

U.S. DOE Lighting/IES R&D Workshop

Humancentric Lighting – Is Light All We Need?

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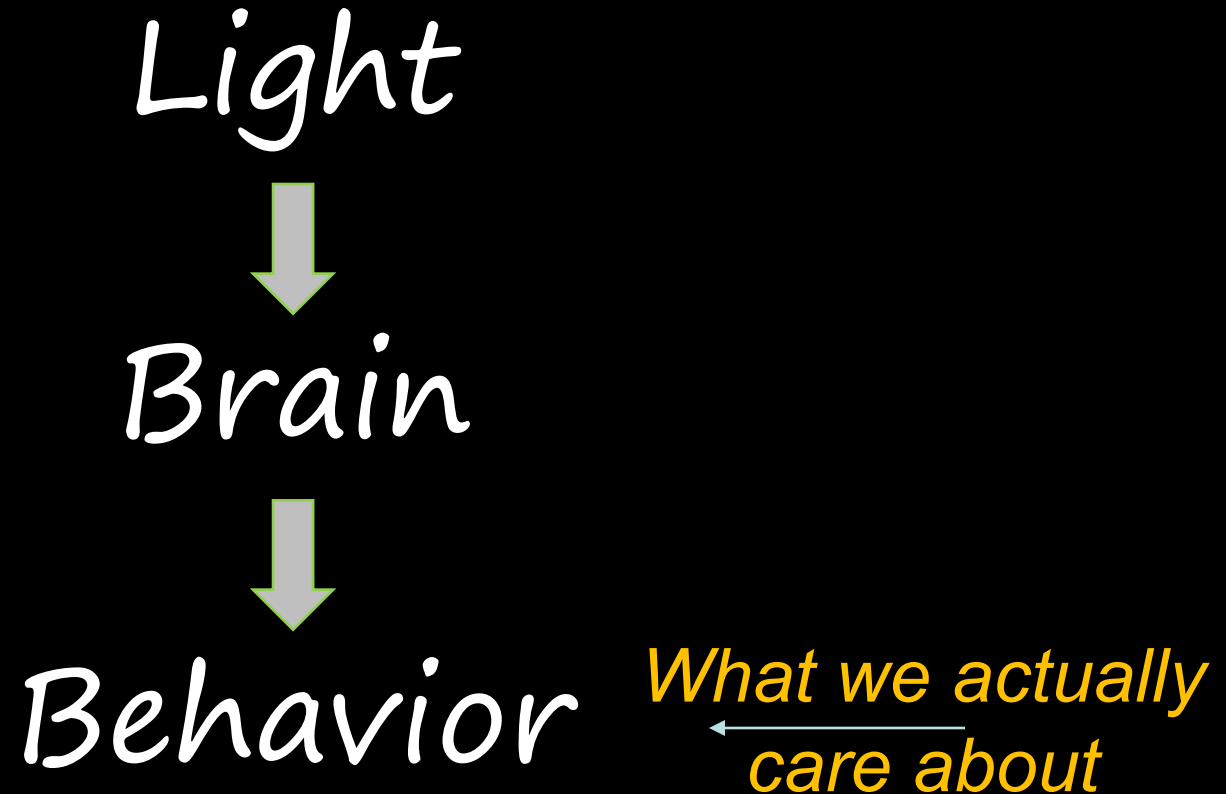
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Basic Paradigm: The Purpose of Humancentric Lighting is to Improve Human Health and Behavior



Basic Paradigm



Light



Brain



Behavior



Highly reproducible responses

Basic Paradigm



Light



Brain

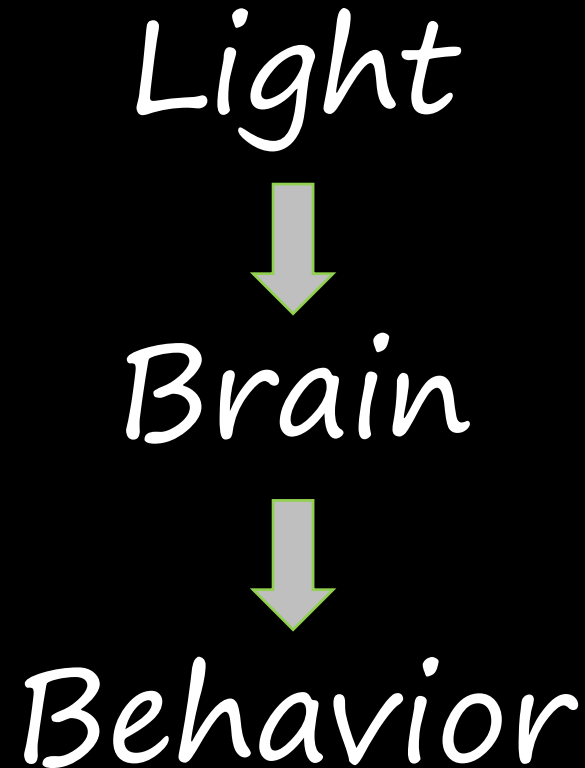


Behavior



Highly variable responses

Case example



Use light to change the timing of the circadian clock and subsequent bed time in teens.

