



Dynamic lighting for well-being in work places

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Lighting design

Visual aspects



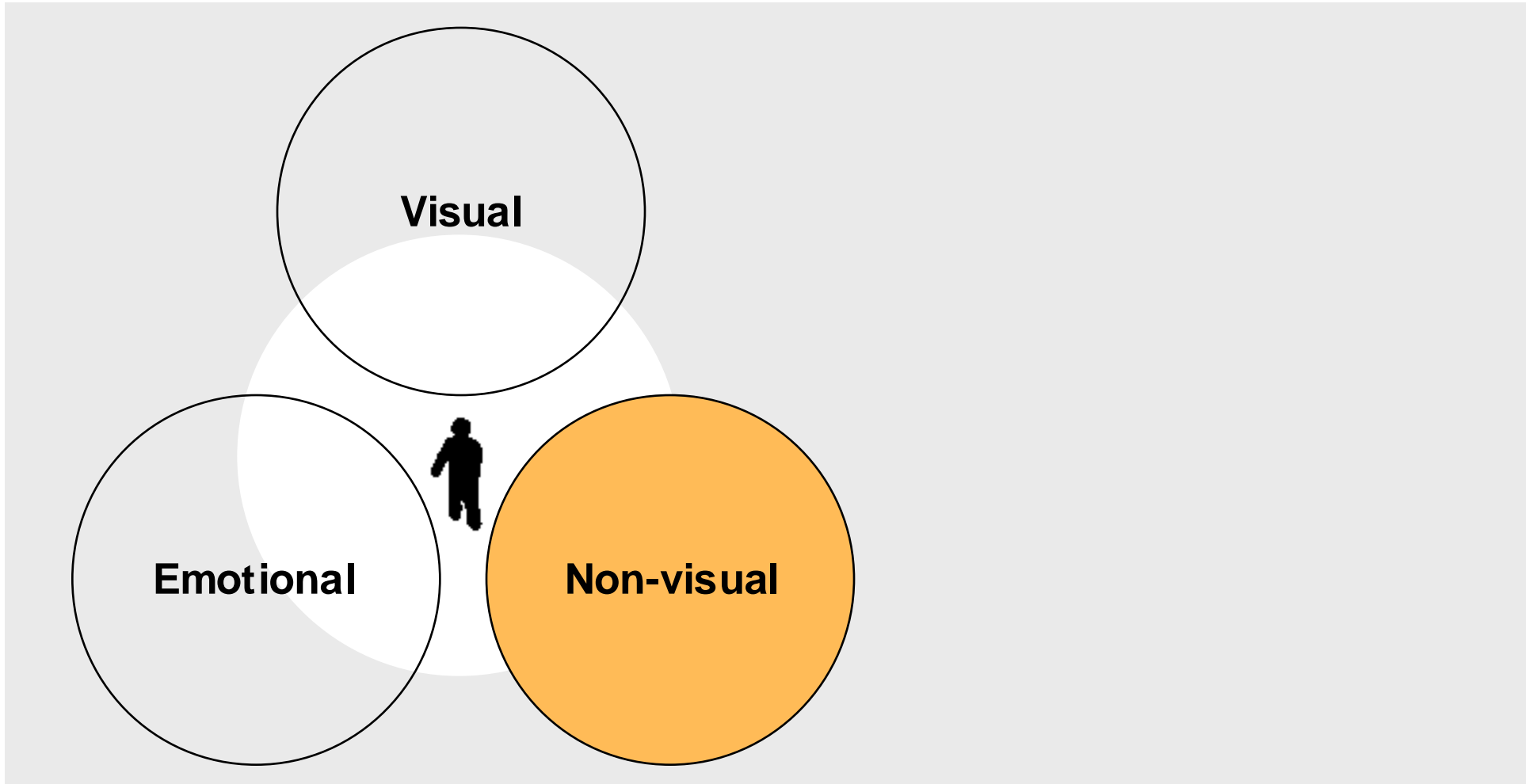
Lighting design

Emotional aspects



Lighting design

Light & well-being: all aspects



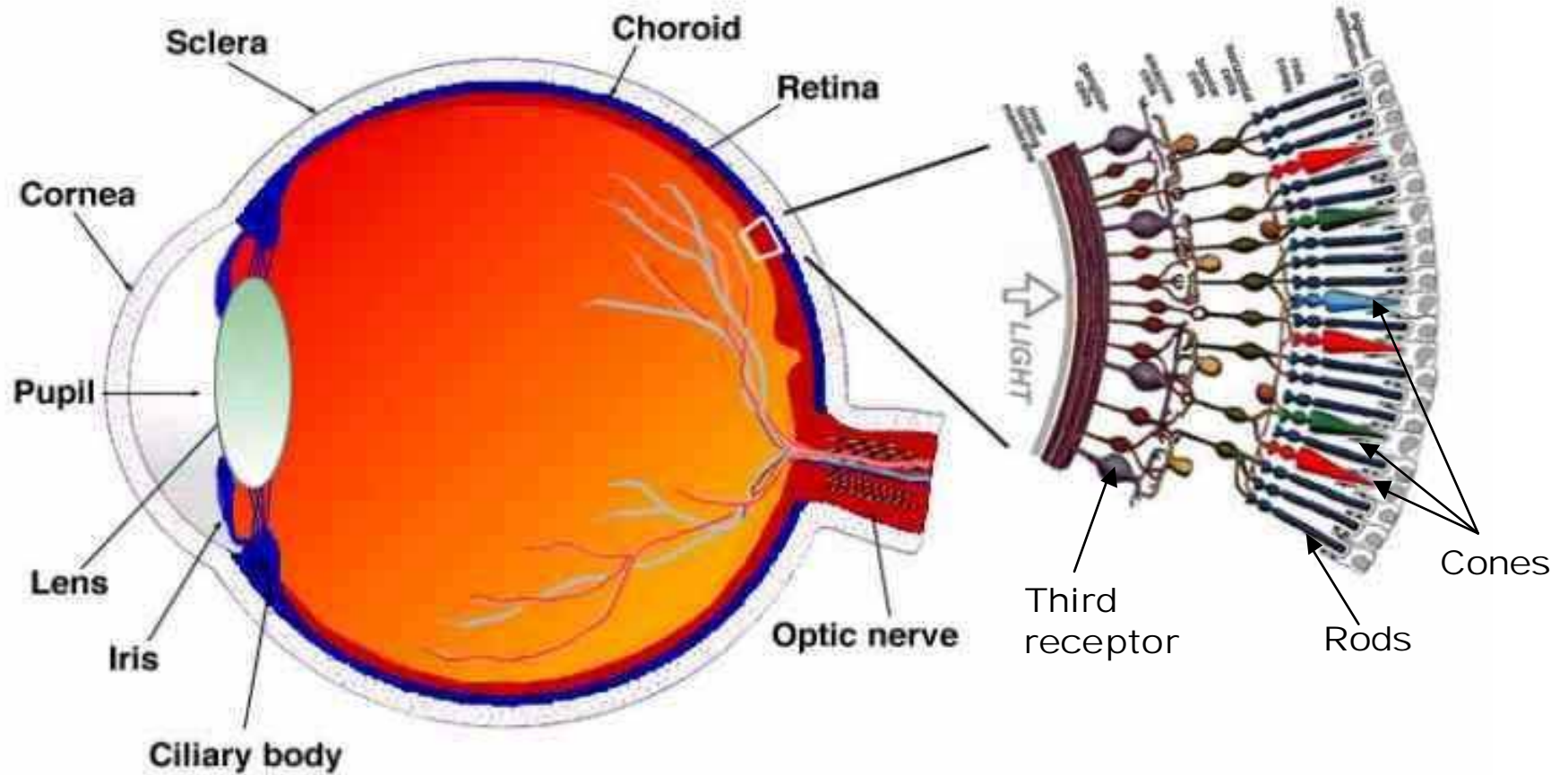
