A photograph of a hospital hallway with a blue tint. On the left, a nurse in blue scrubs and a cap stands looking at a clipboard. In the center, a person in a white lab coat walks away. On the right, a man in blue scrubs and a cap sits on a chair, resting his head on his hand. The hallway has a polished floor reflecting the overhead lights.

Novel Lighting Strategies for Optimizing Circadian Health and Alertness in Shiftworkers

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Shiftwork

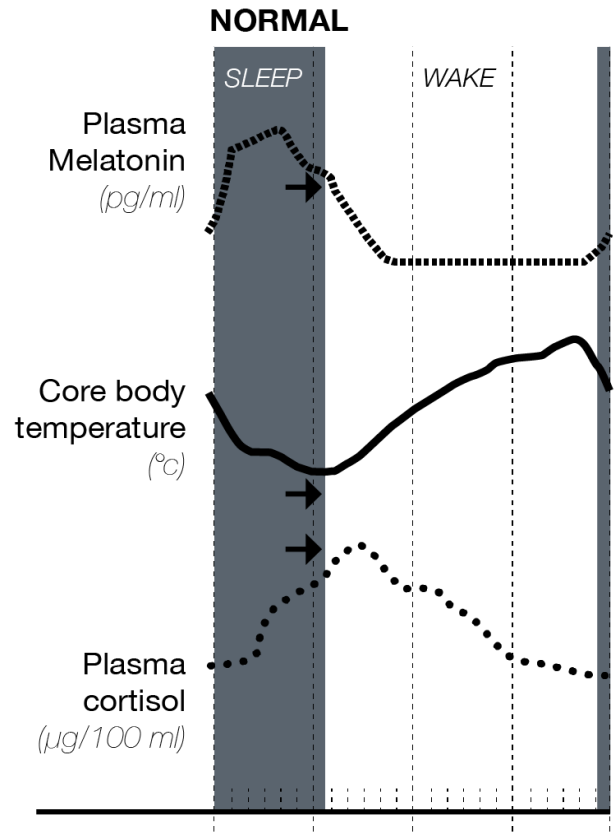
- 15 million individuals work outside regular 9-5 shift (U.S. Department of Labor)
- Increased risk of accident & injury (Folkard & Tucker, 2003)
- Myriad physiological & psychological consequences (Evans et al. 2013; Brown et al., 2009; Lawson et al., 2011)
- Compromised alertness, performance and health costs ~\$200 billion annually (Kerin & Aguirre, 2005)
- Limited practical solutions

What causes the harm?

Three interconnected processes interact in the shiftworker:

- Circadian misalignment
- Sleep deprivation
- Light at night

Circadian Rhythms and Disturbances





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Circadian Rhythms and Shift Work

Policy Resource and Education Paper (PREP), 2010

- “the single most important reason given for premature attrition from the field”
- Lack of guidance:
“Shifts should be scheduled, whenever possible, in a manner consistent with circadian principles. For most settings, scheduling isolated night shifts or relatively long sequences of night shifts is recommended.”