Basic Paradigm



Light



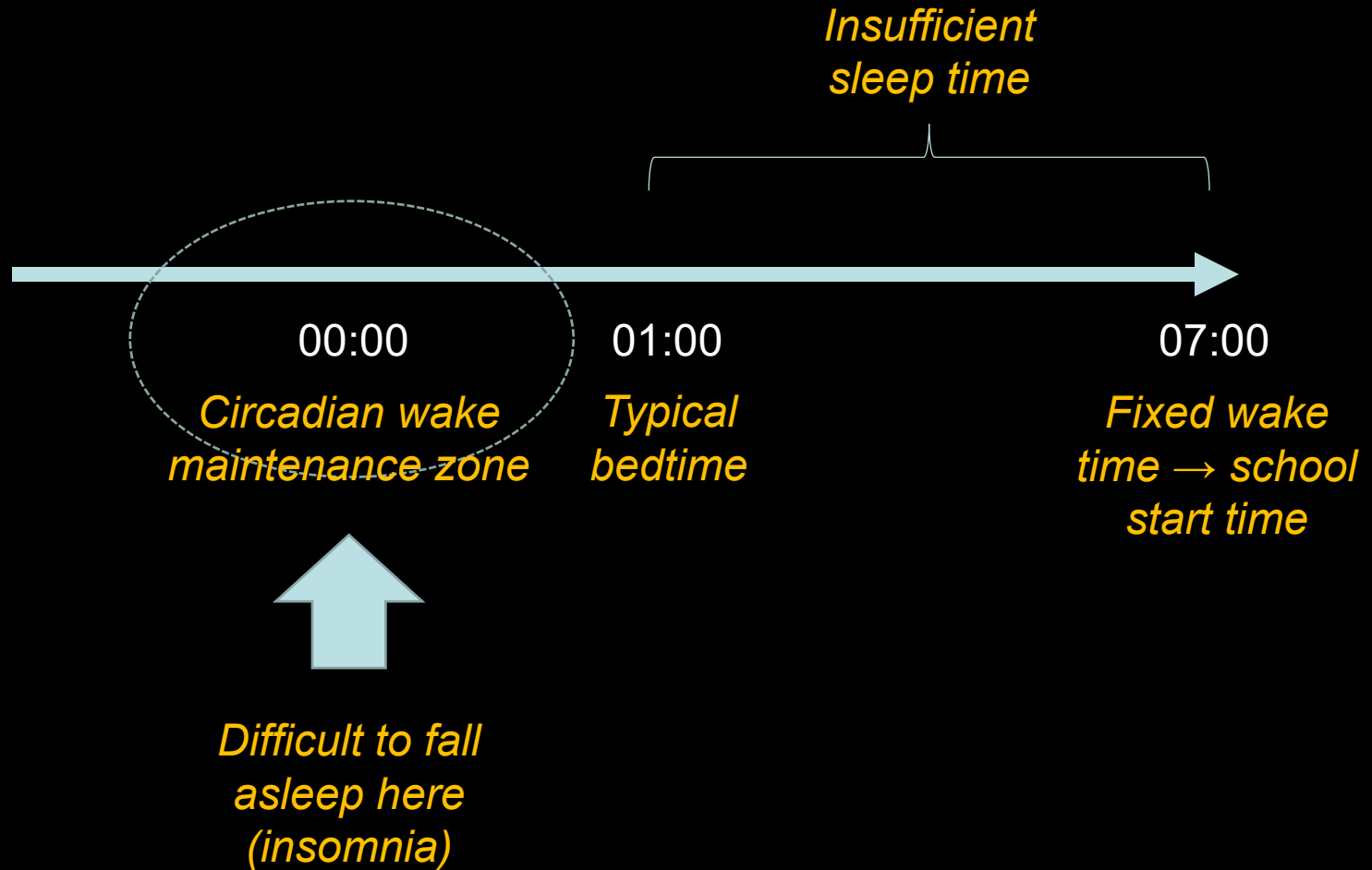
Brain



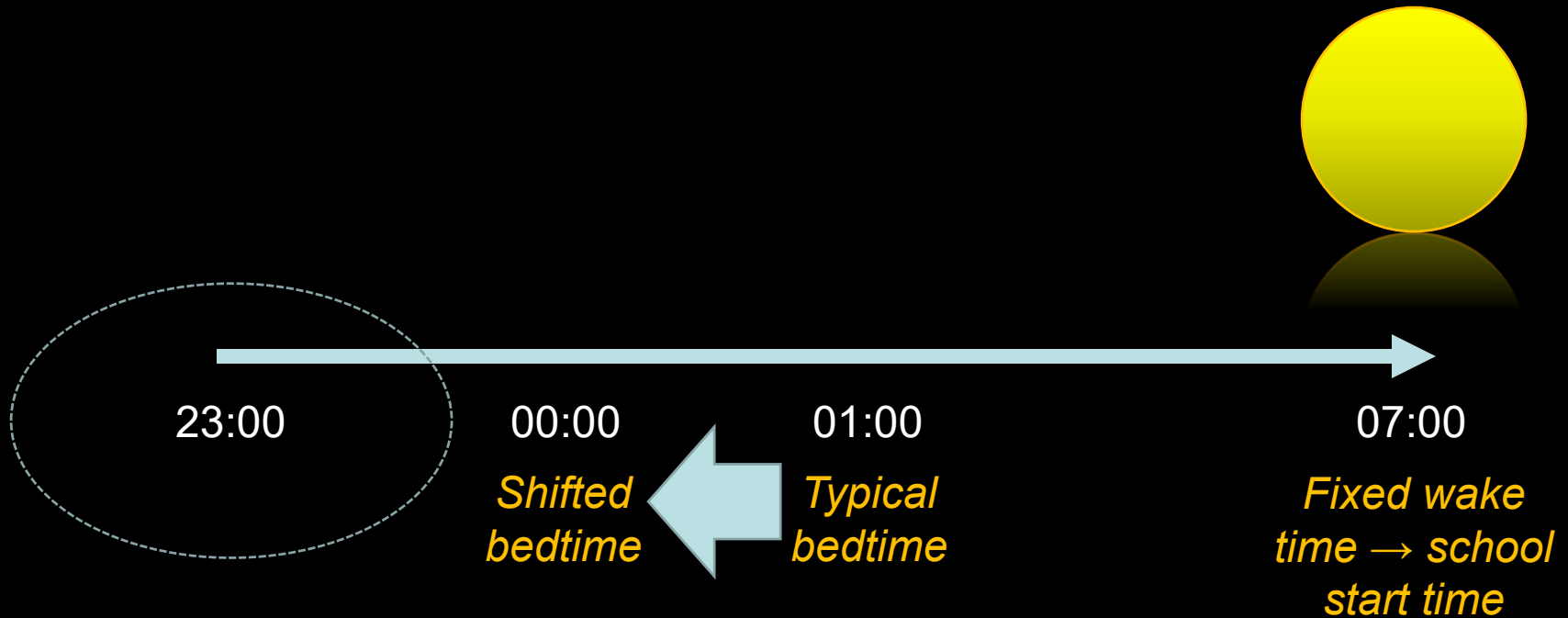
Behavior

Light predictably shifts the timing of sleep in rodents

Case example - teens



Case example - teens



Early morning light administration will shift the circadian clock earlier, enabling an earlier bedtime

Protocol 1: Use light alone