Lighting design

Non-visual aspects



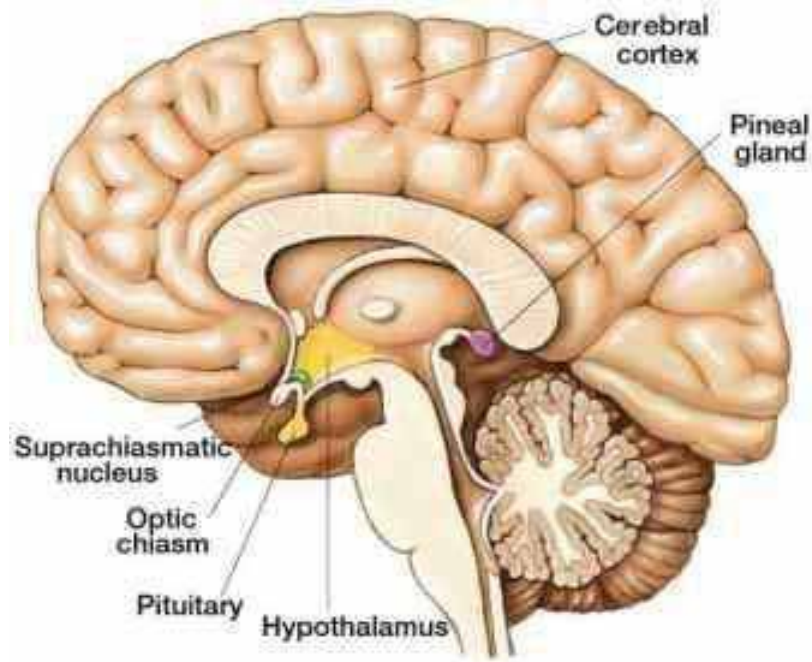
Non-visual aspects of light

Cross-section of a human eye



Non-visual aspects of light

Suprachiasmatic Nucleus (SCN)



The main body clock is in the brain in a little area called the Suprachiasmatic Nucleus

