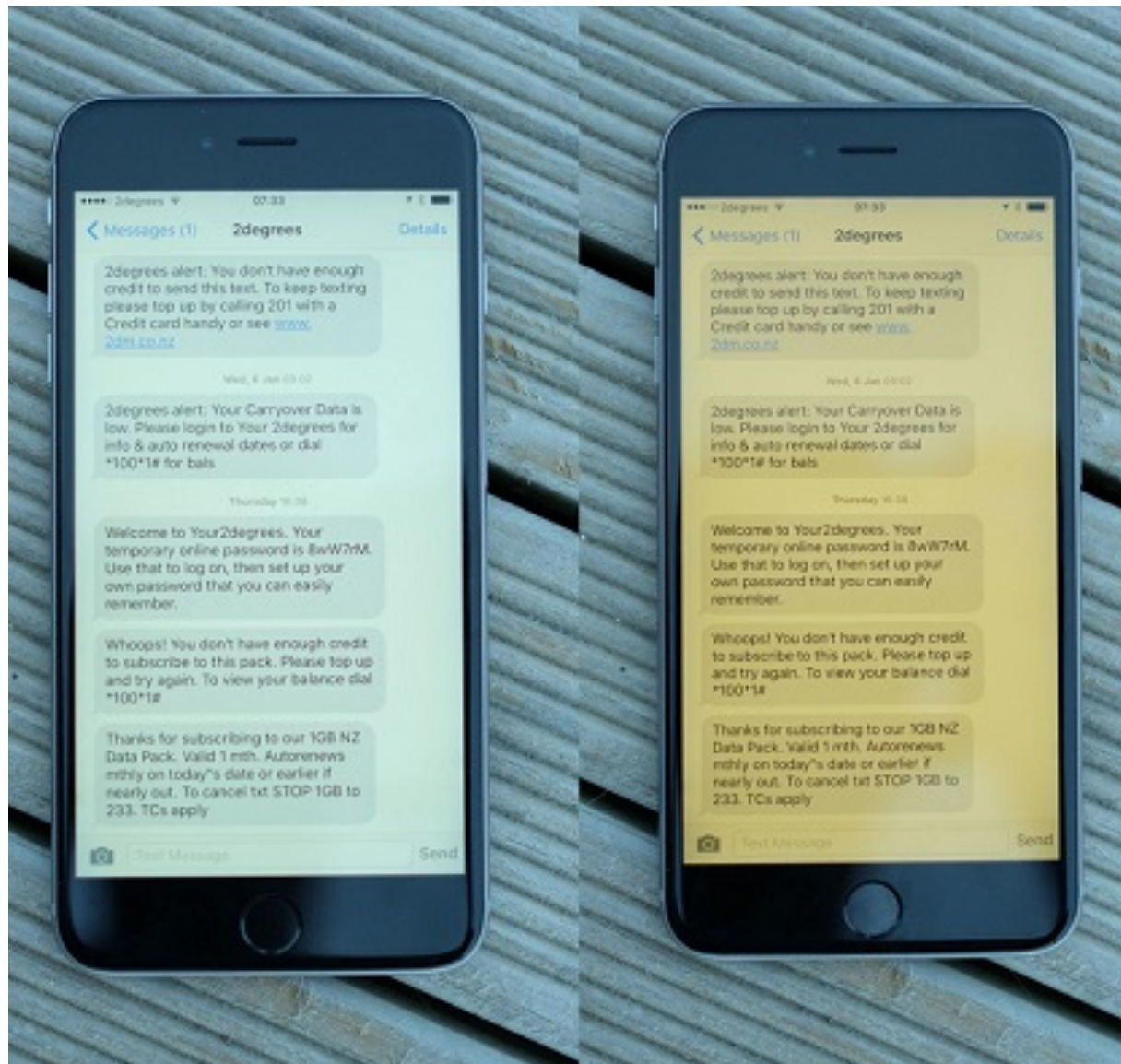
# iPad Light Profile

no solid evidence that mobile screens' color temperature is the real culprit, nor whether devices and monitors can shift enough to matter if they were—or even if blue light on its own is the trigger