72 adolescents (14-18 y.o.) who had difficulty initiating sleep early enough to get sufficient sleep

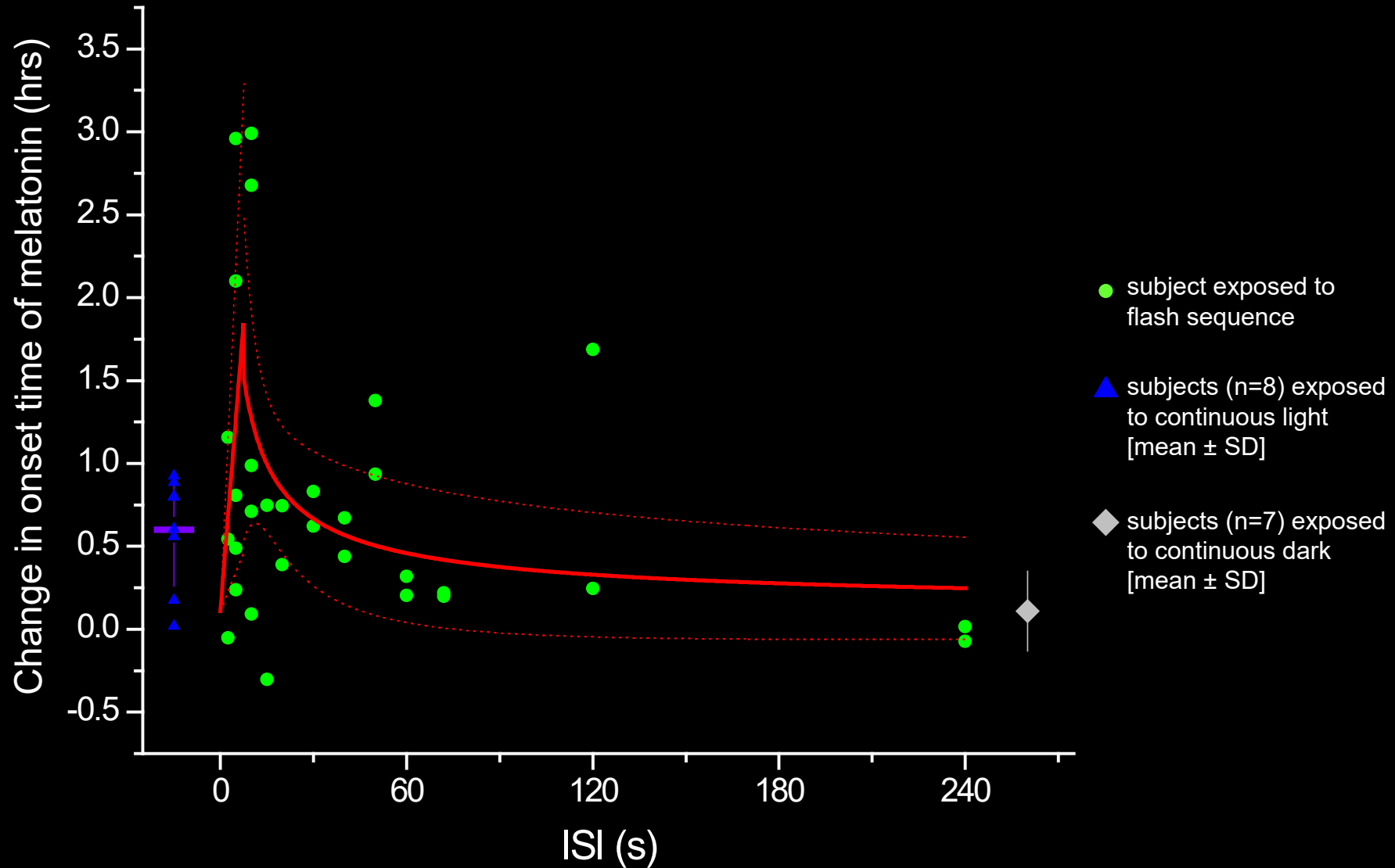
<u>Baseline</u> Diary, EMA 1 week	<u>Active or Sham Light (Randomized)</u> Diary, EMA 4 weeks
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- 3 hours before habitual wake
- ~4,000 lux of broad spectrum white light
(~200-600 lux at the cornea after eyelid filtration)
- 3-ms flash
- 20 s interflash interval