Light is the most powerful time cue for humans

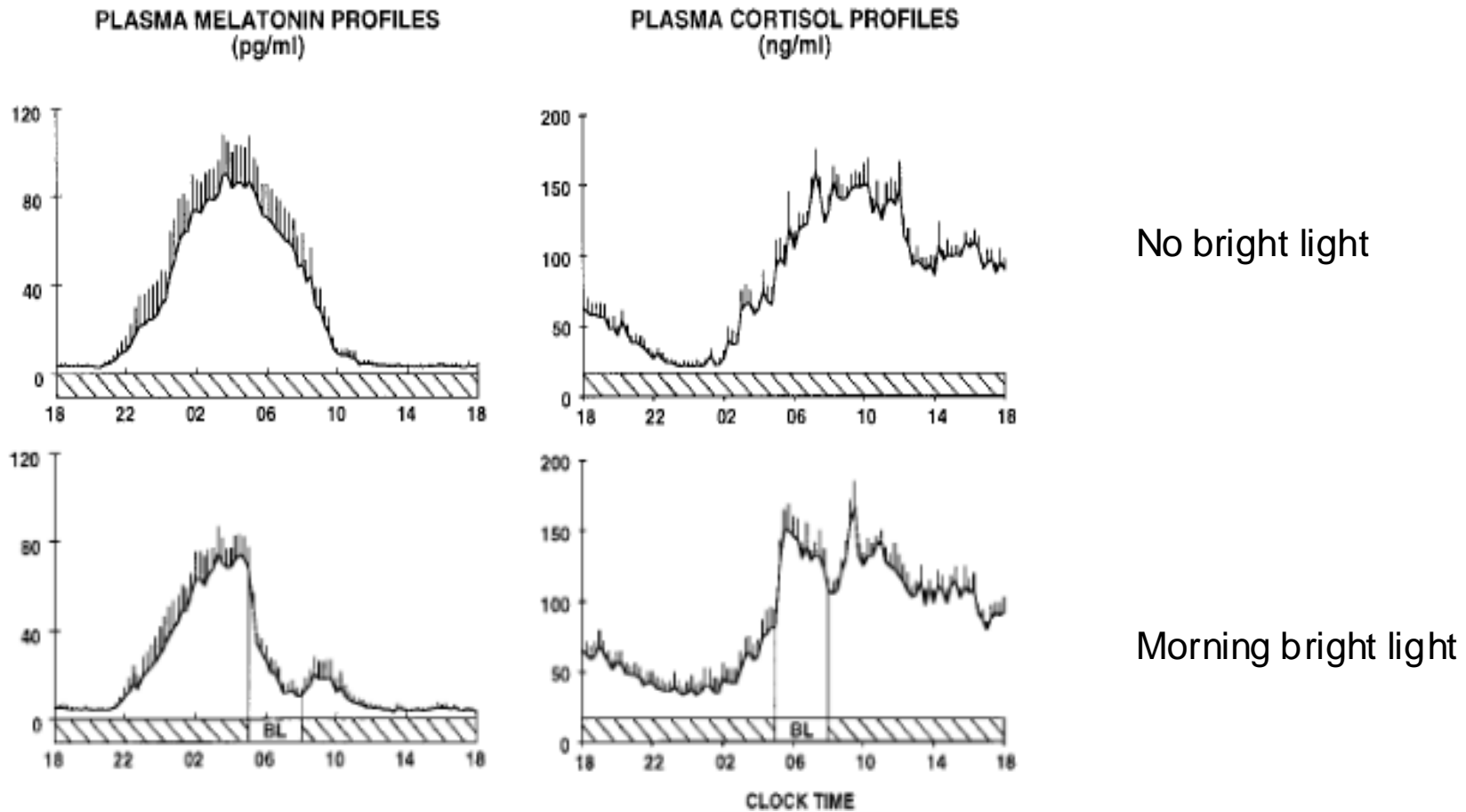
Effects of light

- Direct, non-circadian effects
- Circadian, phase shifting effects

Direct, non-circadian effects of light

- Light at night > suppression of melatonin, reduction of sleepiness
- Daytime bright light > reduce sleepiness and fatigue
- Bright light in the early morning > immediate increase of cortisol
- A temporary increase of light levels > raise vigilance
- Warm white light > relaxation
- Daylight-white light > stimulating

Bright light in the morning induces an immediate elevation of cortisol levels



Direct, non-circadian effects of light

Relaxation and stimulation

“Warm white light facilitates relaxation and improves people’s well-being while daylight-white stimulates and activates the human body”

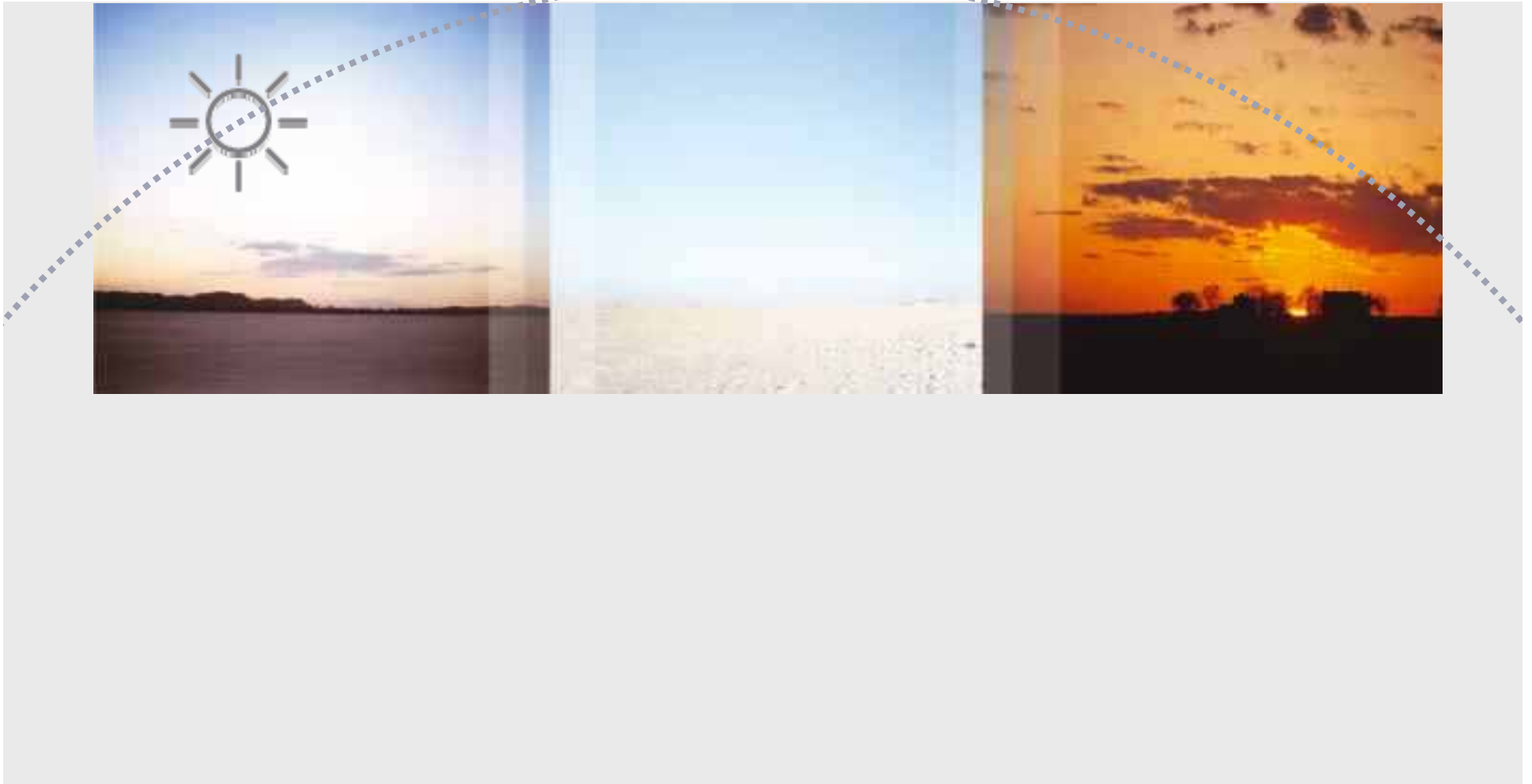


Light at work

Support the working people



Natural daylight changes in brightness and colour temperature ...

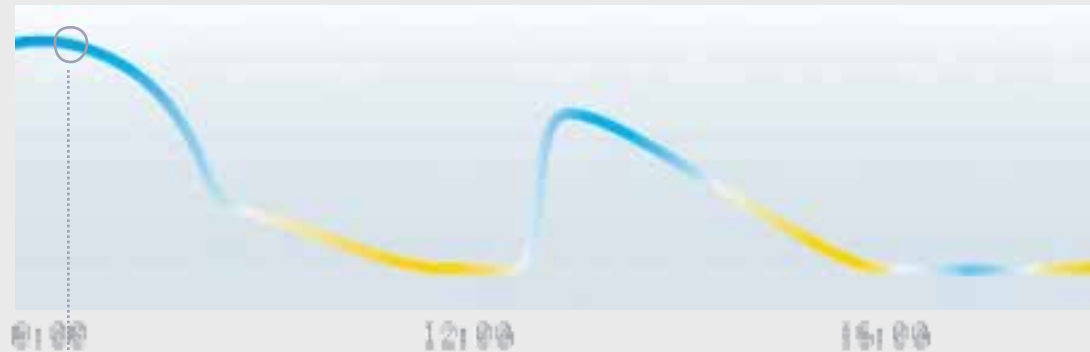


... and so does Dynamic Lighting



Improving well-being

A good start in the morning ...