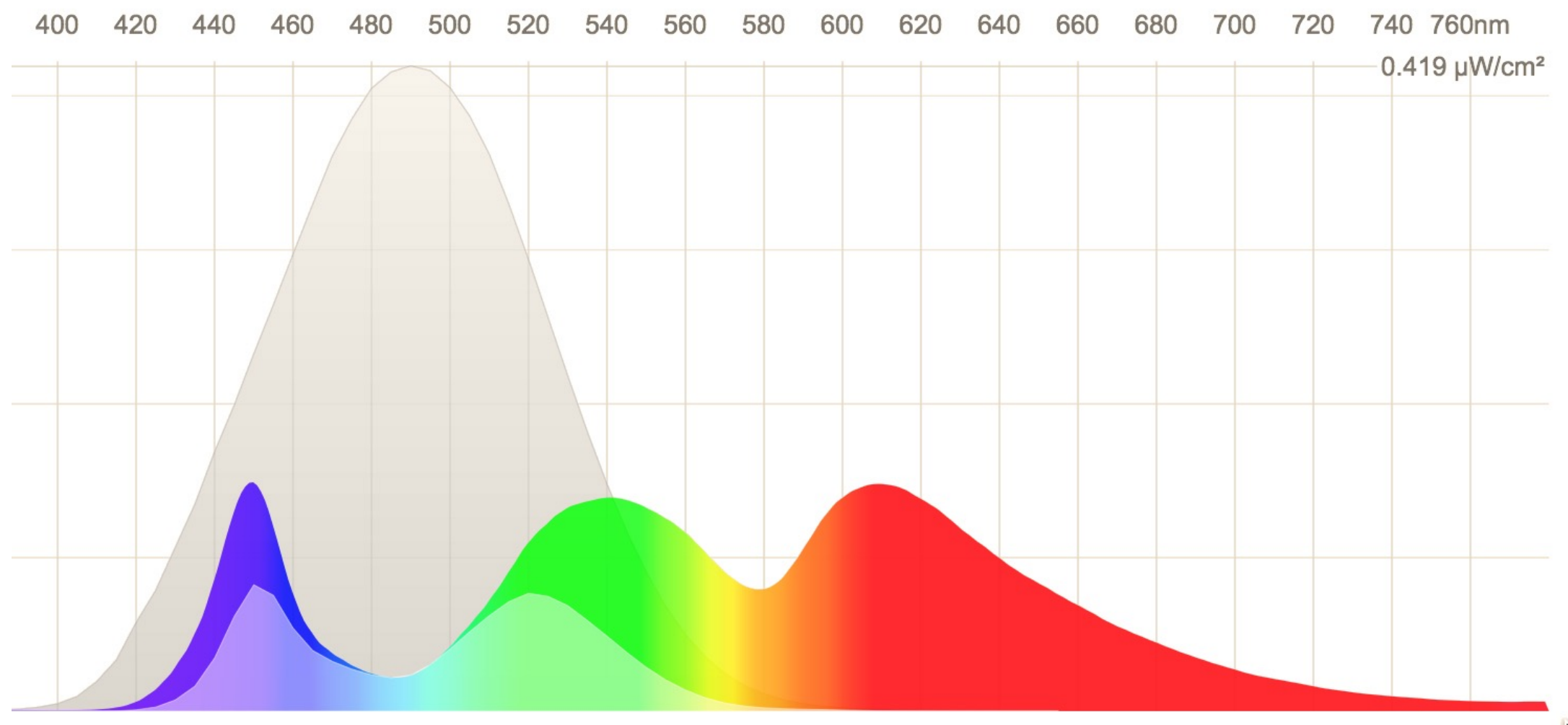


# Night Shift in iOS

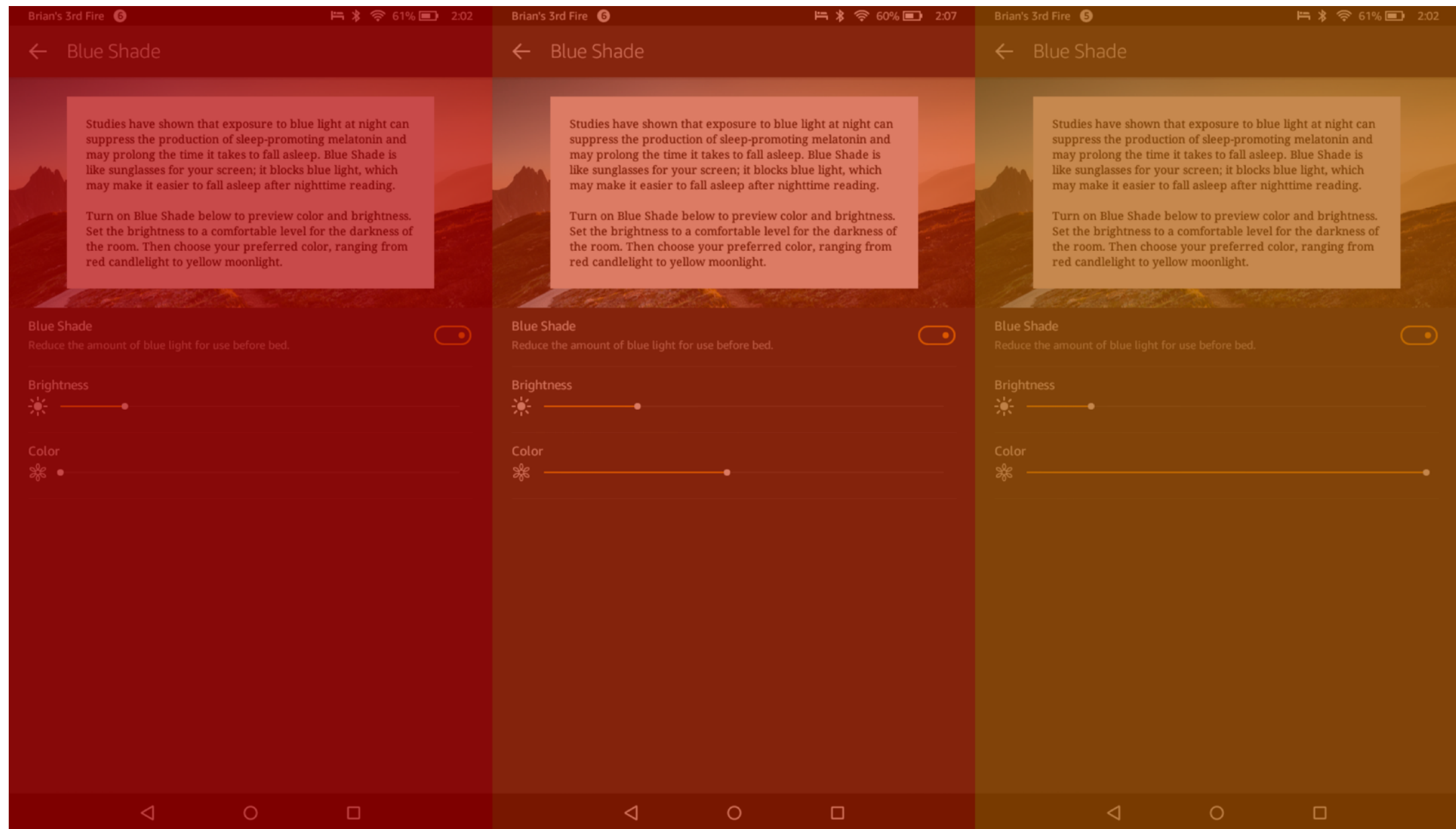




# iPad Light Profile with Night Shift Default Settings



# Blue Shade in Fire OS



# Health Risks

- Melatonin suppression has been linked to:
  - immune suppression
  - significant risk factor for breast, colon, prostate, and endometrial cancer