*Novel exposure regimen – light
flashes during sleep
Maximizes compliance and
sleep gain*

Sequence of light flashes engender robust shifts in circadian timing



Light : sequence of light flashes



Brain : shift circadian clock
earlier by one hour



Behavior : shift sleep onset time
earlier by one hour

Light : sequence of light flashes ✓



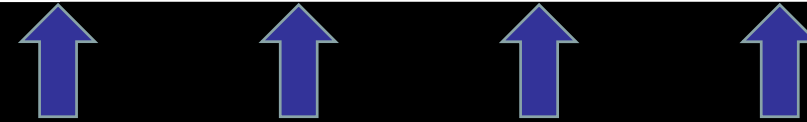
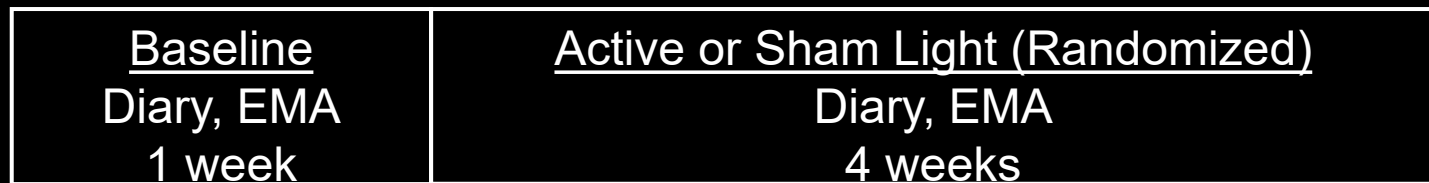
Brain : shift circadian clock earlier by one hour ✓



Behavior : shift sleep onset time earlier by one hour ✗

Protocol 2: Light + Behavioral Modification

Additional 30 adolescents (14-18 y.o.) who had difficulty initiating sleep early enough to get sufficient sleep



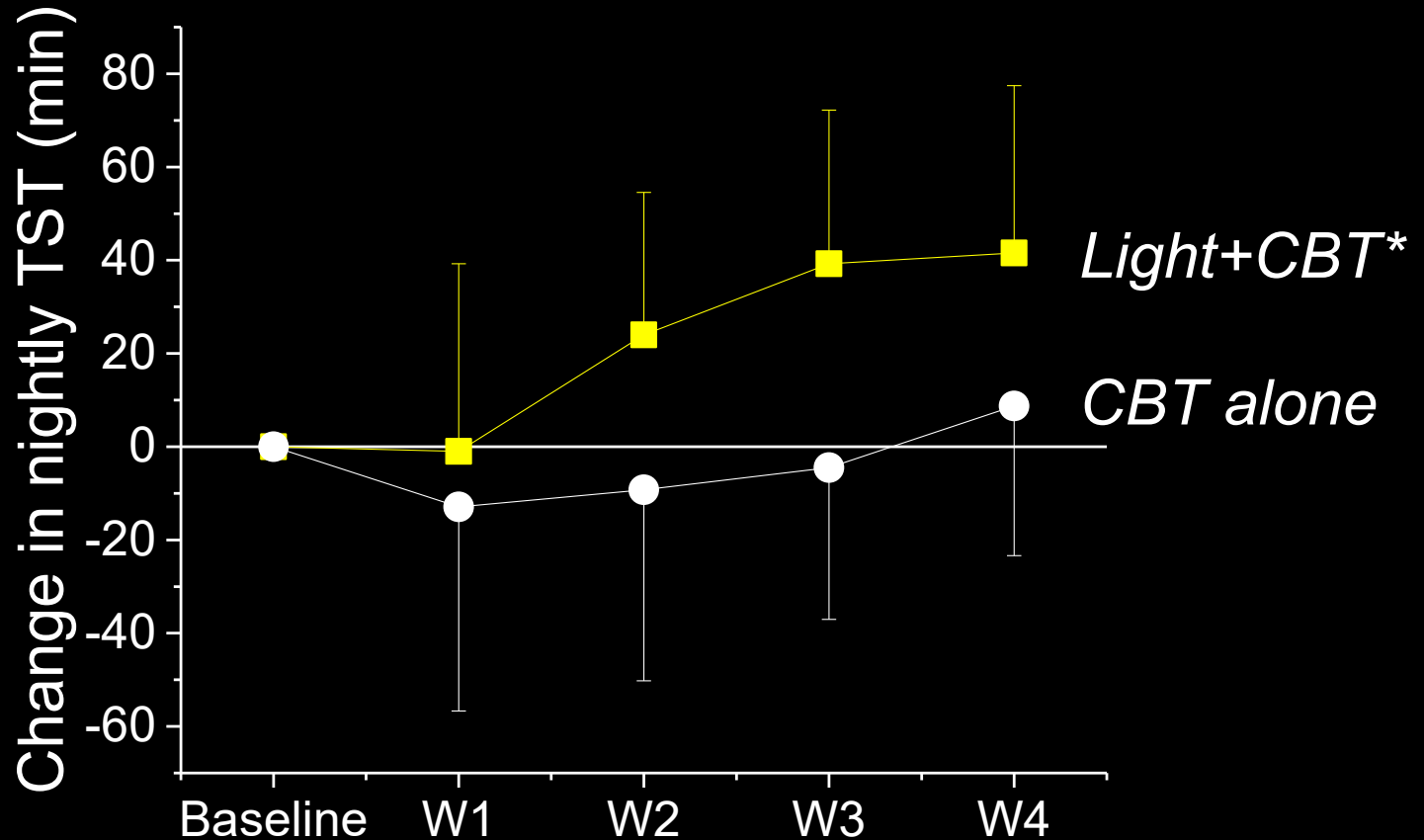
4 weekly brief CBT sessions:

motivational interviewing, values-based clarification, education, sleep hygiene, stimulus control, activity scheduling

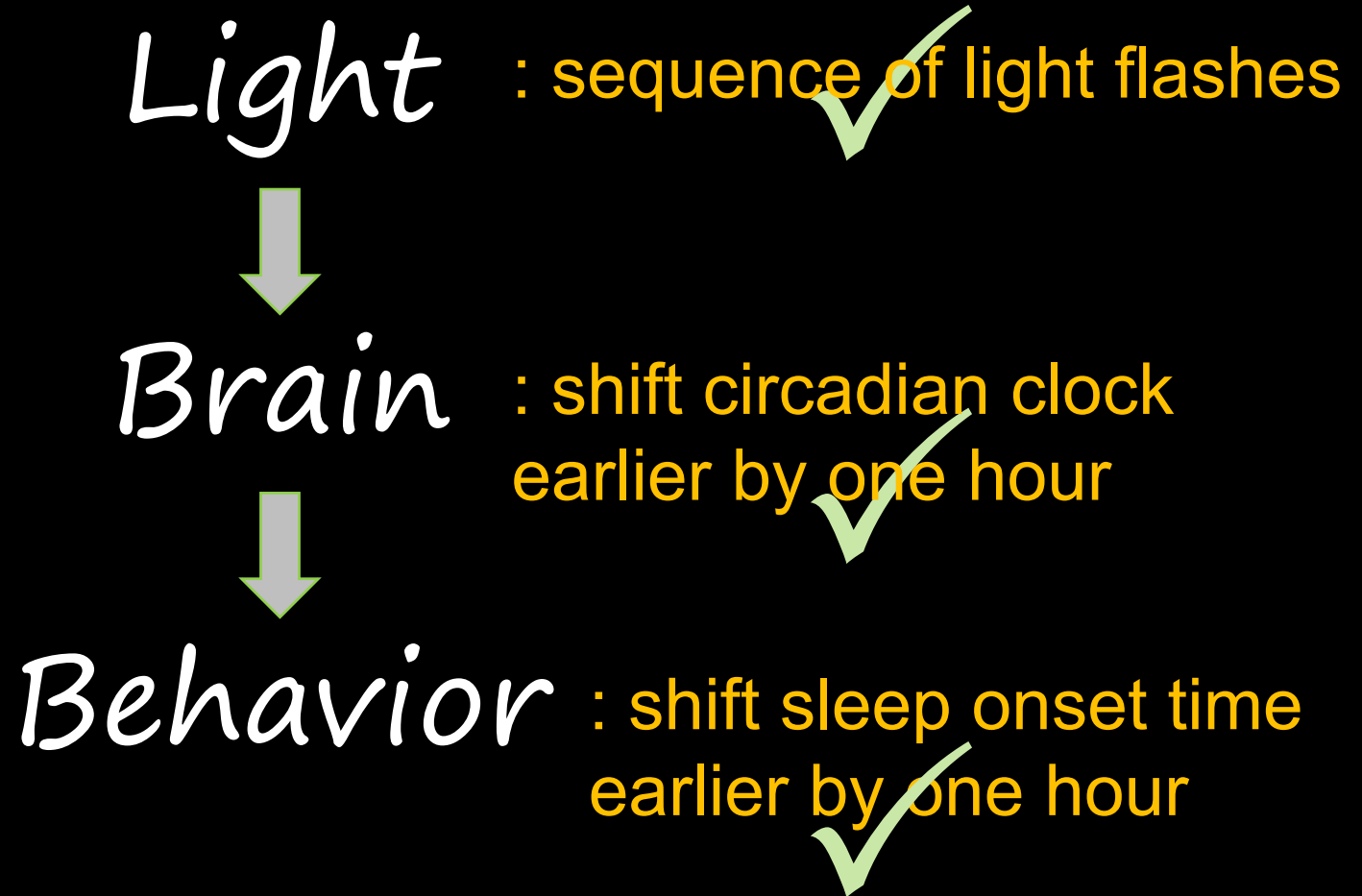
- **2 hours** before habitual wake
- ~4,000 lux of broad spectrum white light (~200-600 lux at the cornea after eyelid filtration)
- 3-ms flash
- 20 s interflash interval