- Cool white light (5000 K)
- Warm white light (3000 K)

- ↑ Lighting level
- ↓ (500 - 900 lux)



- Good morning:
- > cool light, increased lighting level
 - > raise the energy level
 - > provide a good start of the day

Improving well-being ... have a break ...



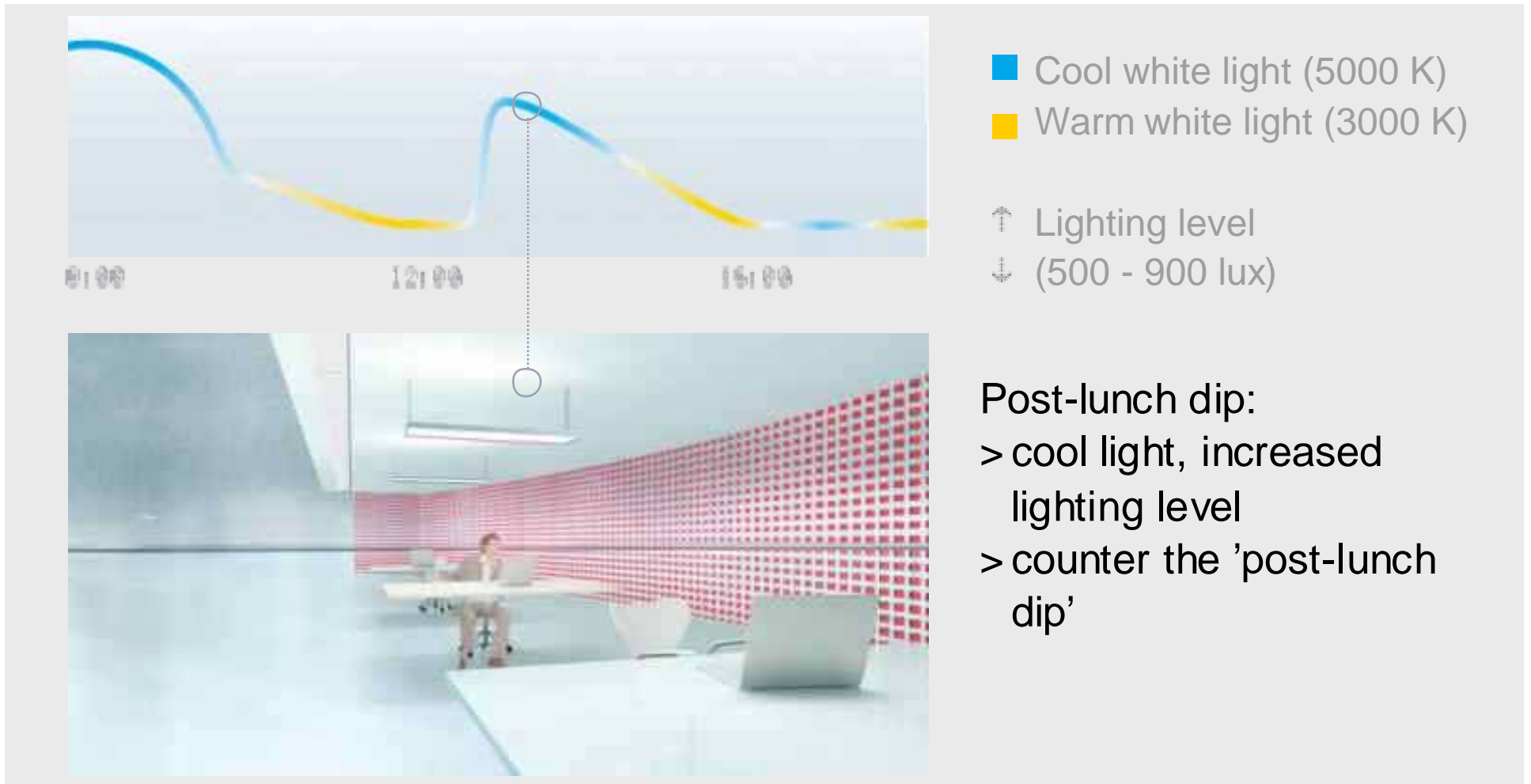
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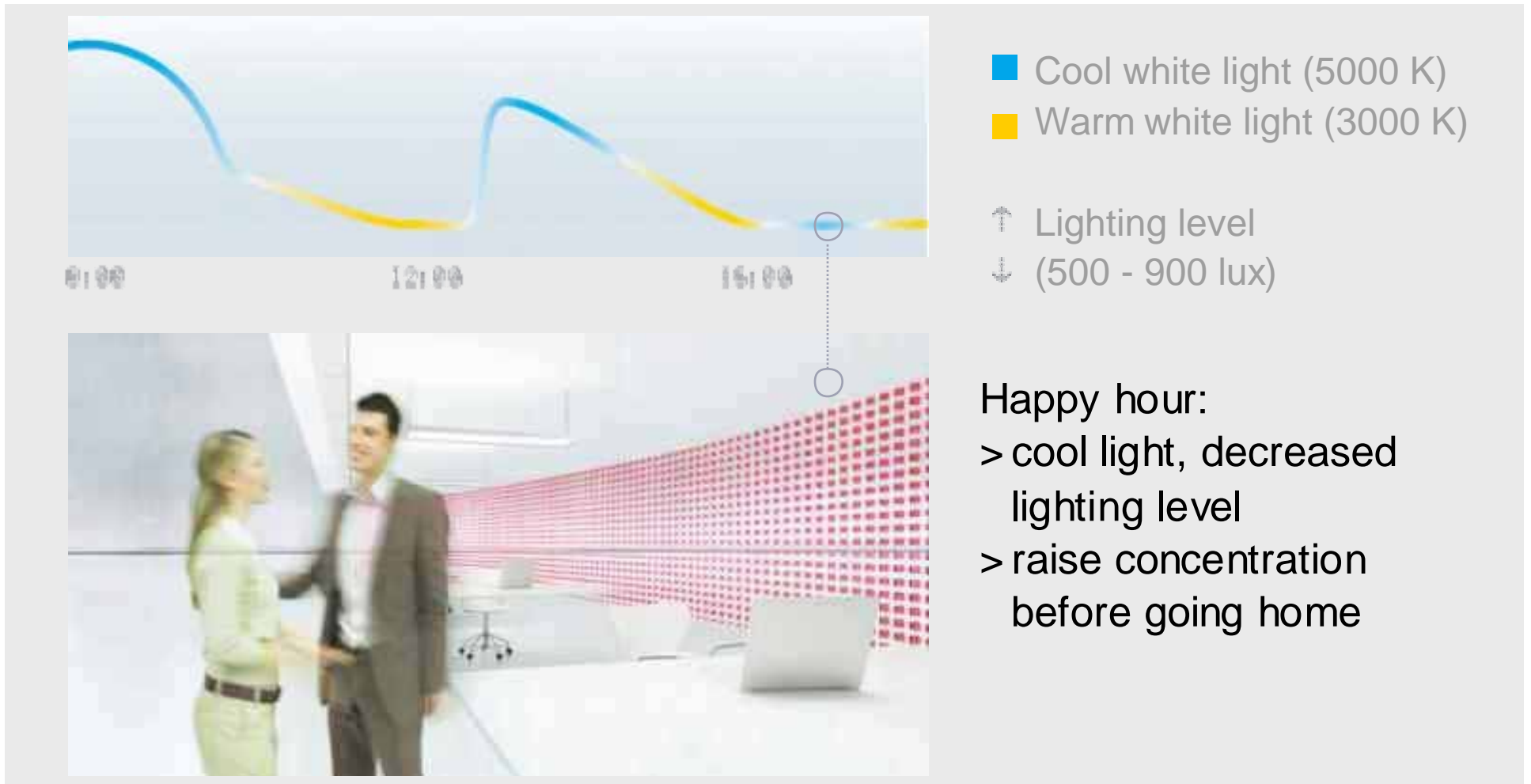
Lunch time:

- > warm light, decreased lighting level
- > time to recharge batteries

Improving well-being ... get over the 'post-lunch dip' ...



Improving well-being ... get home safely and refresh.



Colour mixing with white fluorescent lamps



Project Greenend Primary School, Manchester



Project Greenend Primary School, Manchester



Project Greenend Primary School, Manchester



Project

Greenend Primary School, Manchester



Summary

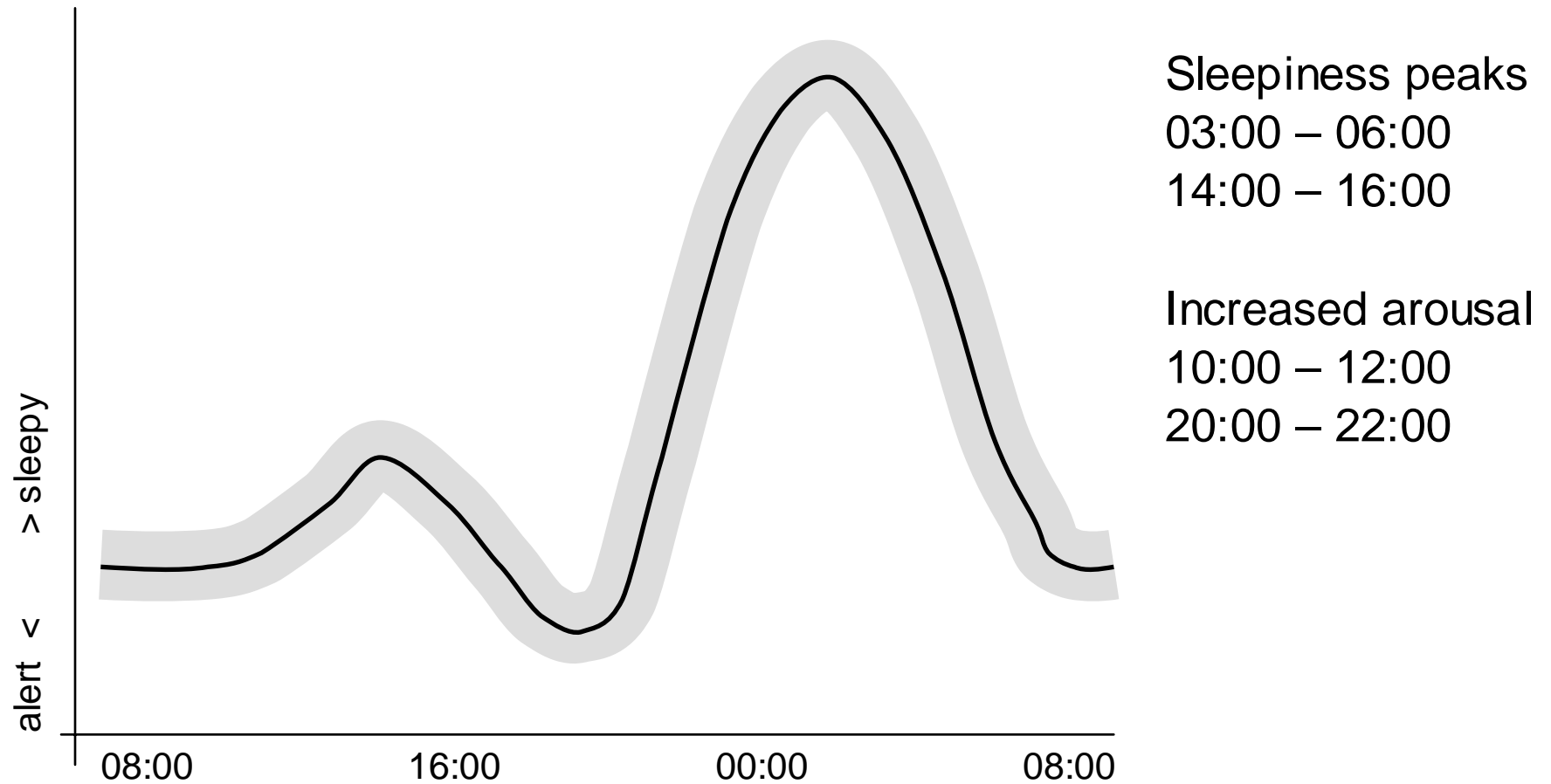
Direct effects of lighting

Lighting, dynamic in
color temperature and level

can be used to increase

- alertness and relaxation, and with that
- motivation and well being

Alertness at night



Night shift Problem

Lower alertness,
higher risk of accidents

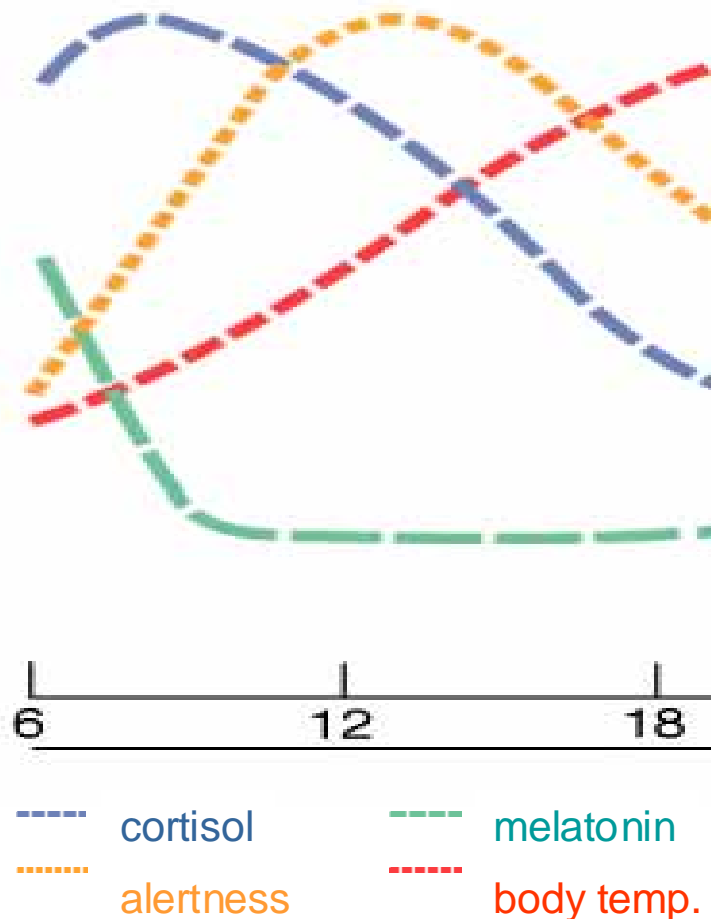
- Three Mile Island (1979)
- Chernobyl (1986)
- chemical accident in Bhopal (1984)
- Exxon Valdez (1989)
- Titanic hitting the iceberg

Night shift Problem

- High incidence of drowsy-driving accidents
- Increased risk of developing colorectal cancer
- Increased risk of infertility, cardiovascular illness, diabetes and gastrointestinal disorders
- Increased social difficulties

Night shift

Normal behavior after night shift



