Modeling dynamic aspects of nonvisual responses to light

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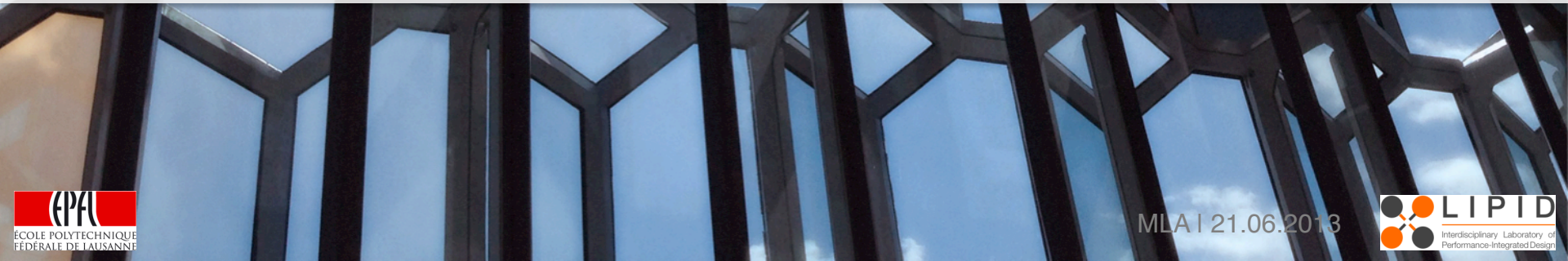
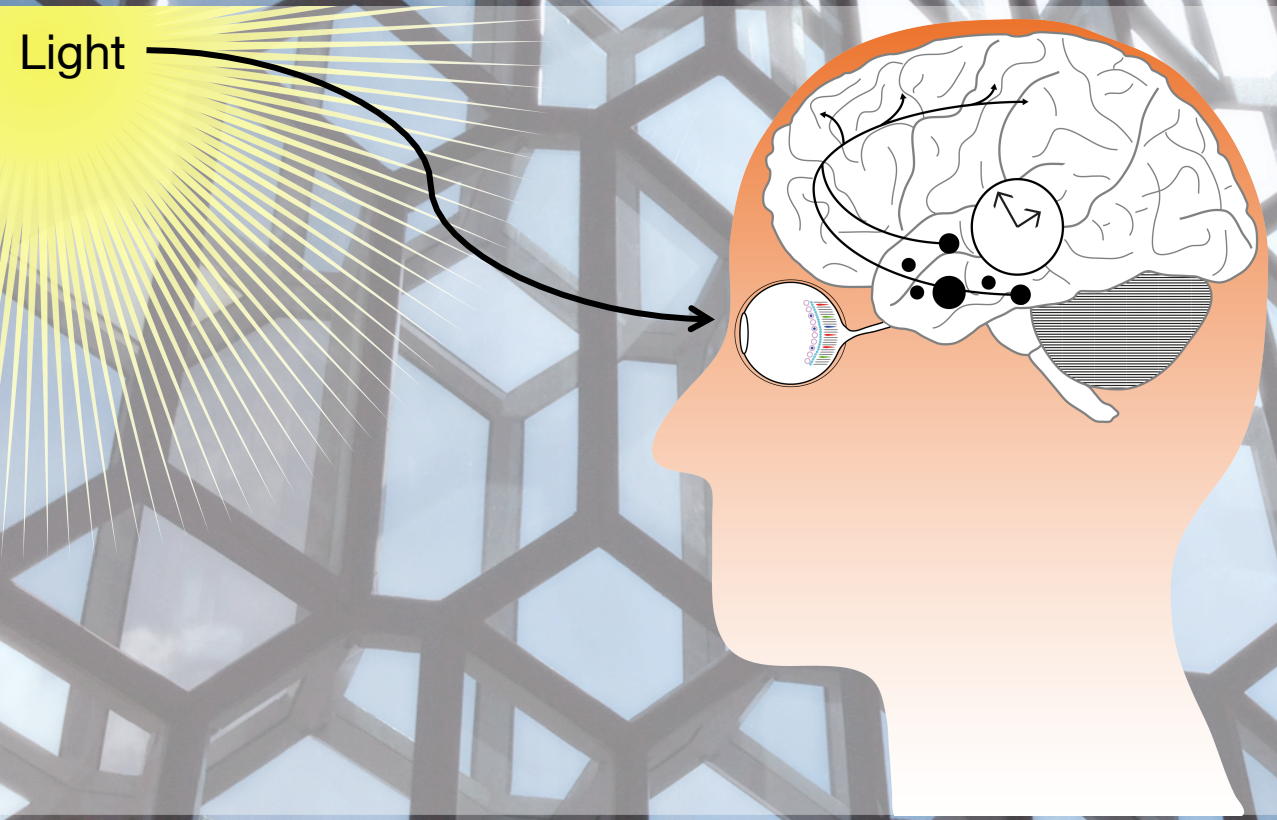
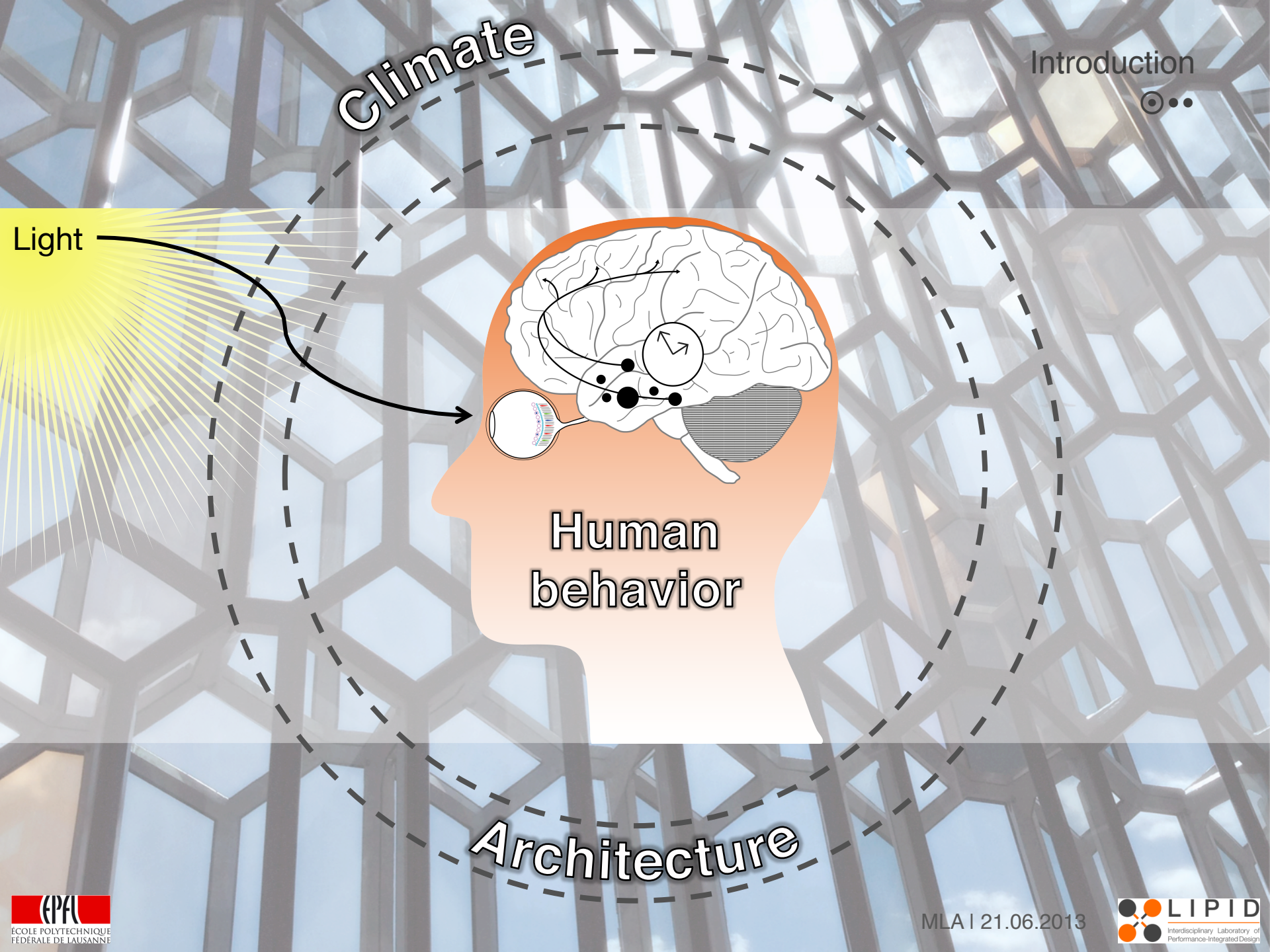
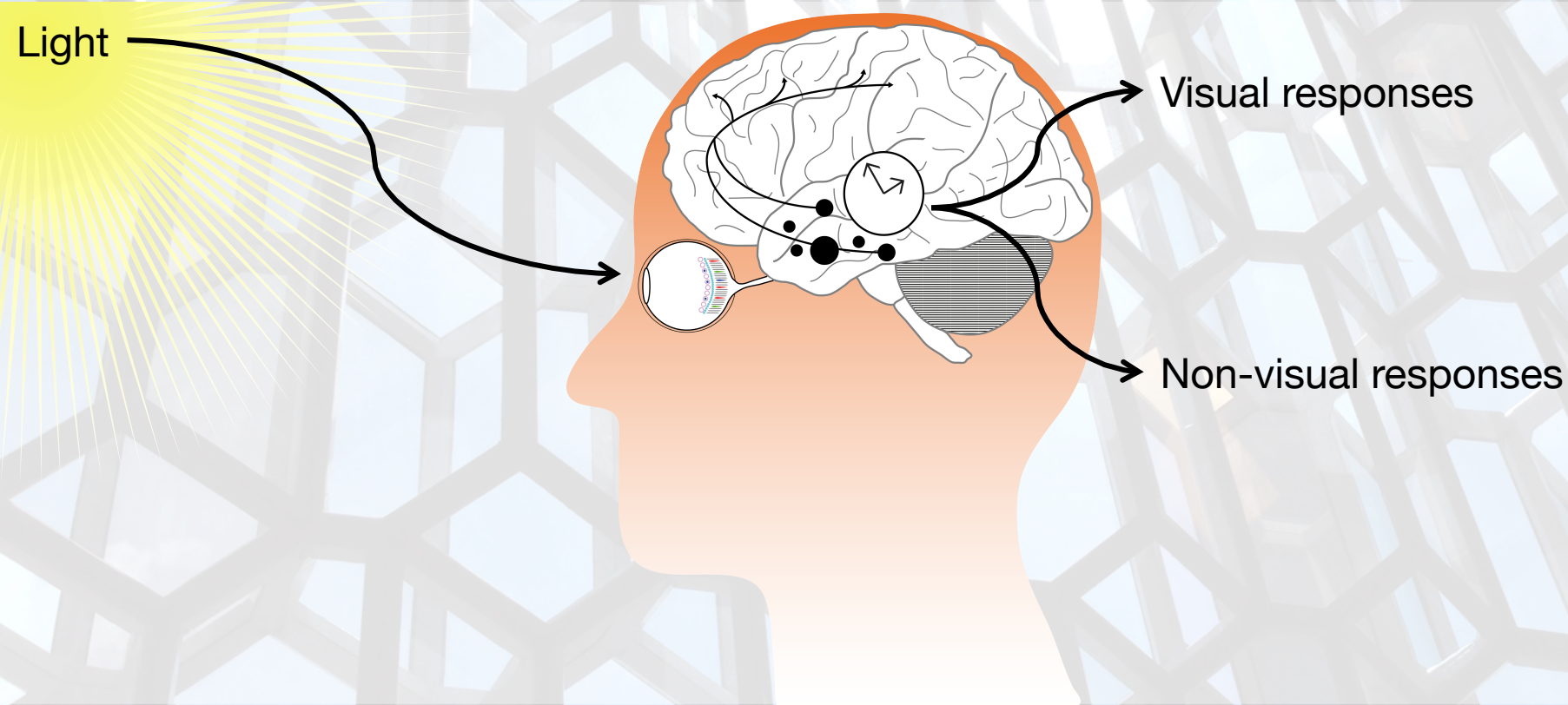