# Health Risks

- Chronic sleep deprivation has been linked to:
  - memory deficits
  - accelerated aging
  - impaired glucose tolerance
  - increased hunger
  - increased accidents and injuries
- Can be caused by decreased sleep quality

# Specific Aim 1

- Collect further evidence that nighttime tablet use causes a circadian phase delay as well as the associated decreased sleep onset, decreased evening sleepiness, suppression of melatonin secretion, and decreased next morning alertness.

PNAS PNAS PNAS



## Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness

Anne-Marie Chang<sup>a,b,1,2</sup>, Daniel Aeschbach<sup>a,b,c</sup>, Jeanne F. Duffy<sup>a,b</sup>, and Charles A. Czeisler<sup>a,b</sup>

<sup>a</sup>Division of Sleep and Circadian Disorders, Departments of Medicine and Neurology, Brigham and Women's Hospital, Boston, MA 02115; <sup>b</sup>Division of Sleep Medicine, Harvard Medical School, Boston, MA 02115; and <sup>c</sup>Institute of Aerospace Medicine, German Aerospace Center, 51147 Cologne, Germany

Edited by Joseph S. Takahashi, Howard Hughes Medical Institute, University of Texas Southwestern Medical Center, Dallas, TX, and approved November 26, 2014 (received for review September 24, 2014)

In the past 50 y, there has been a decline in average sleep duration and quality, with adverse consequences on general health. A representative survey of 1,508 American adults recently revealed that 90% of Americans used some type of electronics at least a few nights per week within 1 h before bedtime. Mounting evidence from countries around the world shows the negative impact of such technology use on sleep. This negative impact on sleep may be due to the short-wavelength-enriched light emitted by these electronic devices, given that artificial-light exposure has been shown experimentally to produce alerting effects, suppress melatonin, and phase-shift the biological clock. A few reports have shown that these devices suppress melatonin levels, but little is known about the effects on circadian phase or the following sleep episode, exposing a substantial gap in our knowledge of how this increasingly popular technology affects sleep. Here we compare the biological effects of reading an electronic book on a light-emitting device (LE-eBook) with reading a printed book in the hours before bedtime. Participants reading an LE-eBook took longer to fall asleep and had reduced evening sleepiness, reduced melatonin secretion, later timing of their circadian clock, and reduced next-morning alertness than when reading a printed book. These results demonstrate that evening exposure to an LE-eBook phase-delays the circadian clock, acutely suppresses melatonin, and has important

sleep, and subjective and objective measures of sleepiness both in the evening while reading and the following morning.

### Results

Twelve healthy young adults (mean  $\pm$  SD: 24.92  $\pm$  2.87 y; six women) completed a 14-d inpatient protocol. The randomized, crossover design (shown in Fig. 1) consisted of two conditions: (i) reading an LE-eBook in otherwise very dim room light for ~4 h before bedtime for five consecutive evenings, and (ii) reading a printed book in the same very dim room light for ~4 h before bedtime for five consecutive evenings. All participants completed both reading conditions but were randomized to the order. Hourly blood samples were collected during portions of

### Significance

The use of light-emitting electronic devices for reading, communication, and entertainment has greatly increased recently. We found that the use of these devices before bedtime prolongs the time it takes to fall asleep, delays the circadian clock, suppresses levels of the sleep-promoting hormone melatonin, reduces the amount and delays the timing of REM sleep, and reduces alertness the following morning. Use of light-emitting

# Sleepiness Measures

- Measured both **evening sleepiness** and **morning alertness**
- Objective Sleepiness: Karolinska Drowsiness Test (KDT)
  - looking at PSG artifacts (i.e. slow eye movements) as subject stares at black dot
- Subjective Sleepiness: Karolinska Sleepiness Scale (KSS)