Desired outcome – change in *behavior*

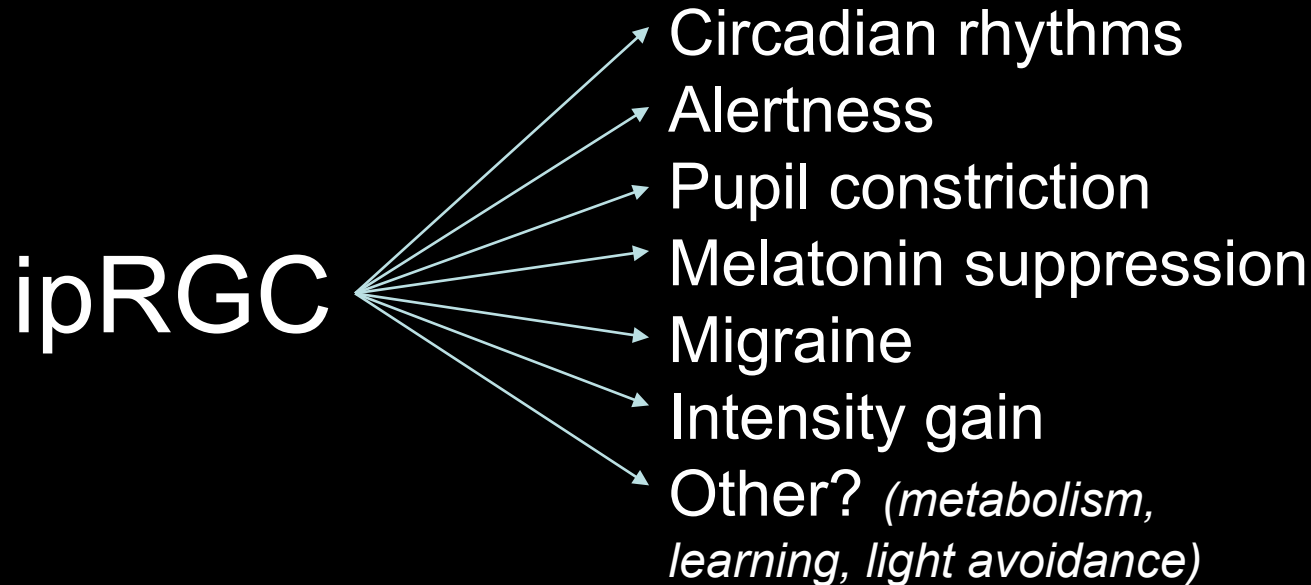


Just changing the timing of the circadian clock with light is *insufficient* to engender changes in sleep timing in teens