Light


Climate
Light
Human behavior
Architecture

The eye as a dual role



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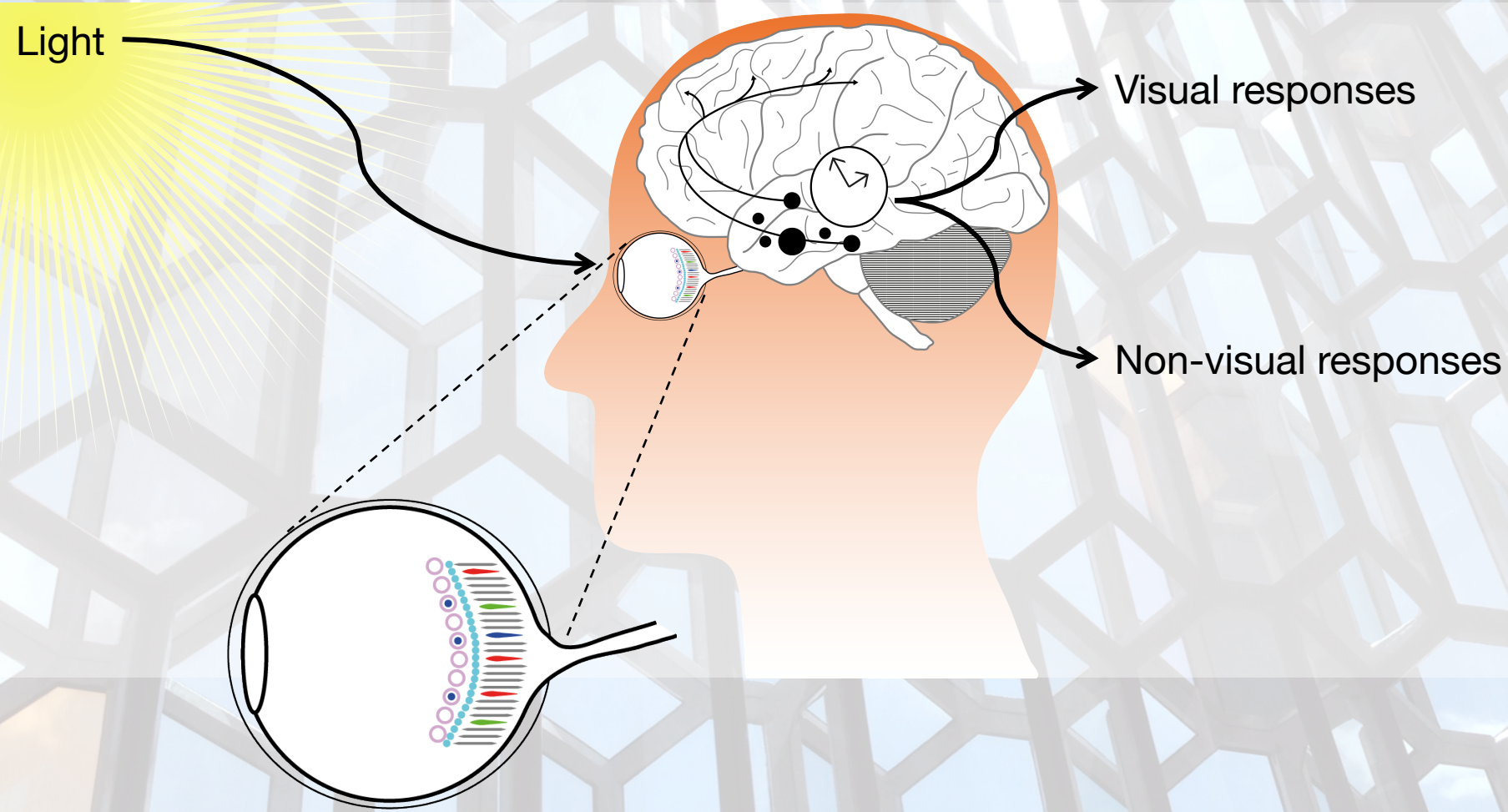

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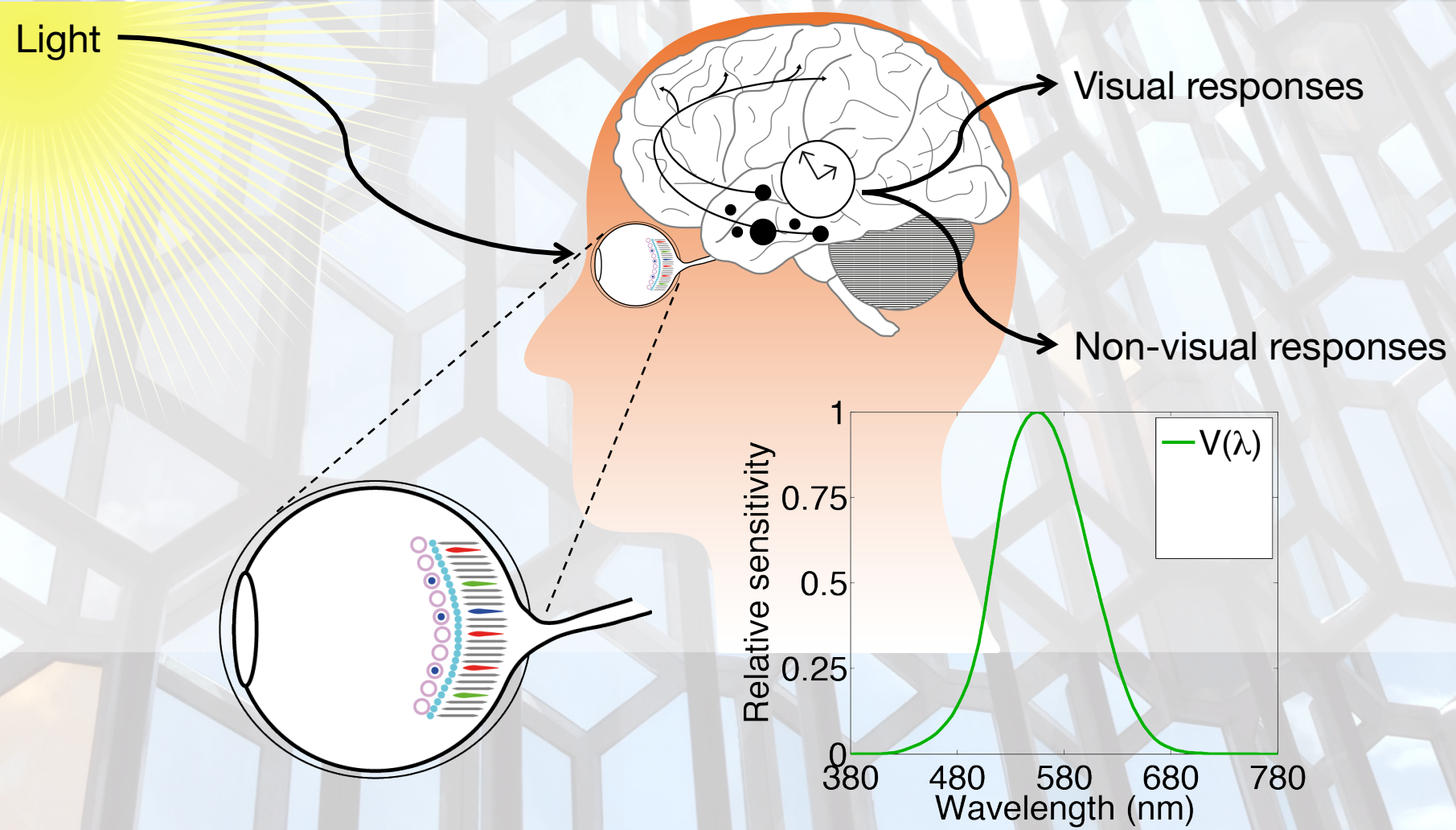