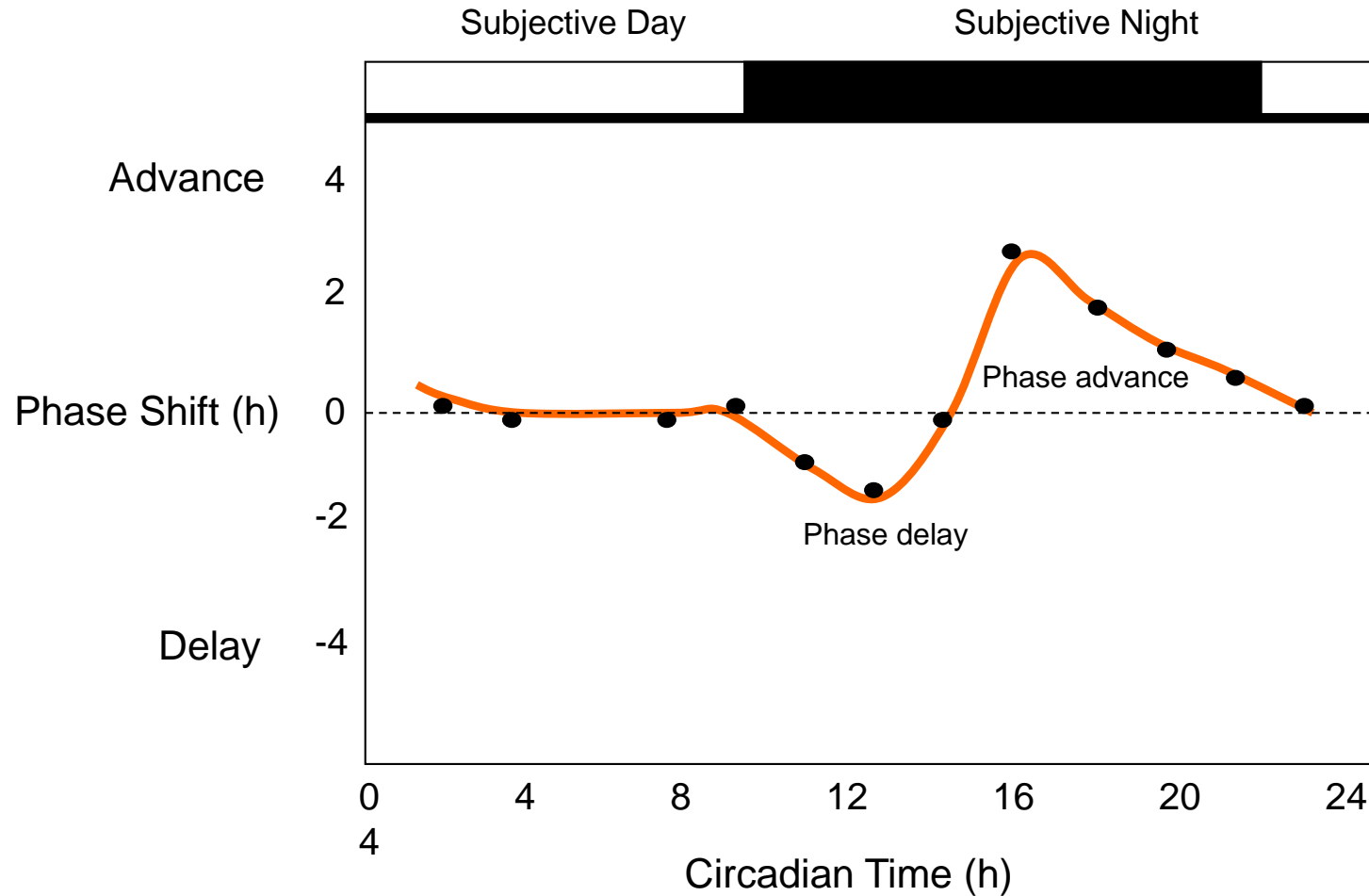
Lighting Countermeasures for Shiftworkers

- Facilitate circadian adjustment
- Increase alertness/performance on-shift
- Increase sleep duration/quality

