Circadian Modulation of Photoreception: A Study Protocol

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BACKGROUND

Regular changes in our physiology, behavior and cognition are partially caused by **regular behaviour** (e.g. activity, metabolism, sleep) and the endogenous **circadian rhythm** (Broussard, et al. 2017).

The circadian rhythm is **stable yet flexible** — it can adapt to the external light-dark-cycle **in response to light signals**, *i.e.* visual signals are an important signal for the circadian pacemaker (Blume et al., 2019).

Evidence points to time-of-day variations in the visual system. Candidate sites of circadian modulation are retina cells that receive, combine and process light signals — particularly, **cones** and the **intrinsically photosensitive retinal ganglion cells** (de Andrade, et al. 2018).

Does the circadian system affect photoreceptor function? To investigate this question, different parts of visual processing — **from light incidence to neural processing** need to be considered.

HYPOTHESES

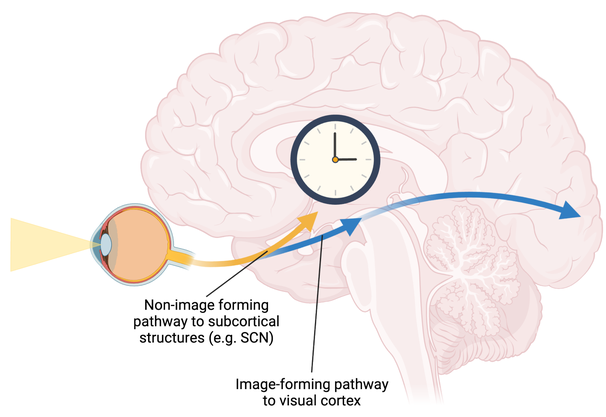


Image-forming pathway to V1 mediates visual perception; non-image forming tracts mediate visual functions such as pupillary light response, circadian effects, etc.

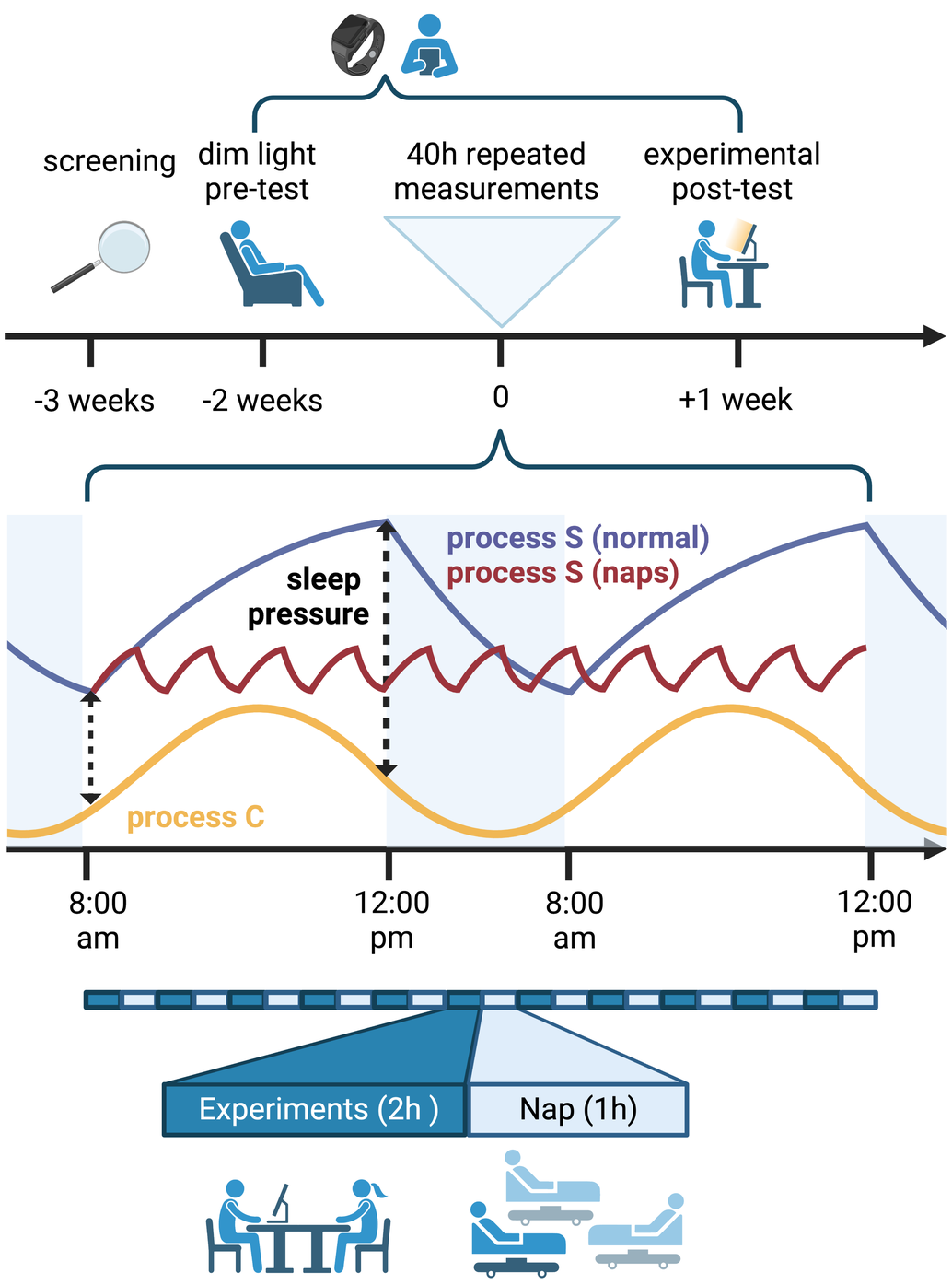
1. **Chromatic & achromatic contrast sensitivity** show a circadian rhythmicity.
2. **Photoreceptor-specific pupillary light responses** show a circadian rhythmicity.
3. Circadian effects of **ipRGC-specific are stronger than the cone-specific** pupillary light responses.