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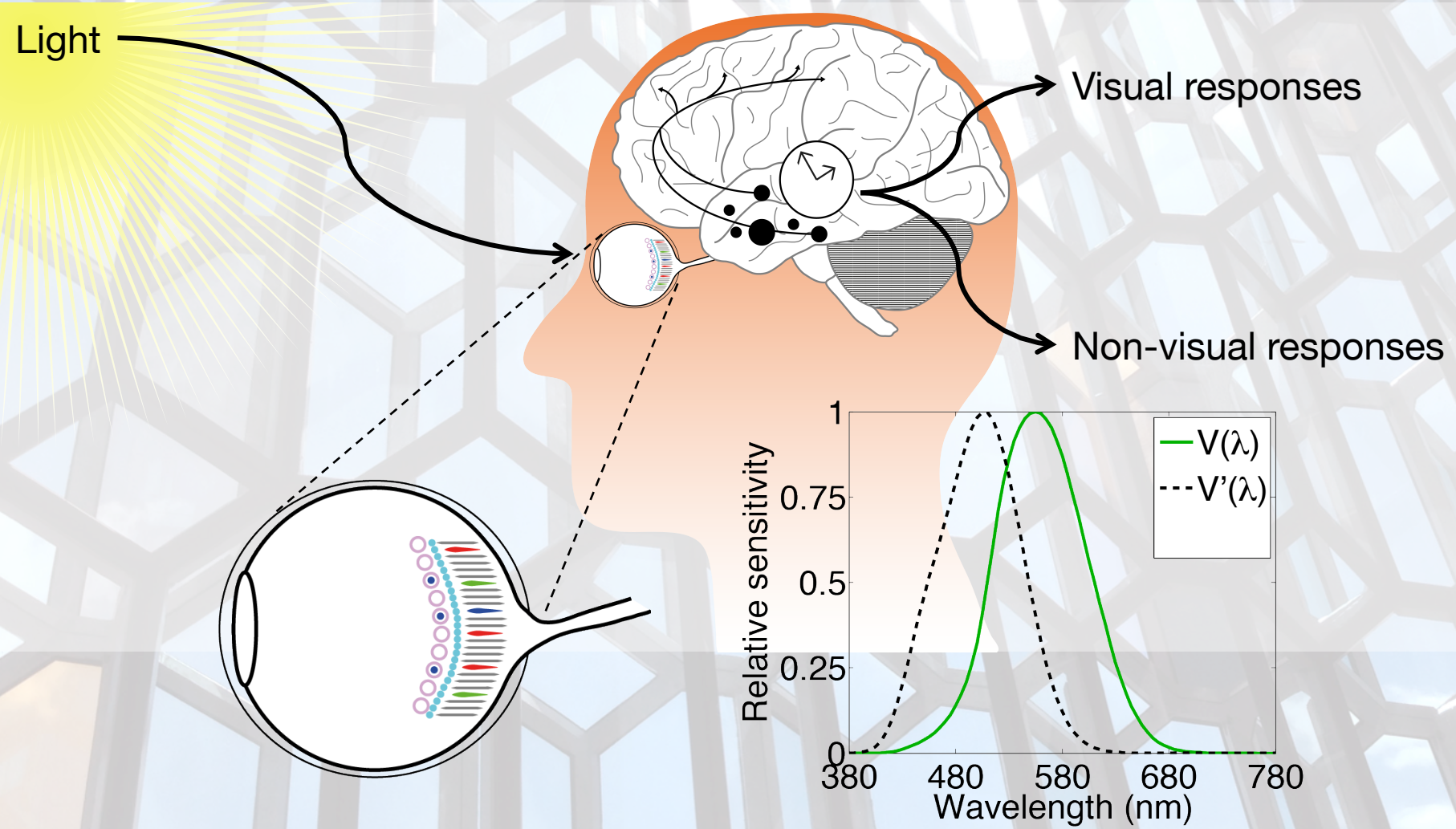

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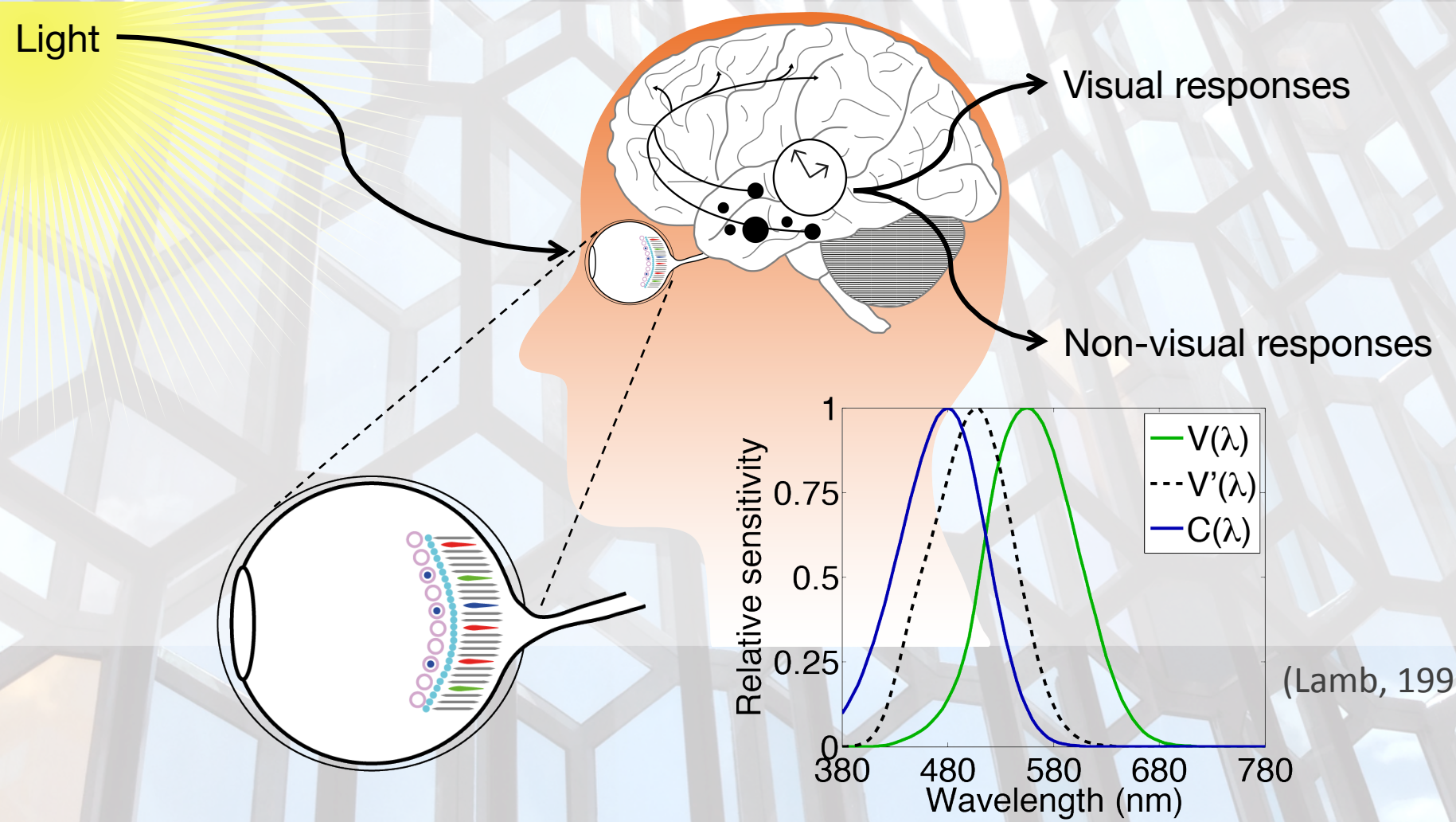
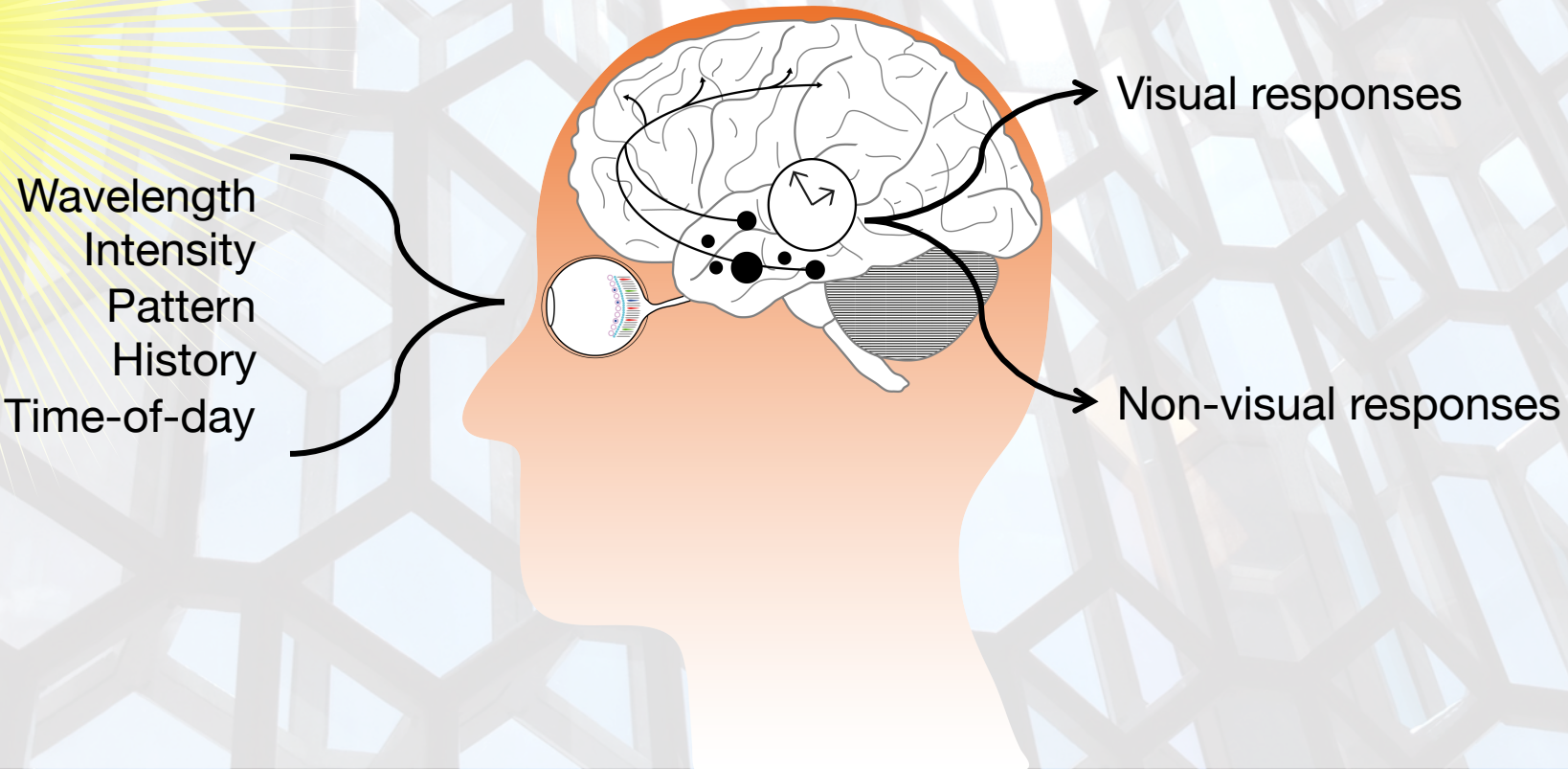