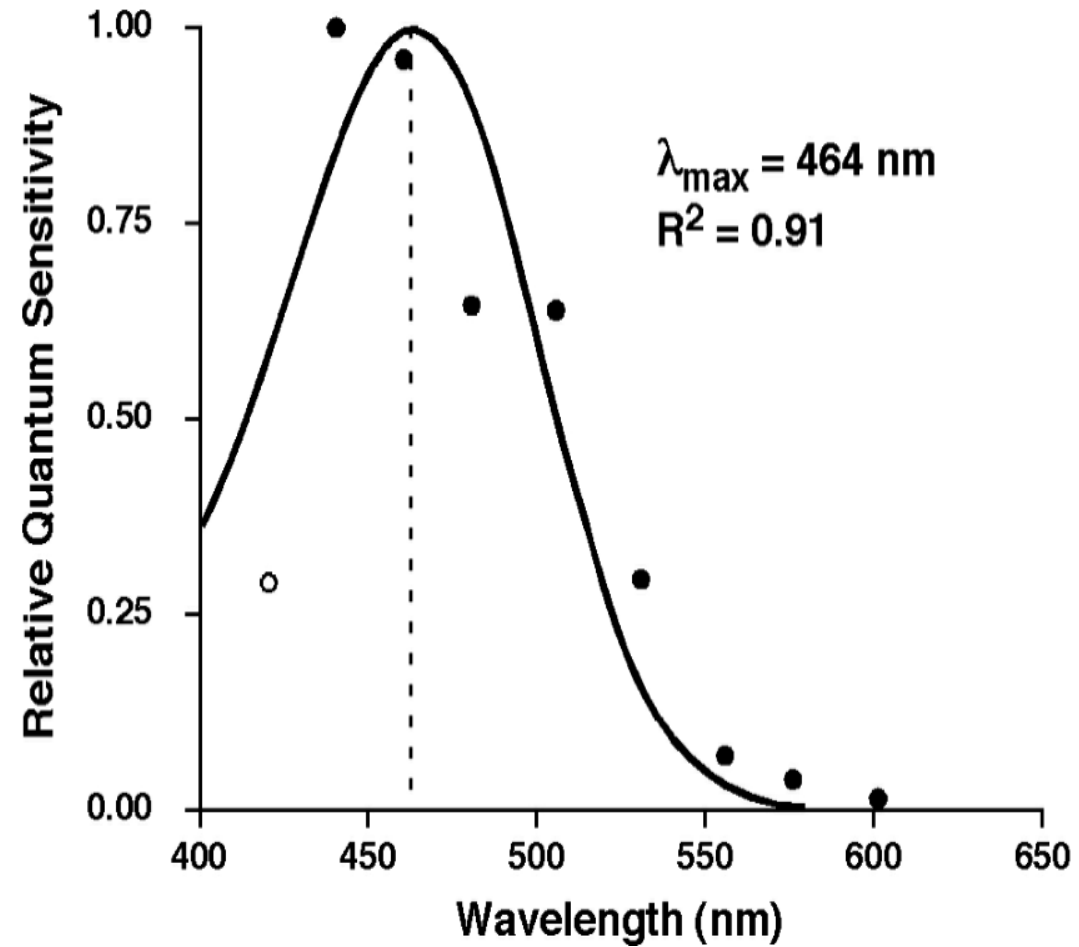
Elements Mediating the Effects of Light

- Timing
- Wavelength

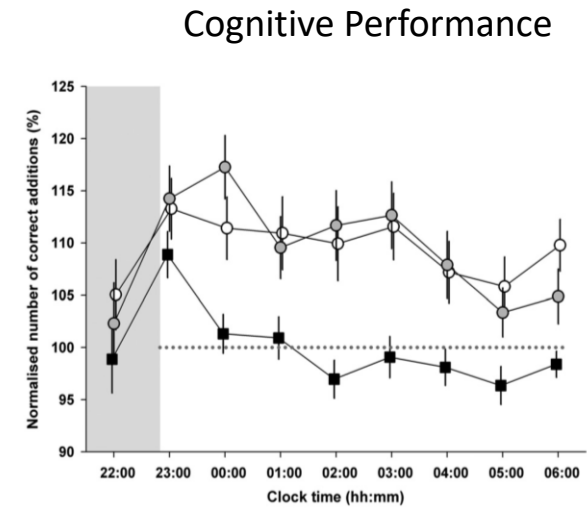
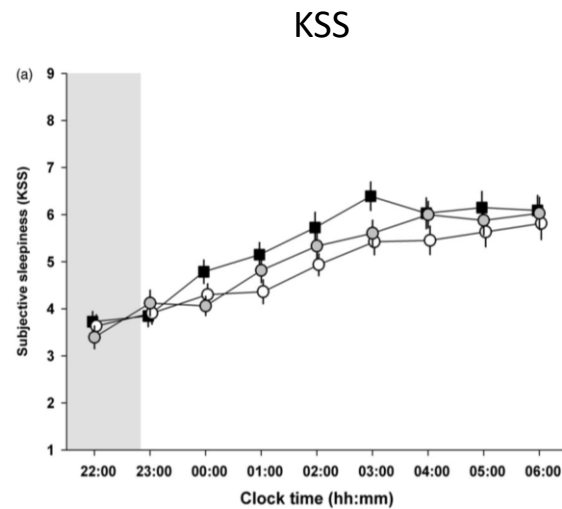
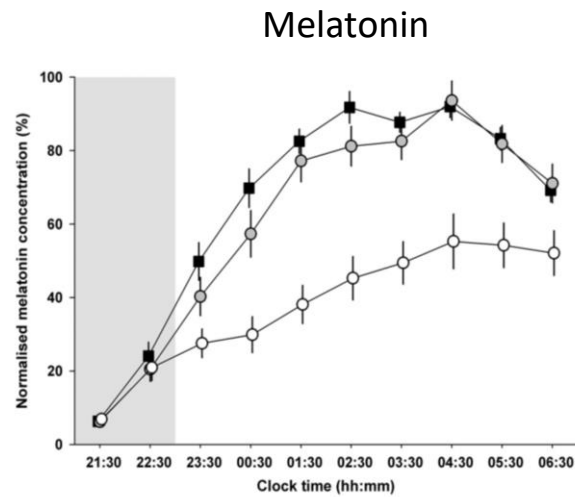
Phase Response Curve