- driving home around 6 a.m.
body temperature rises
- straight to bed
body temperatures keep rising
- peak around noon to 1 p.m.
person typically wakes up
- between 2 p.m. to 5 p.m.
body temperature dips slightly
good time to sleep

Night shift Sleep

Night workers are forced to sleep during the day, when their circadian rhythm makes them feel more awake

- day sleep is usually shorter
- day sleep also is lighter
- rotating shift workers sleep the least of all

Night shift ... and other side effects

- to stay awake during shift:
use of coffee and other stimulants
- when shift is over:
problems to fall asleep
- need to drink alcohol or take
sleeping pills

Night shift Phase shift

Without additional means it takes

- 15 nights before core body temperature has adapted to night shifts (Monk et al. 1978)
- 24 hours to reset circadian rhythm of all organ systems by 1 hour (Jian M. Ding)

With means to entrain circadian rhythms, phase shifts of about 6 h can be realized (Eastman 1991)

Night shift Solution?

Resetting internal circadian timing system

- imposed work / sleep schedules
- light therapy

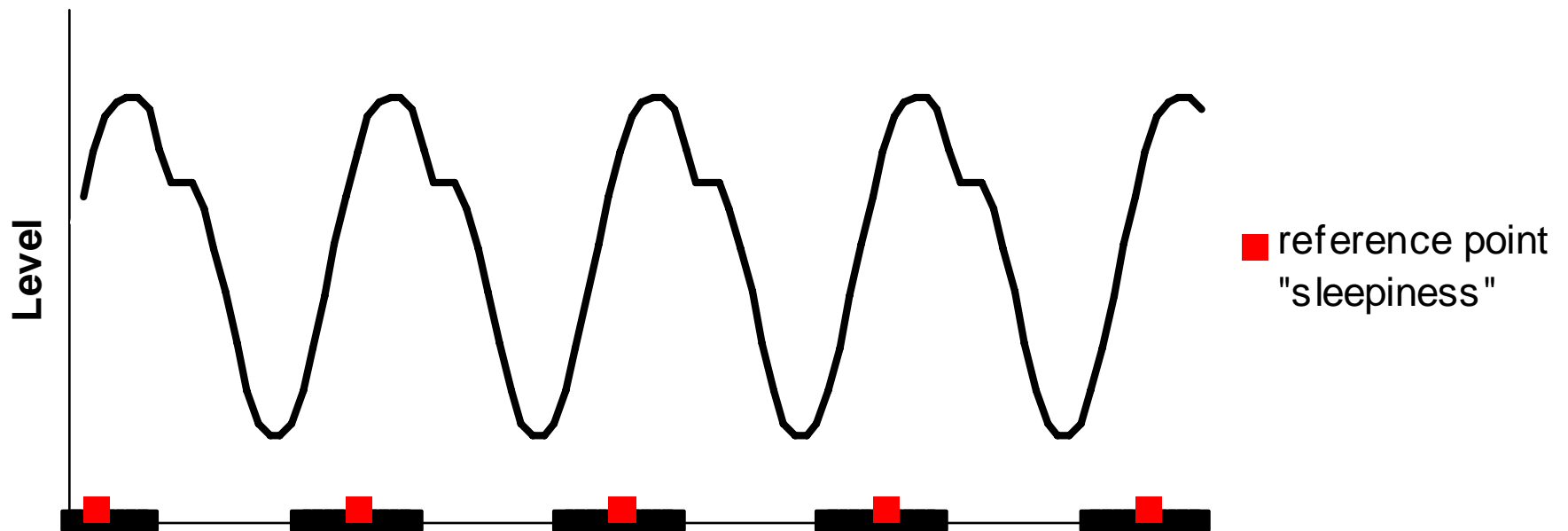
Demonstrated benefits:

- better performance
- longer and more restorative sleep

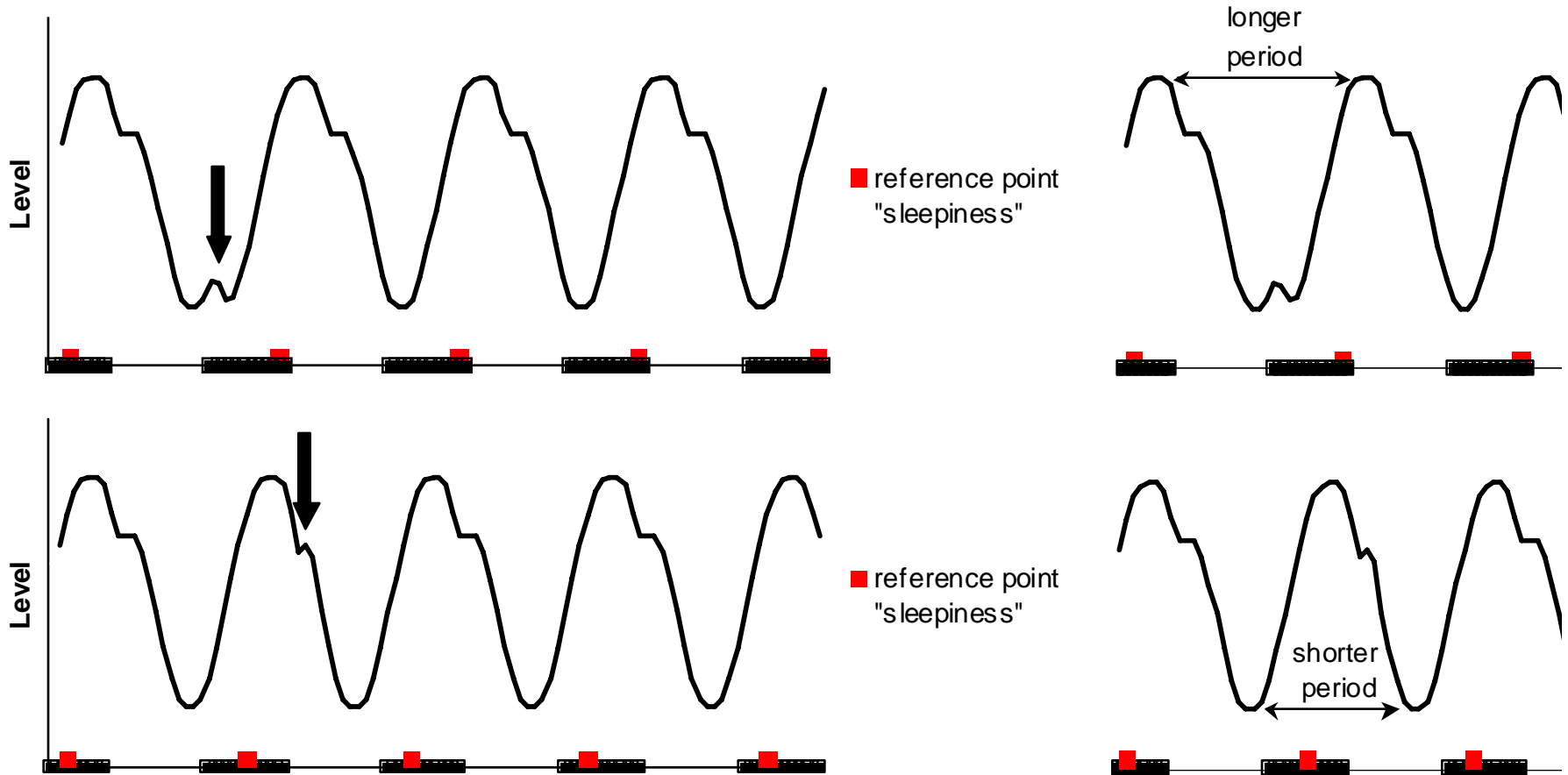
Phase shift principles

- In laboratory research, people exposed to a few hours of **bright light** in the **morning** felt **alert** earlier in the **day**.
They also felt **sleepier earlier** in the night.
- People exposed to **bright light** late in the **afternoon** felt most **alert** in late **evening**.
Their low-point in alertness during the night also was delayed.

Phase shift principles

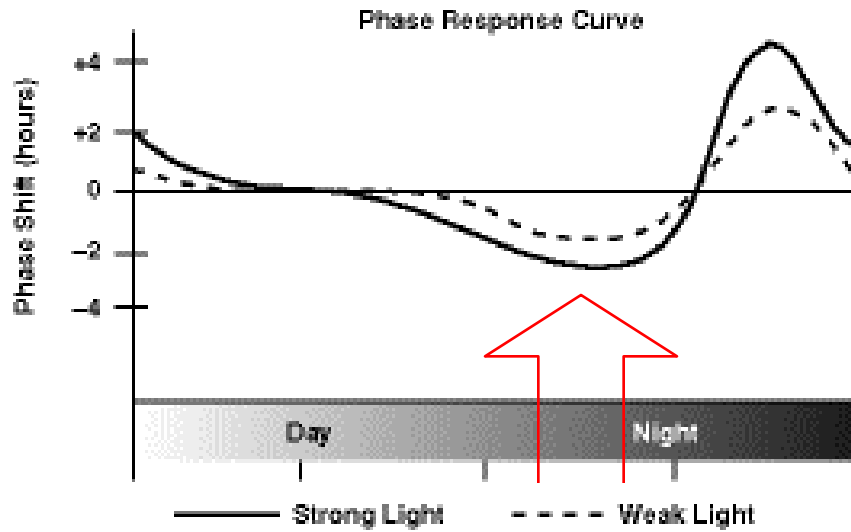


Phase shift principles



Light at night

Phase shift: advance & delay



advance region:
morning light
sleepiness earlier

delay region:
evening light
sleepiness later

Night shift Parameters

- timing
- light doses
- spectral distribution
- spatial light distribution
- phase delay
- phase advance
- intensity
- duration
- melatonin suppression
maximum around 460 nm
- type III ganglion cells melanopsin
absorption maximum between 440-460 nm
- sensitivity of the retina