(Lamb, 1995)

Light properties

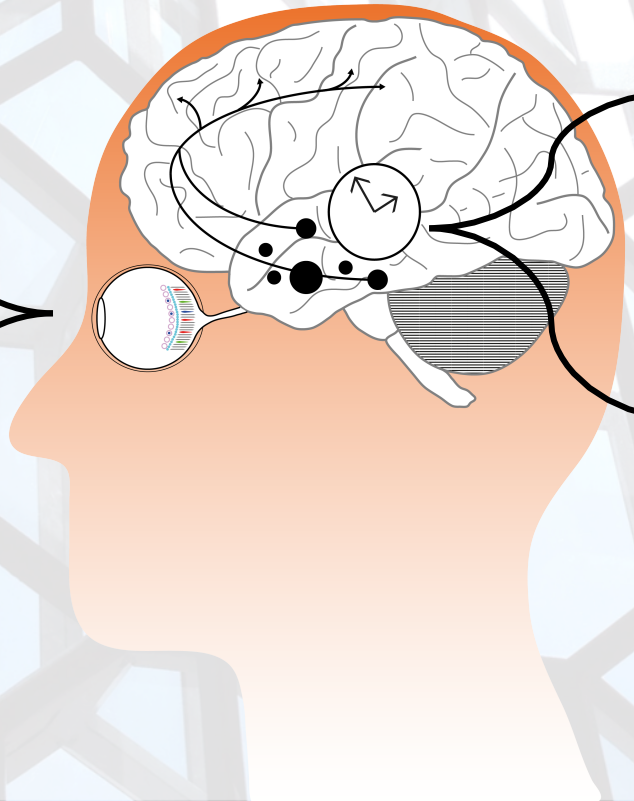
Light



Light properties

Light

Wavelength
Intensity
Pattern
History
Time-of-day

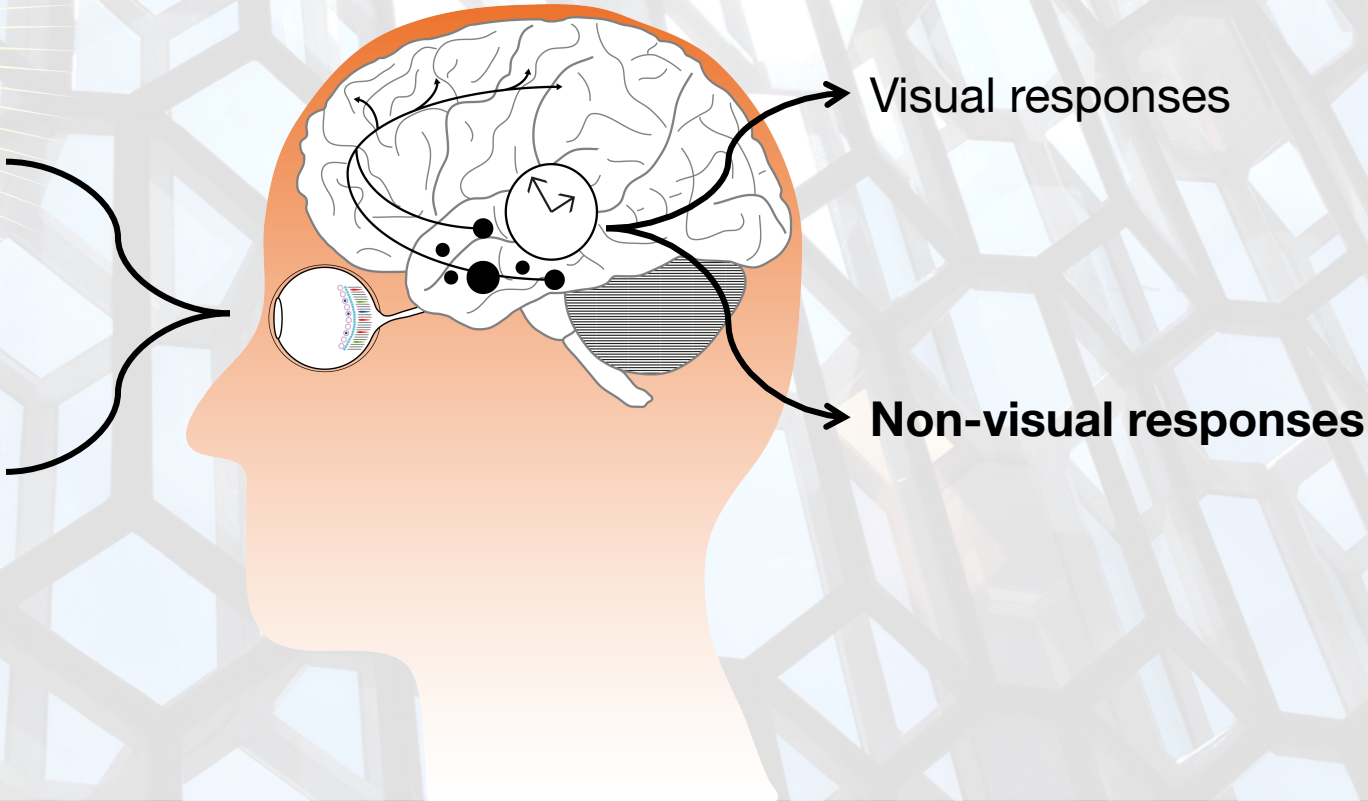


Visual responses

Non-visual responses

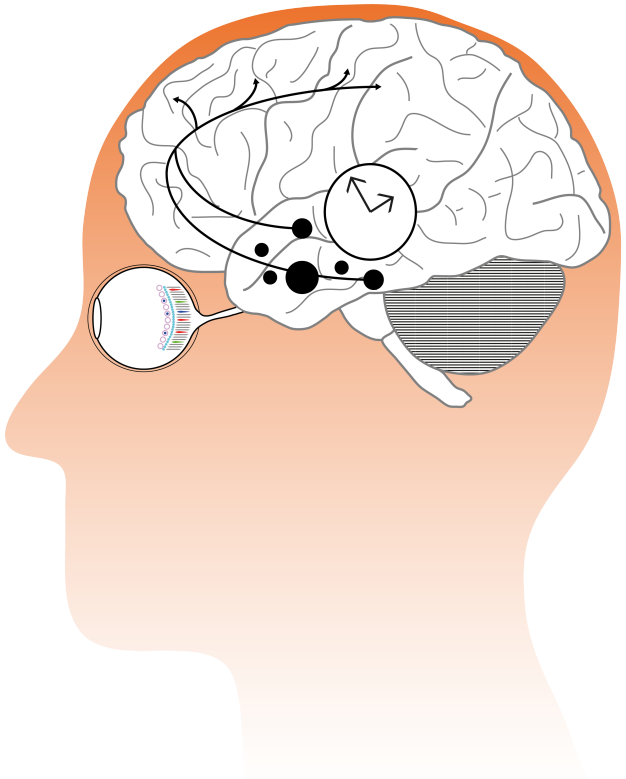
Light properties

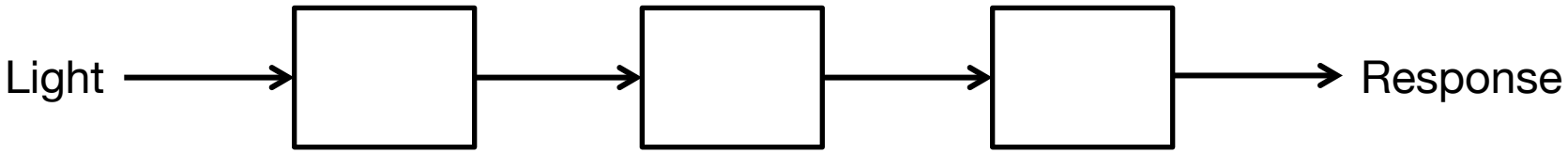
Light



Model structure

Represented by a sequence of blocks





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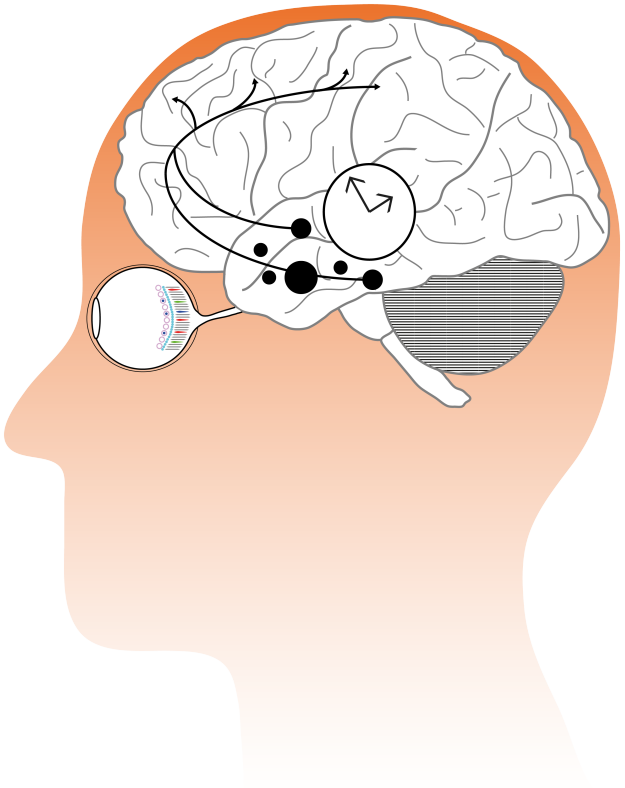
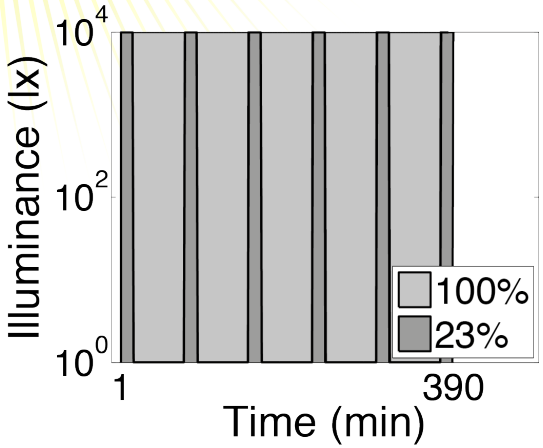