# Measure of Subjective Sleepiness

- Karolinska Sleepiness Scale (KSS)
  1. Extremely alert
  - 2.
  3. Alert
  - 4.
  5. Neither alert nor sleepy
  - 6.
  7. Sleepy, but no effort to keep awake
  - 8.
  9. Very sleepy, great effort to stay awake



# Specific Aim 2

- Determine how much software countermeasures, specifically Apple's Night Shift and Amazon's Blue Shade, reduce the effects of nighttime tablet use in these human subjects.

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## iOS 9.3: The new Night Shift feature probably won't help you sleep better

There's no solid evidence that mobile screens' color temperature is the real culprit to keeping you up at night.



Credit: Apple

13 COMMENTS

**Glenn Fleishman** | @GlennF  
Senior Contributor, Macworld Mar 25, 2016 5:30 AM

The Night Shift feature in iOS 9.3 lets you adjust the color temperature of the display, shifting away from blue spectrums of light, in the putative interest of improving sleep. But Apple makes no promises. On its website, Apple notes,

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**EBOOK**  
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**WHITE**  
10 Cust  
Watch i

See All Search

**POPULAR IPHO**

Access  
Planet  
Purple  
TPU Pc

iPhone  
iPhone  
Tempe  
Glass S  
Protect

iPhone  
Cover f  
Access  
Purple

iPhone  
iPhone  
Wallet f  
Studde  
Leopar

AJ11 Br  
Textur

# Specific Aim 3

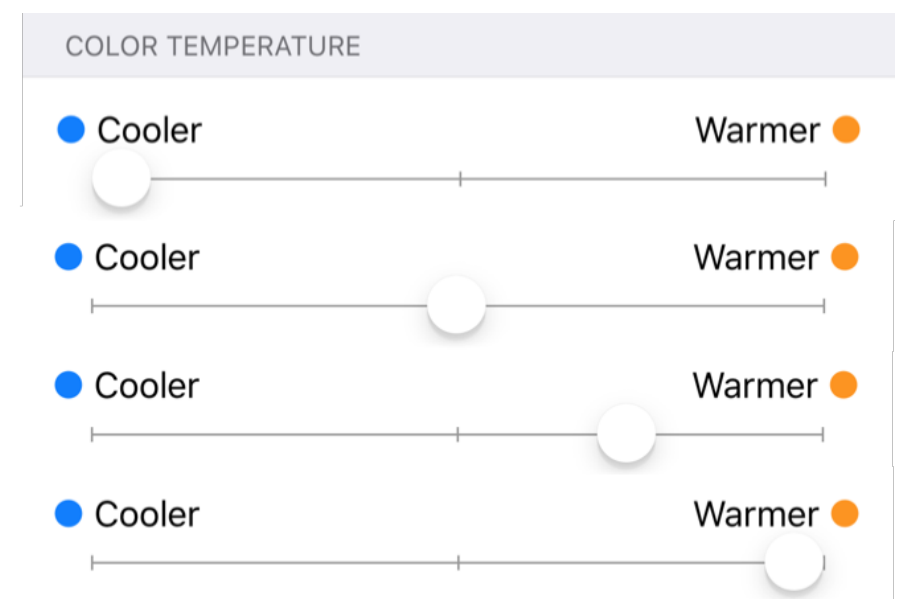
- Determine the ideal tint degree, tint color, and screen brightness settings to minimize the effects of nighttime tablet use in human subjects while maintaining device usability.

Setting A

Setting B

Setting C

Setting D



# Summary

- Numerous known health risks associated with nighttime circadian photoentrainment
- Nighttime use of tablet devices is known cause
- Need evidence whether screen temperature is only culprit of photoentrainment
  - Are there any other factors?
- Is more blue light reduction needed?