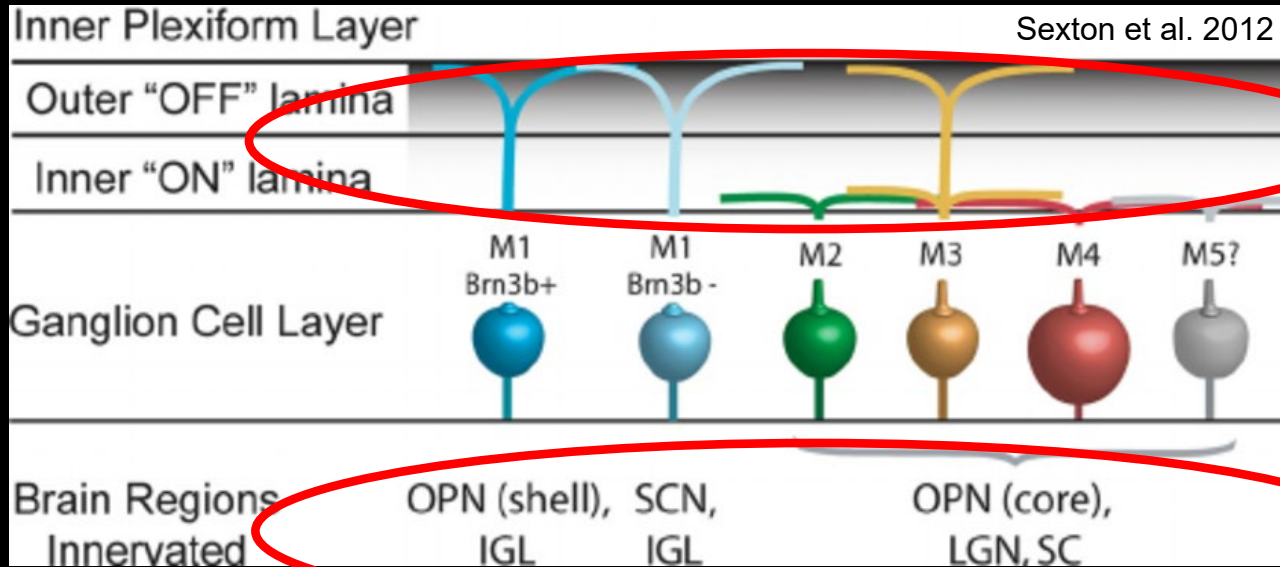


Point 1: In many instances, just providing light is insufficient to engender the health or behavior changes that we expect

To Proxy or not to Proxy?



To Proxy or not to Proxy?



Varied extrinsic inputs

Varied outputs: circadian entrainment, mood, hormone, cognition, pupil, etc.

Recording the impact of a specific light source or sequence on a specific non-image forming output may not be valid for understanding the impact of that light on another non-image forming output

Point 2: Measure the endpoint of interest –
not all non-imaging forming aspects of light
follow the same physiology

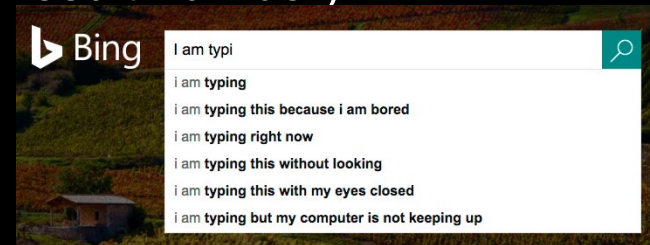
Moving Away from the Laboratory

Studies need to:

- have ecological relevance
- have endpoints that are important to the consumer
- have large enough sample sizes to detect small effects
- ideally be conducted in settings in which data can be collected passively and have functional relevance in a B2B framework

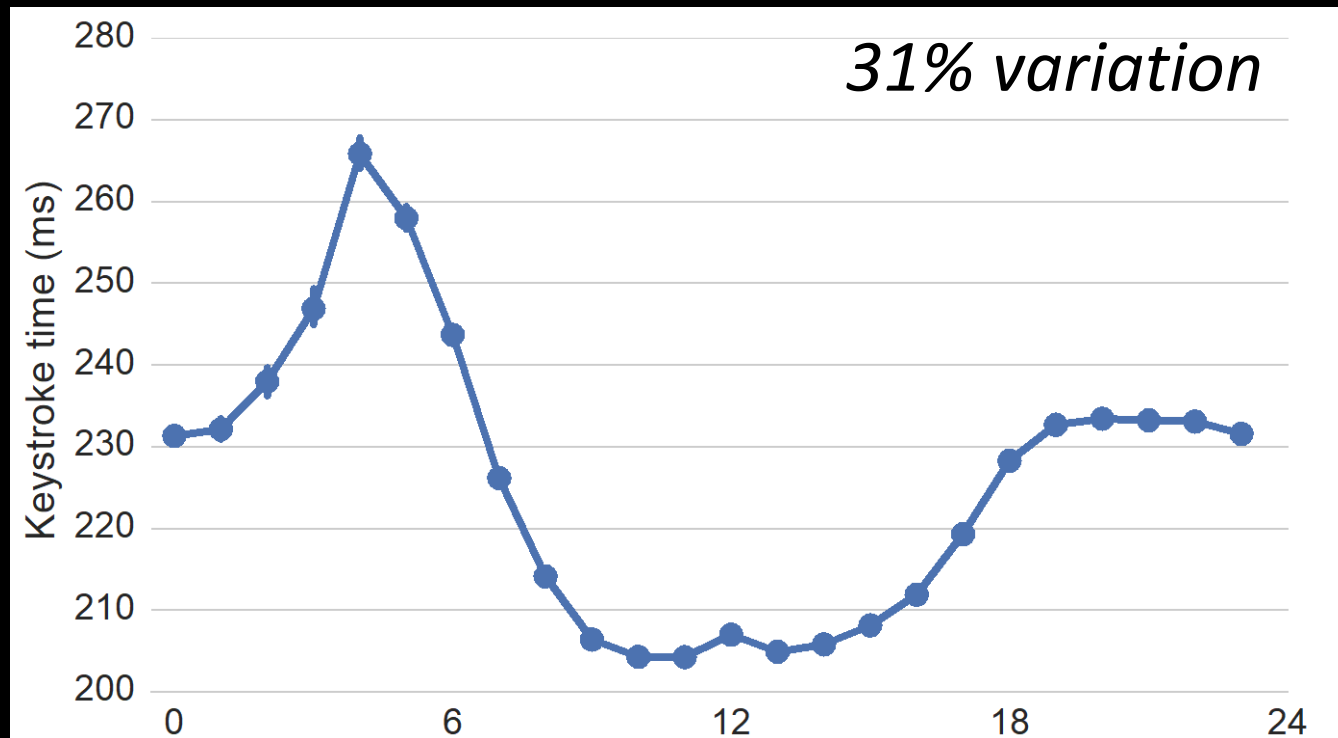
Moving Away from the Laboratory – Example: search engine metadata