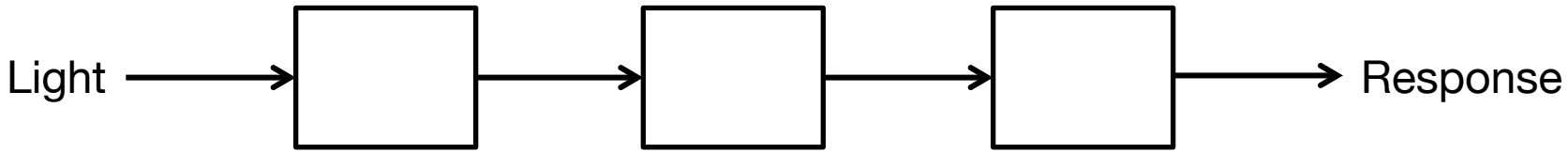






Experimental findings

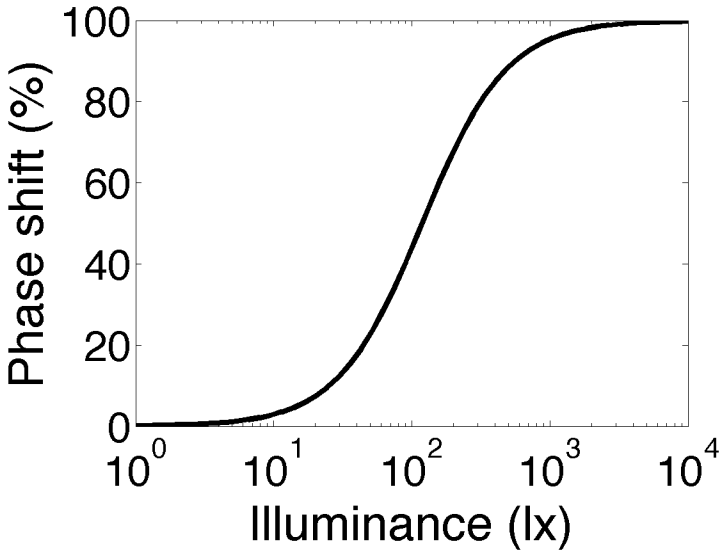
Intensity

Higher levels of light **intensity** are more effective than low

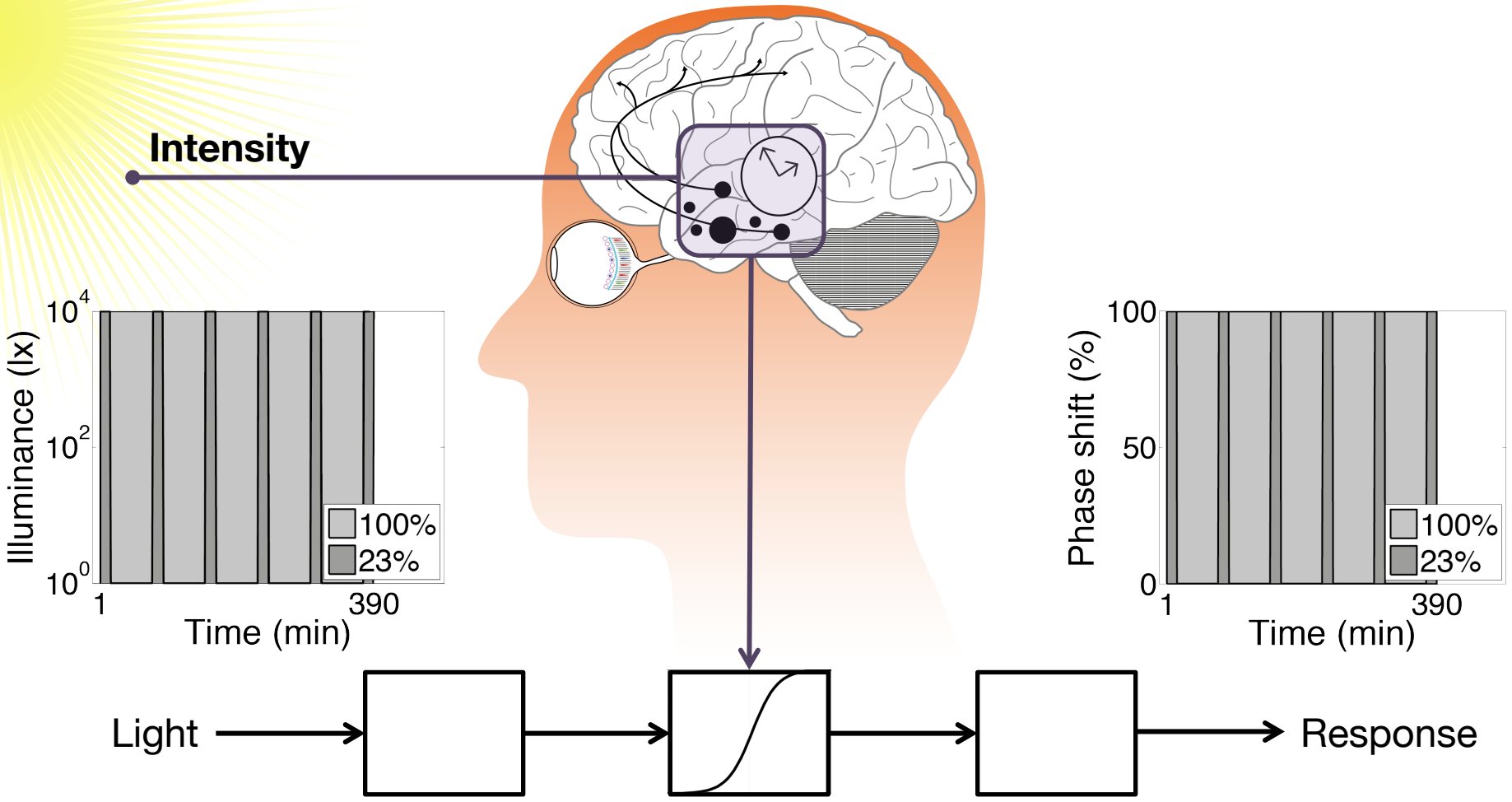
A nonlinear intensity-response curve

- Melatonin phase shifting
- Melatonin suppression
- Subjective alertness

(Zeitzer et al., 2000; Cajochen et al., 2000)



Model structure



Experimental findings

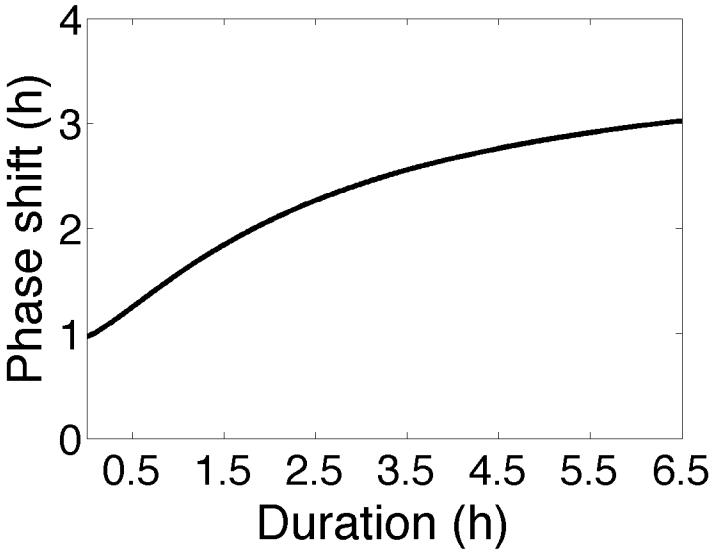
History

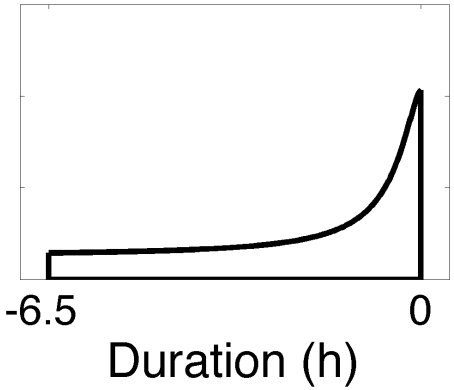
Comparison of brief bright light exposure:

- 12-min induced a 1-h phase shift
- 240-min induced a 2.7-h phase shift

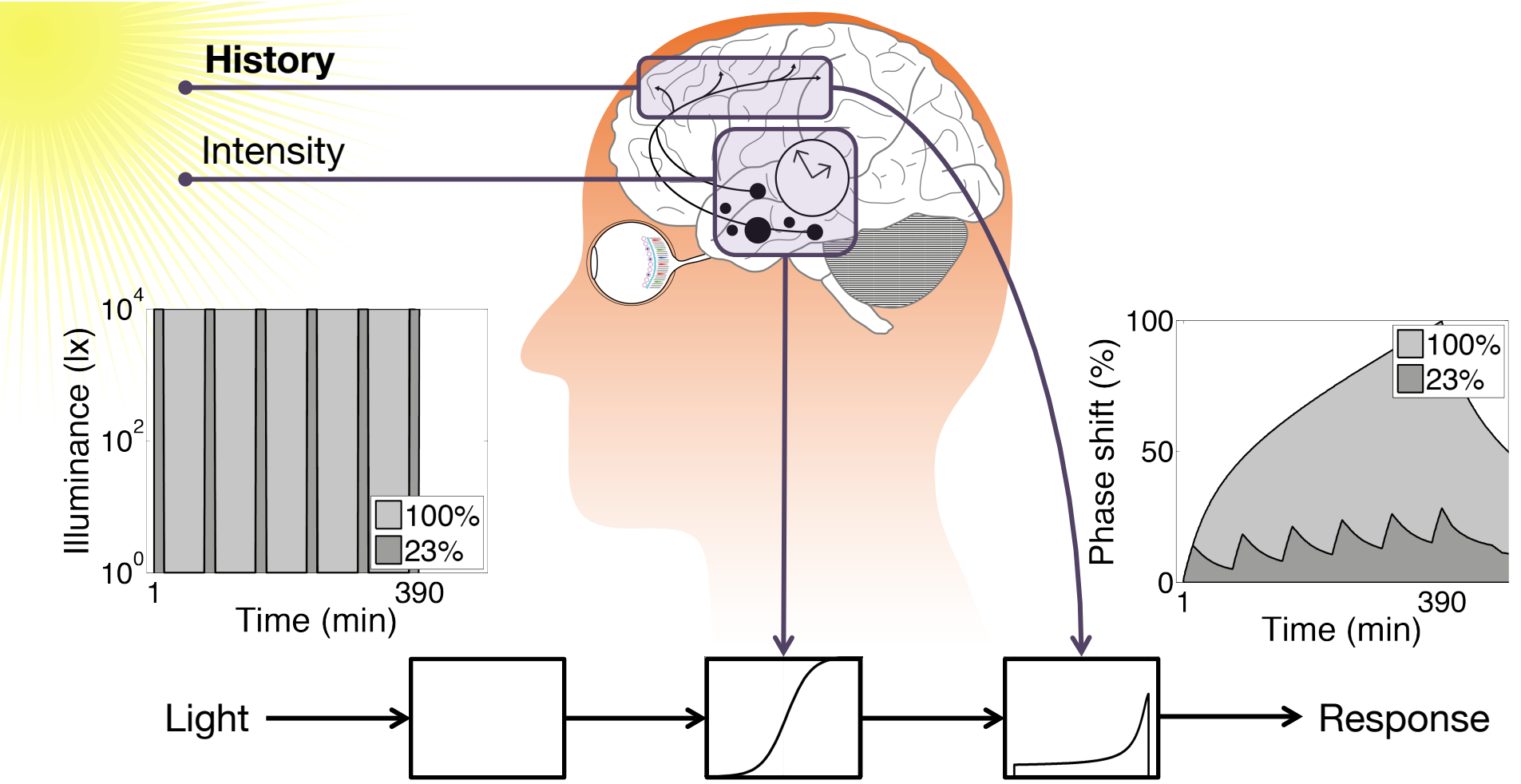
A linear filter was derived by taking the inverse of the duration-response curve with length set to 6.5 hours

(Chang et al., 2012)





Model structure



Experimental findings

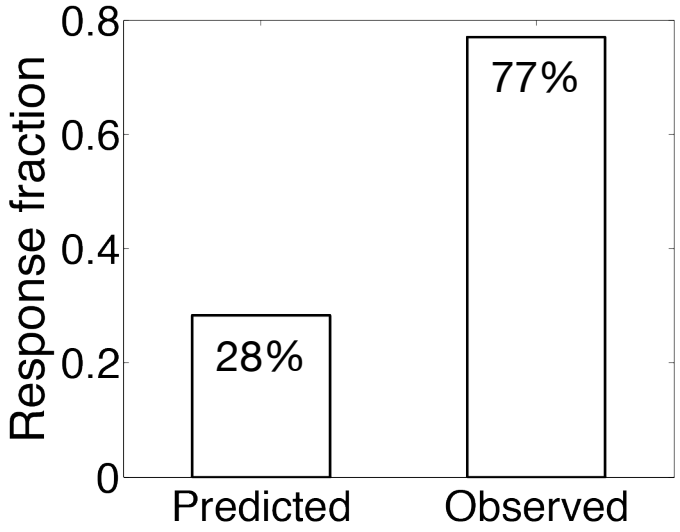
Pattern

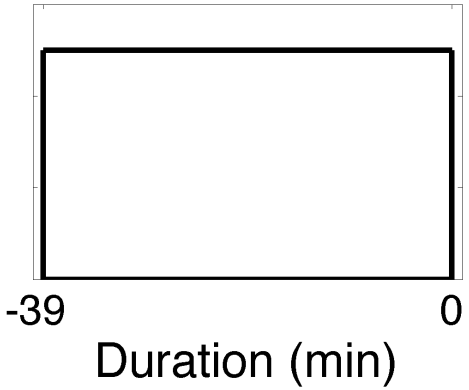
Short-**duration** light pulses cause stronger effects

23% of intermittent light exposure provides ~77% of the continuous light response

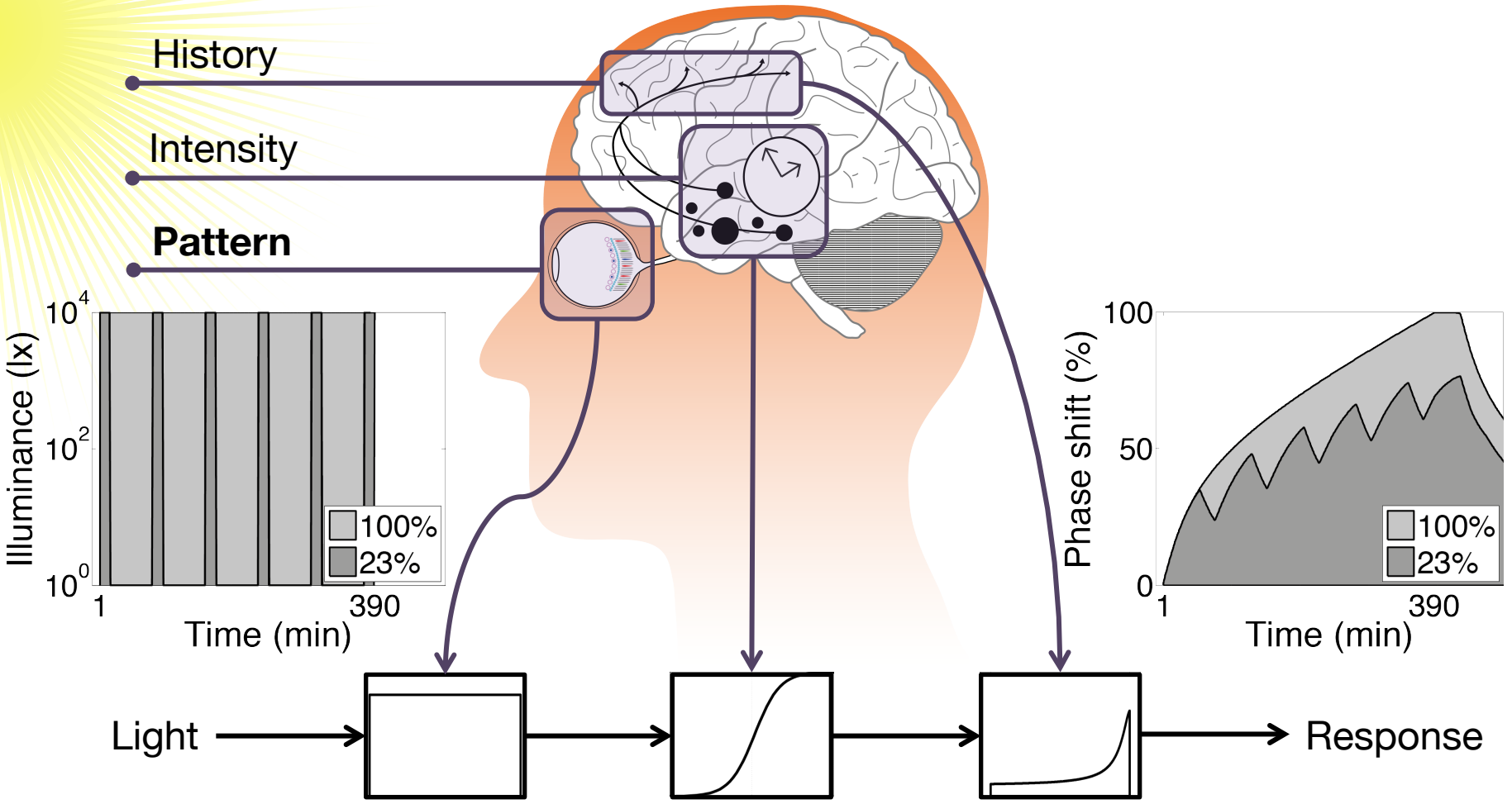
A linear filter with a length of 39 minutes can replicate the results in Gronfier et al. (2004)

(Gronfier et al., 2004; Rimmer et al., 2000)





