



# Non-visual lighting: Are integral measured values sufficient?

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## Agenda

- Introduction
- State of the art
- Problem
- Hypothesis
- Methodology
- Results
- Conclusion
- Outlook







### Introduction

- Non-image forming or non-visual effects of light are becoming increasingly important
- Light is used to increase alertness or sleep quality, to reduce desynchronization of the circadian rhythm or to treat seasonal affective disorders
- Currently dependencies between:
  - illuminance at eye-level,
  - duration,
  - temporal and
  - spectrum (respectively CCT)

and the NIF effects are under investigation





#### State of the art - current situation

- NIF effects at night correlated with the spectral sensitivity of melanopsin (or spectral sensitivity of melatonin suppression) (ipRGC; found 2002)
- Only a very small number of the retinal ganglion cells are photosensitive (about 1%) and probably not evenly distributed throughout the retina
- Not in focus but also of interest seems to be the dependency on directionality and position of the light source
- Studies are predominantly done at night





### State of the art

- Large sources are more effective than small sources [1].
- Binocular light exposure realizes a higher melatonin suppression than monocular light exposure (spatial summation in [2]-[3]).
- Nasal exposure is more effective than temporal exposure [4]-[5].
- Inferior retinal light exposure seems to induce a greater response than superior exposure [6]-[8].





#### Problem

• Under daytime conditions some studies find and some do not find NIF effects

Different lighting condition between studies which cannot be identified due to lacking or insufficient description of applied lighting conditions!!!









#### Visual field





 [F1]
 [F2]

 Effective radiant flux for non-image forming effects | Kai Broszio | Lux Junior 2017

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## Effective regions





# **Hypothesis**

#### Precondition

Daytime NIF effects depend on the ipRGC and maybe in combination with other receptors. These cell types are or their sensitivity is not evenly distributed throughout the retina.

#### Assumption

Measurement of the (melanopic) illuminance at eye-level does not reflect the light's stimulation potential in terms of NIF effects correctly.





## Laboratory and reality









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# Methodology





# Methodology

 $E_p = \int L(\theta, \psi) \cos(\vartheta) d\omega_s$ 

 $E_p$  illuminance

- L luminance of each pixel, which position is determined by  $\theta, \psi$
- $\omega_s$  solid angle
- $\vartheta$  tilt angle







#### Test room











#### Lighting scenes







#### Results

Regions					Lighting	Scopes			
		а	b	С	d	е	f	g	h
Illuminance	E <sub>v</sub> [lx]	500 +/- 2,5%							
	E <sub>v</sub> [%] <sup>b</sup>	15.1	19.2	5.6	17.3	24.3	29.2	28.6	19.1
	E <sub>v</sub> [%] <sup>b</sup>	20.7	25.5	9.5	22.6	43.7	50.8	43.8	34.9
	E <sub>v</sub> [%] <sup>b</sup>	37.7	39.9	30.0	43.6	50.7	58.0	56.1	52.9

a. horizontal Illuminance at 0.85 m | b. vertical Illuminance in percent of the luxmeter-measured value





#### Conclusion

- Development of an evaluation method to determine the spatially resolved partial illuminance values
- Regions were chosen to fit illumination of the lower left and right eye's nasal part of the retina and the illumination of the lower halves of both retinas simultaneously
- More standard-like office lighting scenes cause only weak illumination of the defined regions.
- Lighting of the opposite wall leads to much higher values in these regions
- Higher vertical luminances in the central part of the field of view, such as daylit rooms or lighting solutions with wall washers, will result in a higher efficiency to induce NIF effects





#### Outlook

- Theoretical approach
- May explain why some studies do find NIF effects, and others do not (even with similar vertical illuminances and spectral power distribution)
- Next step:
  - s<sub>mel</sub>-filtered measurements
  - Field measurements
- Future studies should take the light incidence in account and describe the lighting conditions with a representation that accounts for the origin of light







# Thank you very much!





#### Literature

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[F	1]
[F	2]
[F	3]

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