- **Cohort: 32,000** users over 18 months
 - US representative age, BMI, sleep; mostly male (93%)
 - Opt-in to link Bing searches and Band data
- **Performance: 75 million** interaction tasks
 - Microsoft Bing search engine
 - Keystroke time in search bar
 - Click time (adjusted for complexity and result number)
- **Sleep: 3 million** nights of sleep
 - Microsoft Band
 - Accelerometry
 - “I’m awake” button

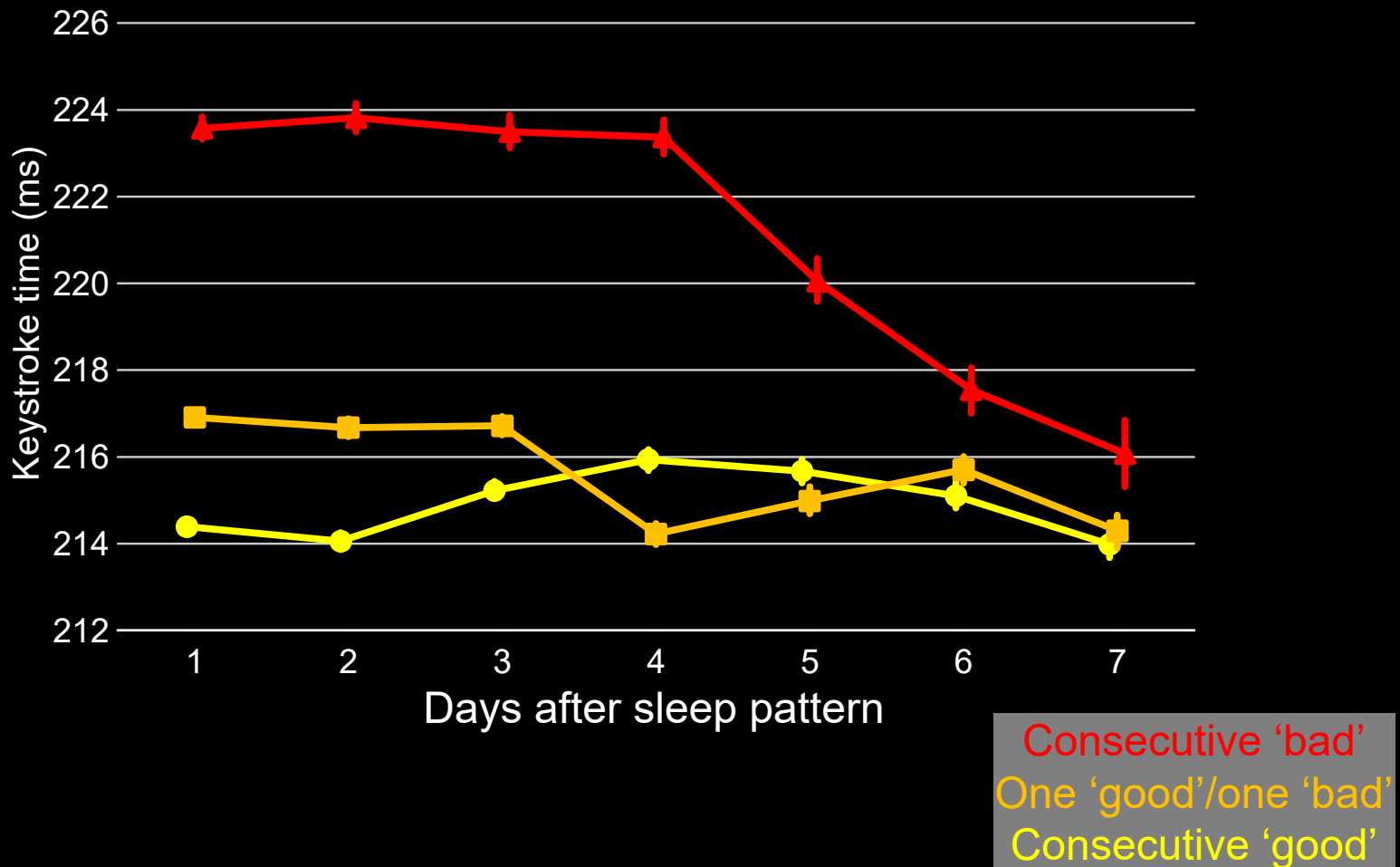


fa ← $\Delta t(\text{"c"}) = 237\text{ms}$
fac ← $\Delta t(\text{"e"}) = 219\text{ms}$
face ←
...

Moving Away from the Laboratory – Example: search engine metadata



Moving Away from the Laboratory – Example: search engine metadata



Point 3: Small effect sizes can be potent at scale, but need to be studied appropriately

Summary

Point 1: Capacity vs. reality – often need more than light to engender changes in health and behavior

Point 2: Measure the endpoint of interest, not a proxy

Point 3: Small effect sizes can be potent at scale, but need to be studied appropriately