Night shift

Proposal light therapy – shift start

- 30-minute light burst before shift
- 15 minutes of light every 2 – 3 hours during shift
- wear sunglasses and avoid any bright light when going home

Within three days, the body clock will have shifted to a night shift schedule

Night shift

Proposal light therapy – shift end

- receive bright morning light
- use the light in the morning for approximately 30 – 45 minutes
- wait at least three hours before going to sleep

Projects

Jeroen Bosch hospital



Projects

Rhoon & Palace 't Loo



Night shift Problem areas

Constant exposure to conflicting light signals will weaken the circadian rhythm system and cause fatigue

Night shift

Application challenges

- Shift workers in areas where other people need to sleep (hospitals, care homes)

Task lighting, not interfering with circadian rhythms of people not involved in the task

- Rapidly rotating night shifts
- Single nights of work

Light that increases alertness during the night, but does not phase shift

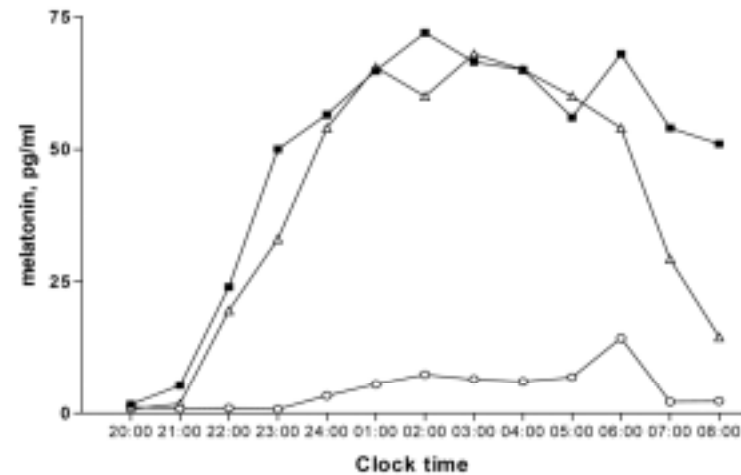
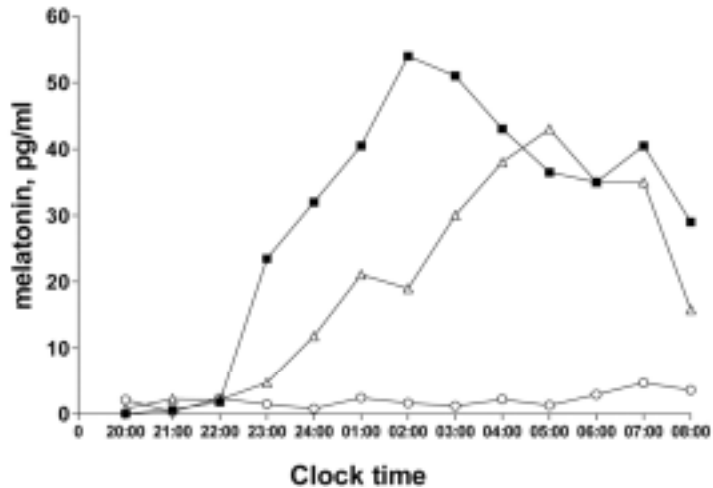
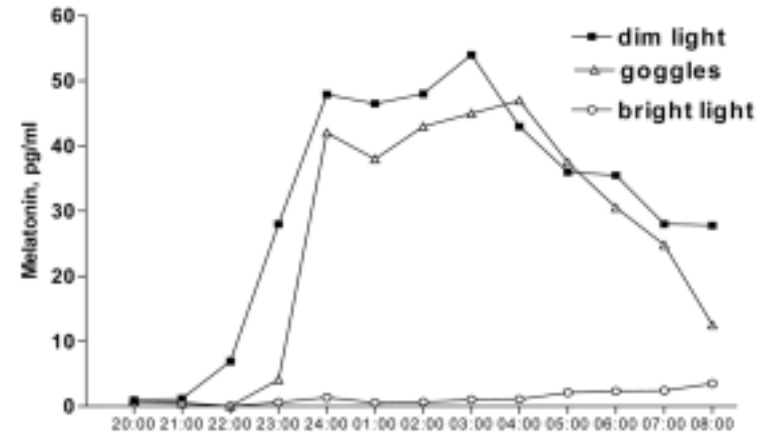
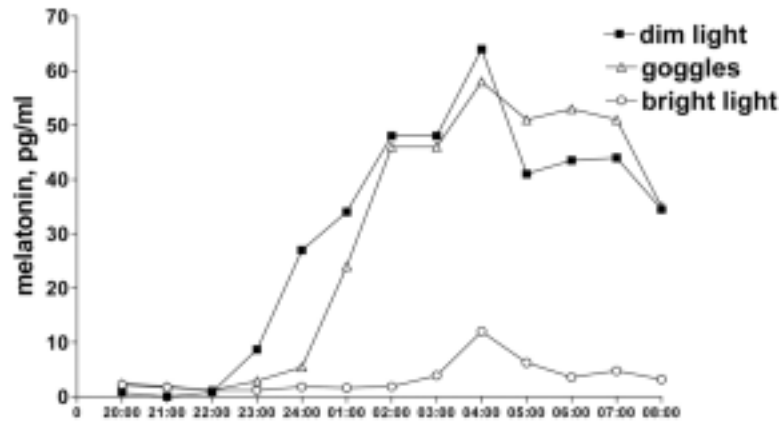
Night shift



Light, without biological effect =
Low effective in NIF
(non-image forming) effects

Light at night

Blue deficient light



Light at night

Blue deficient light

There were no significant differences in performance

between the nights under different conditions:

- bright light (800 lux)
- goggles letting through 800 lux, wavelength > 530 nm
(Kayumov et al.)

Summary

Phase shifting effects of lighting

Lighting, dynamic in **color**
temperature and **level** at night,
darkness during the day

can be used to **adapt**
the circadian rhythm to conditions
that are not synchronous with it

If phase shifting is not required
wavelength of the light needs to
be taken into consideration

Summary

Implementation of current results of research on biological effects of light

- (circadian) phase shifting effects
- (non-circadian) direct effects.

- adapt the circadian rhythm to conditions that are not synchronous with it
- to increase alertness and reduce sleepiness, during day- and nighttime

Dynamic lighting for well-being in work places