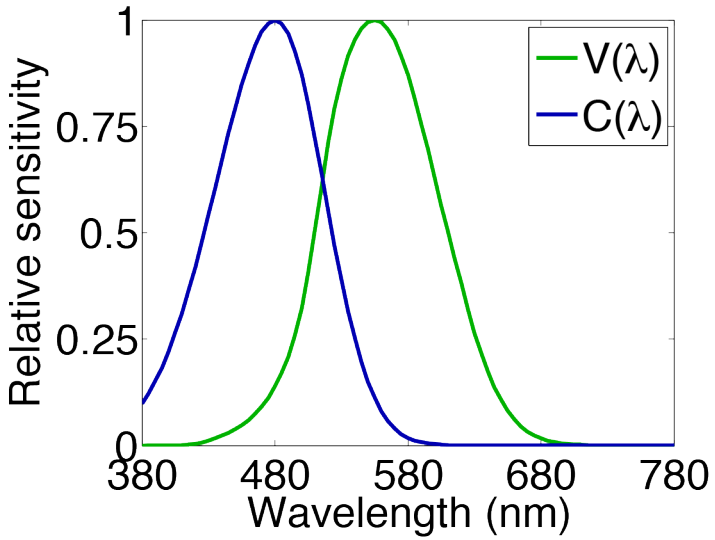
Model structure



Model structure

Spectral sensitivity

The **ipRGCs C(λ)** are the primary photoreceptors for non-visual responses



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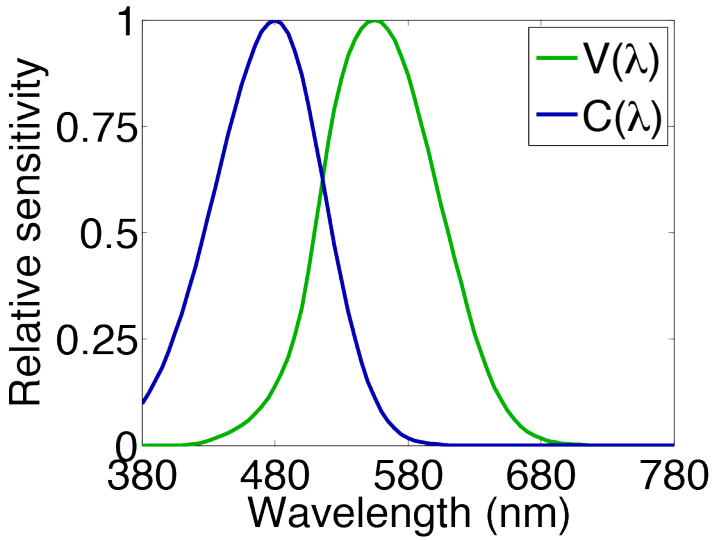

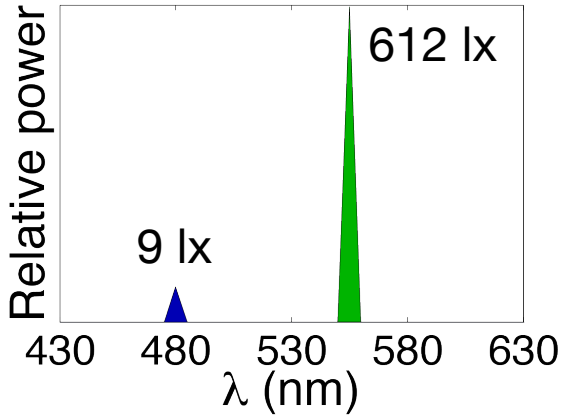

Model structure

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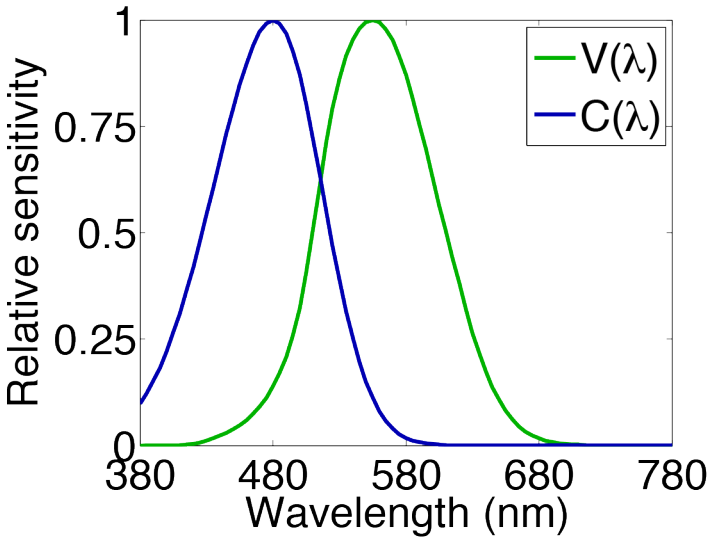
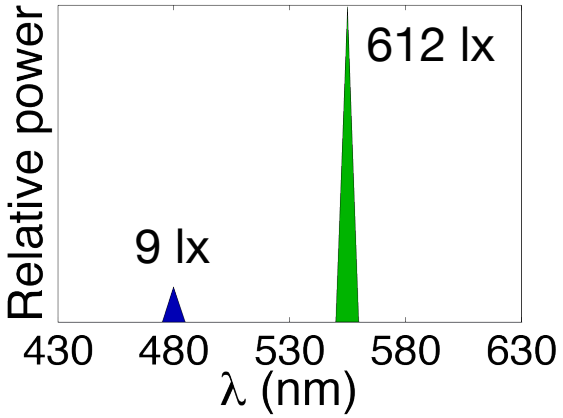
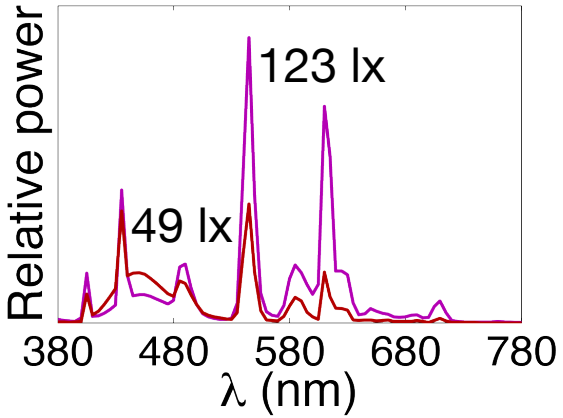


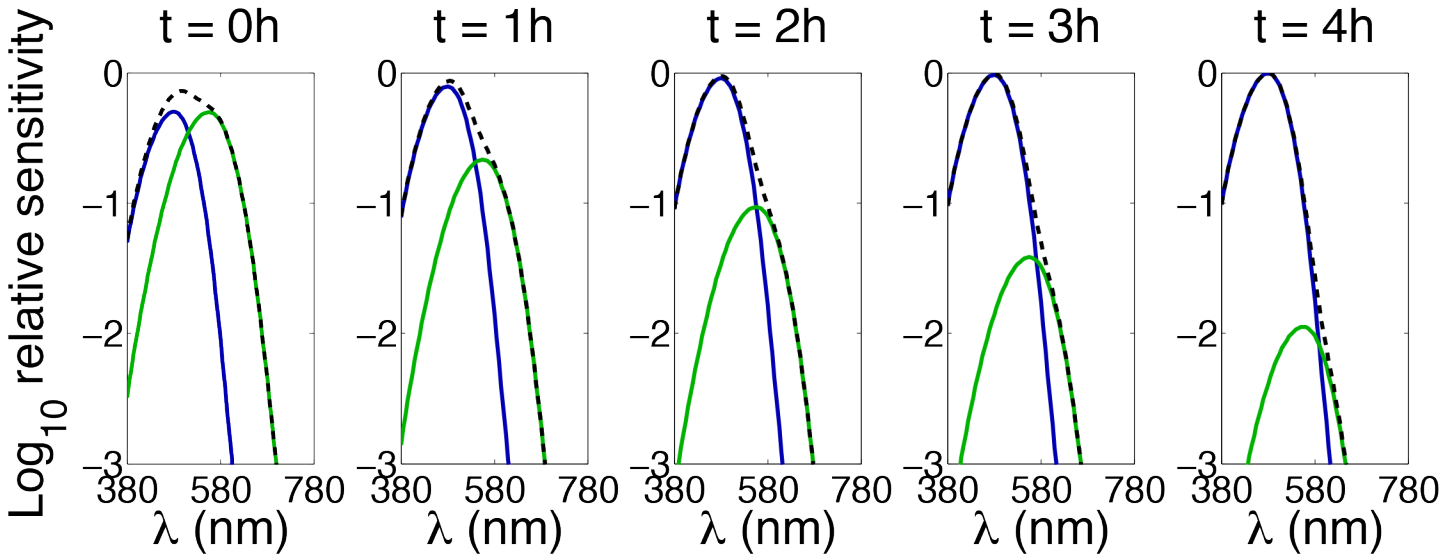




Model structure

Spectral sensitivity and duration

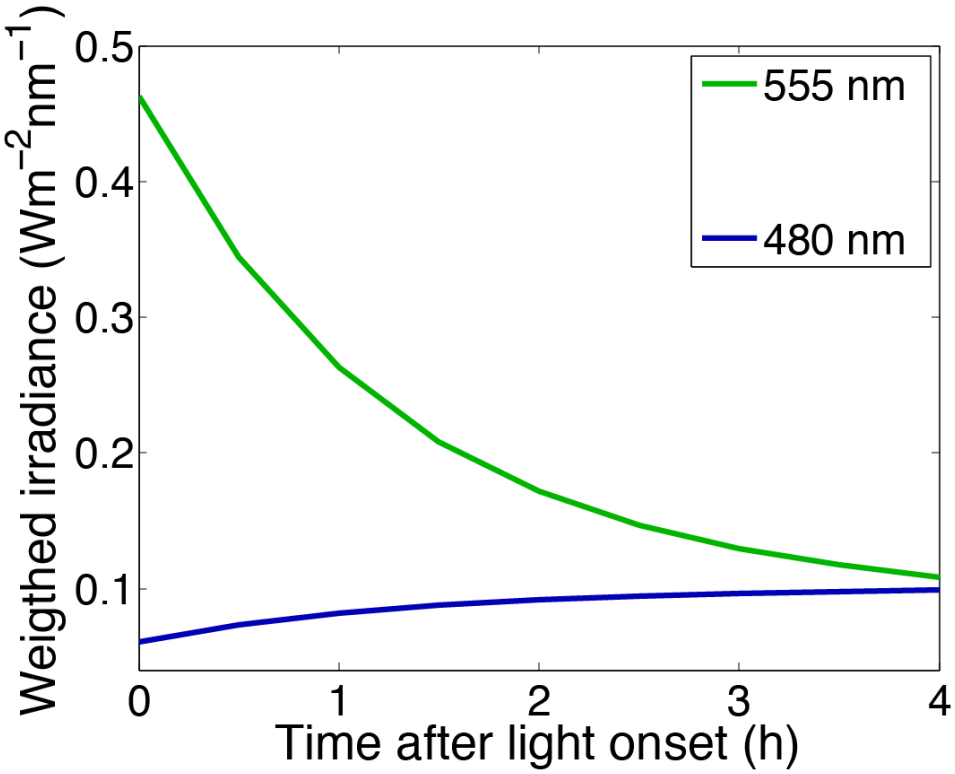
Cones V(λ) contribute to non-visual responses at the beginning of light exposure and at low light intensity (Gooley et al., 2010)