Spectral Sensitivity



Responses to “Blue-Attenuated” Light



- Van der Werken et al., 2014

Proposed Intervention for Night Shiftworkers

Combines two evidence-based lighting interventions to address two different light responses:

Circadian Phase Resetting, architectural

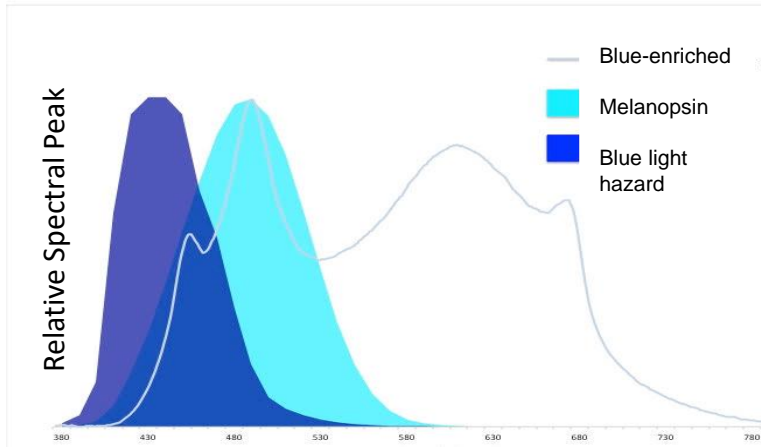
- maximize input during subjective day
- minimize input close to desired bedtime

Acute Alerting, individual

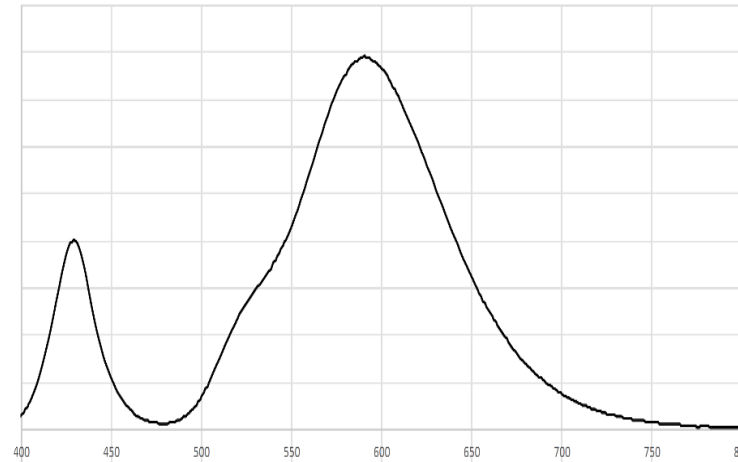
- light for alerting ONLY
- only when KSS ≥ 6 and/or increased reaction time on PVT (need based*)