Does our visual perception show time-of-day variations?

Which visual mechanisms are subject to circadian influences?

CONSTANT ROUTINE PROTOCOL

The effects of two **independent processes,** circadian rhythm and sleep homeostasis, need to be disentangled to isolate circadian modulation.



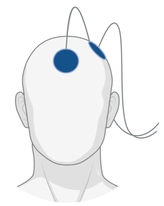
MAIN VARIABLES

Circadian phase

Melatonin secretion — Core body temperature

Melatonin onset & temperature → peripheral indicators of circadian phase

Homeostatic sleep drive



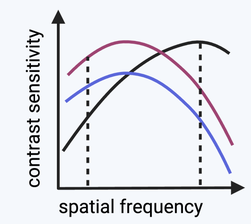
Monitor of EEG → sleep staging and sleepiness evaluation

Behavioral Influences

Questionnaires — Actigraphy

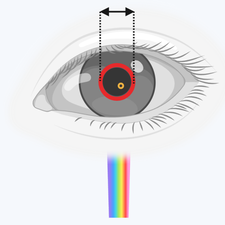
Activity, light exposure, sleep diary, chronotype → circadian stabilisation

Contrast sensitivity



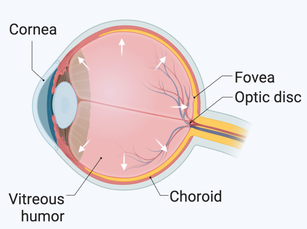
Chromatic & achromatic perception → sensitivity of post-receptoral mechanisms

Pupillary light response



Constriction in response to receptor-targeting stimulation → non-canonical photoreception

Ocular physiology



Cornea & macula thickness, choroid bloodflow → light incidence & retinal physiology

Independent variables: Circadian & homeostatic processes
Dependent variables: Photoreceptor sensitivity (& ocular physiology)

CONCLUSION

The detection of circadian influences on vision beyond homeostatic effects provide important indicators of **how the brain is tuned** to be more or less receptive towards **light as a circadian signals**.

Our findings will provide a empirical and methodological foundation for more extensive forced-desynchrony studies to **decouple both processes,** and **neuroimaging studies of non-image forming pathways**.

References
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