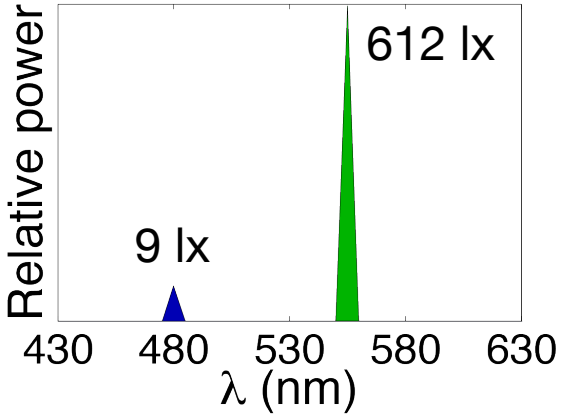


The relative contribution of **ipRGCs C(λ)** and **cones V(λ)** derived from melatonin suppression data

Comparison of light sources

Interaction of ipRGCs and cones





Comparison of light sources

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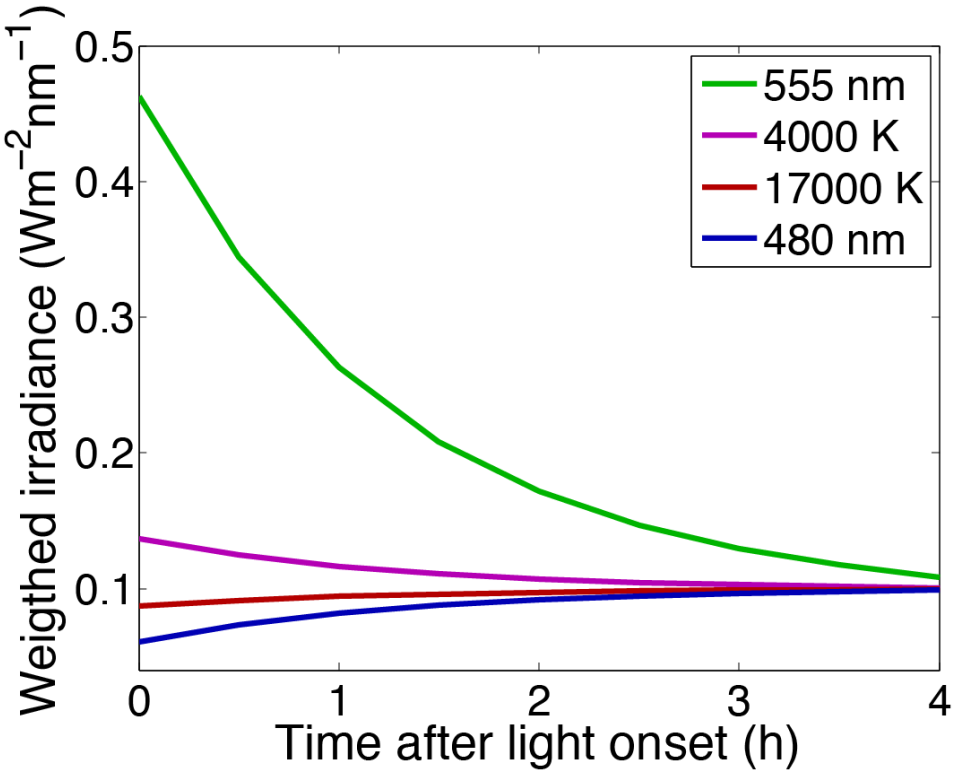
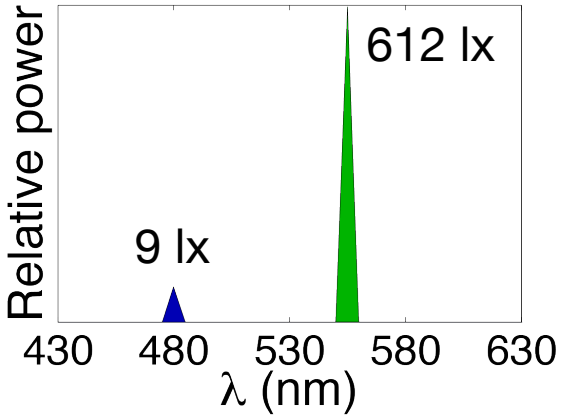
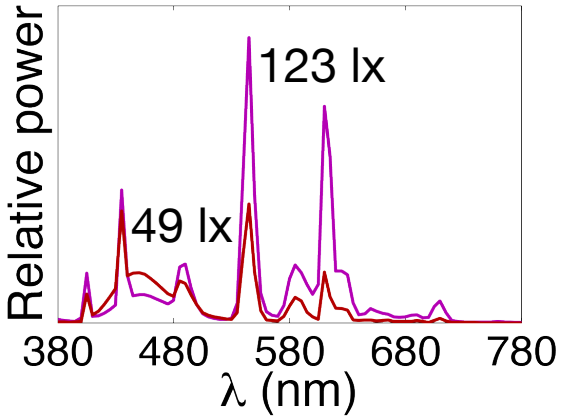
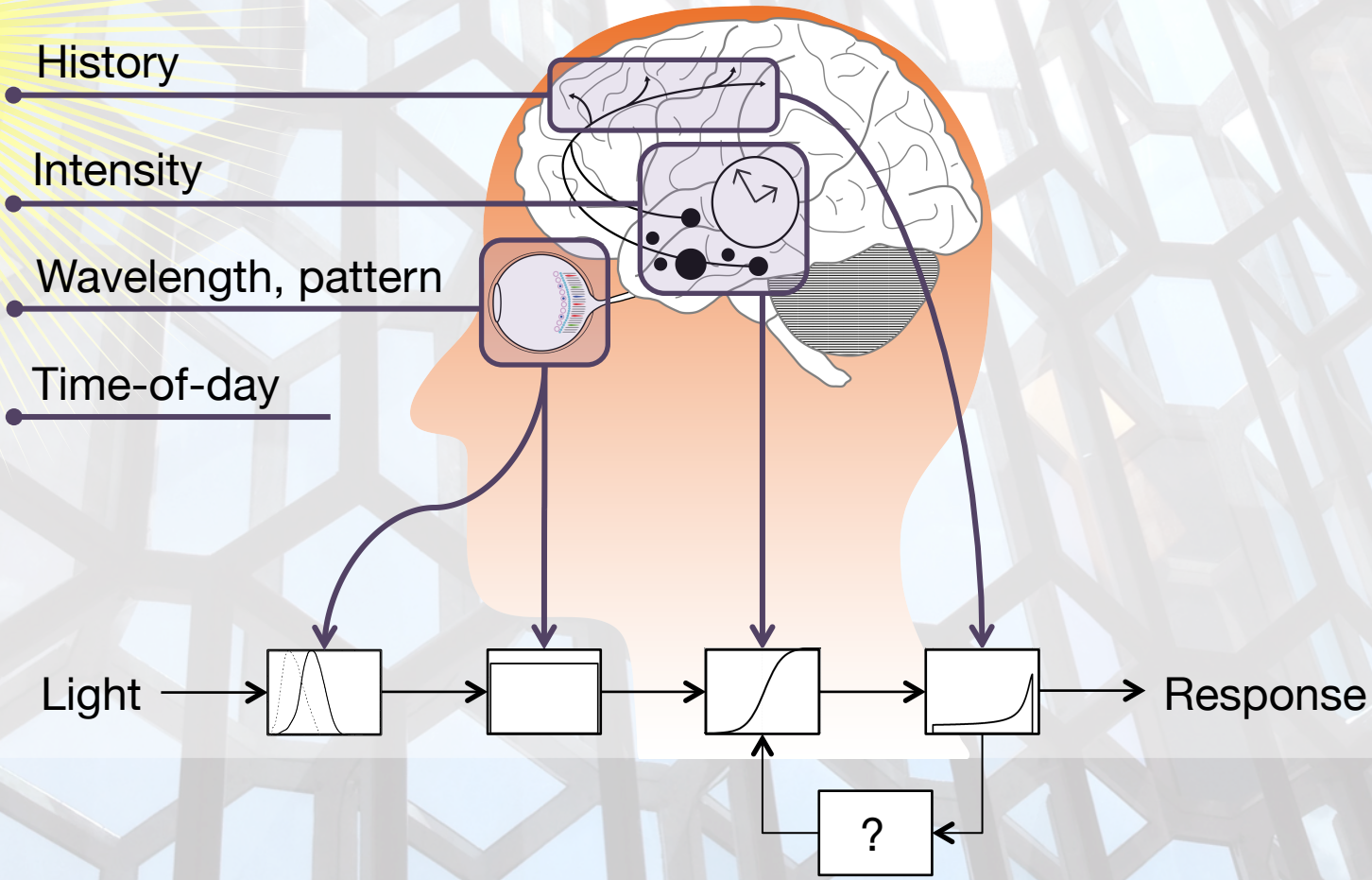






Conclusions



Questions?

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- Zeitzer et al., 2000. Sensitivity of the human circadian pacemaker to nocturnal light: melatonin phase resetting and suppression. *J Physiol,* 526(3):695-702.
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- Gronfier et al., 2004. Efficacy of a single sequence of intermittent bright light pulses for delaying circadian phase in humans. *Am J Physiol-Endoc M*, 287(1):E174-E181.
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