Study Light Sources

Blue-enriched, architectural

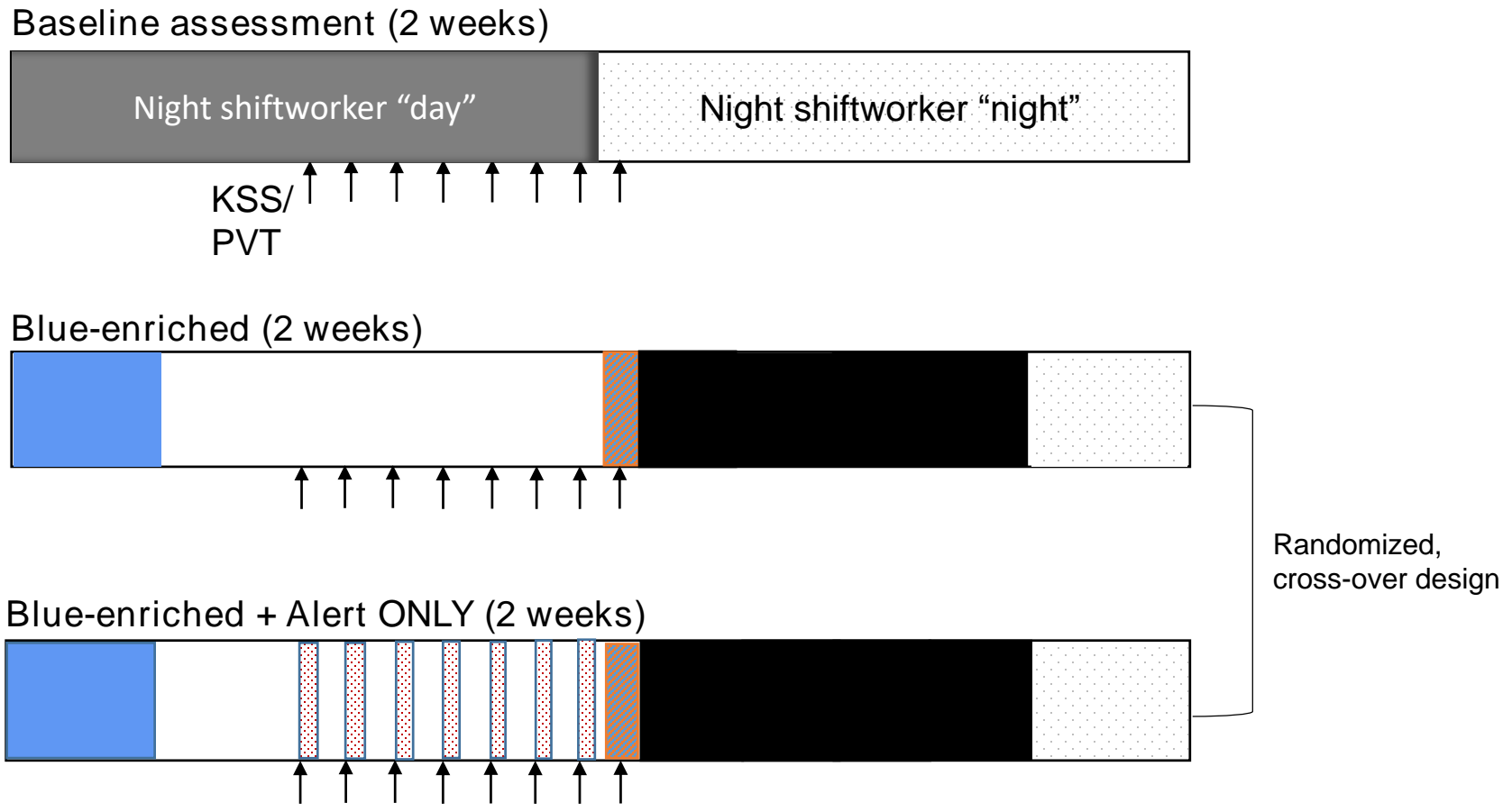


Alert ONLY, individual



Light Source	CCT (K)	Melanopic lux (m-lux)	Photopic lux (lux)	m-lux/lux	CRI
LA sky at 2 PM	5107	1.12e+3	662	1.69	100
3500K fluorescent	3562	50.4	100	0.504	75.2
Blue-enriched	3483	93	100	0.931	84.26
Alert ONLY	TBD	~30	100	~0.30	>80

Shiftworker Intervention Protocol (N=30)



Measures

- Sleep and work diaries
- Continuous actigraphy
- Hormone profiles (melatonin and cortisol)
- Karolinska Sleepiness Scale (KSS)
- Psychomotor vigilance test (PVT)
- Subjective measures of health, quality of life, turnover communication

Conclusions

- Biological effects of light may be influenced via a variety of variables (timing, intensity, wavelength, photoperiod history)
- However, not all light responses are necessarily influenced in the same way
- Those disassociations may be utilized in the development of optimal treatment strategies
- Further, individualized and dynamic lighting environments have the potential to be particularly effective in populations with significant variability in circadian phase, such as shiftworkers

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