Biosignals as an Indicator for Human Responses to Light

S. Beck, Prof. T. Q. Khanh

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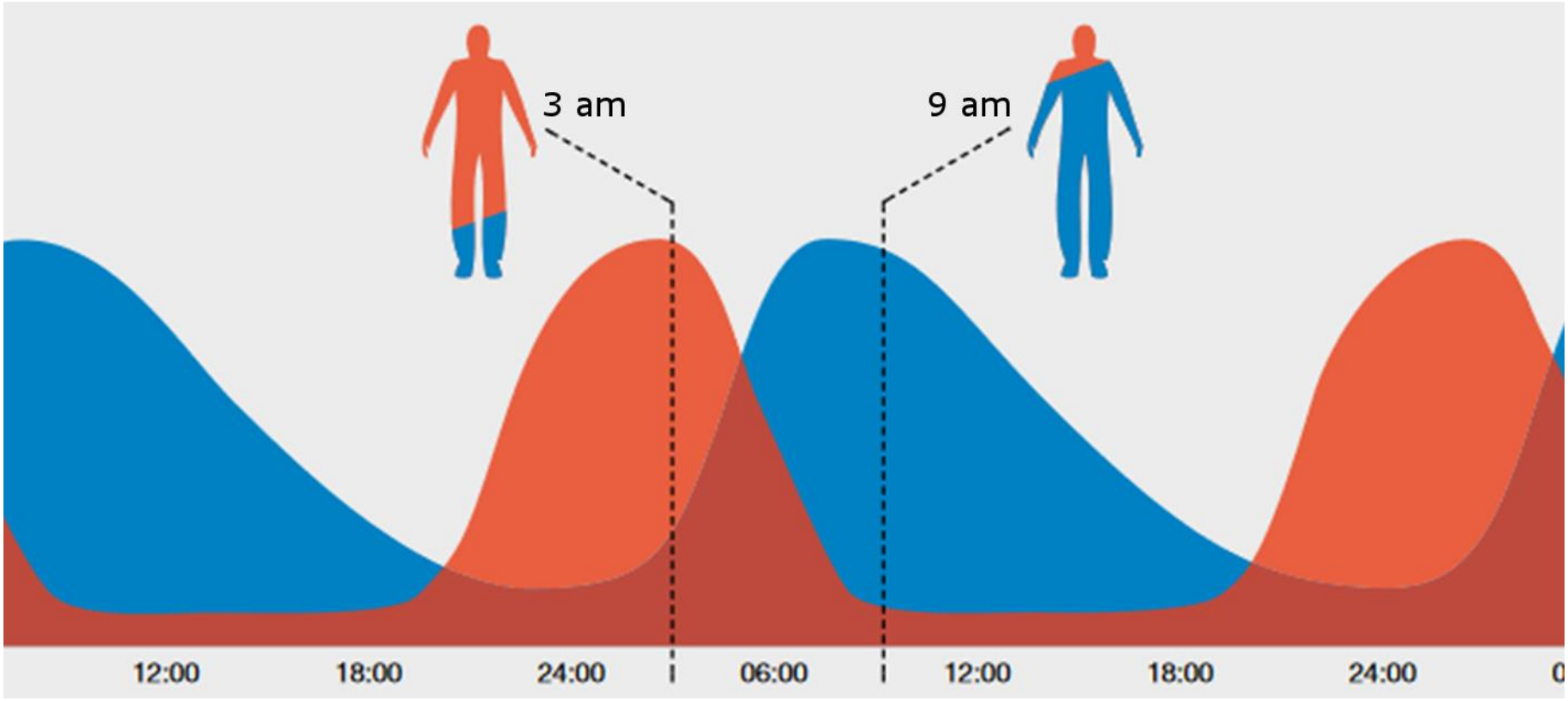
FACHGEBIET LICHTTECHNIK



Motivation: Effect of Light on the Human Body

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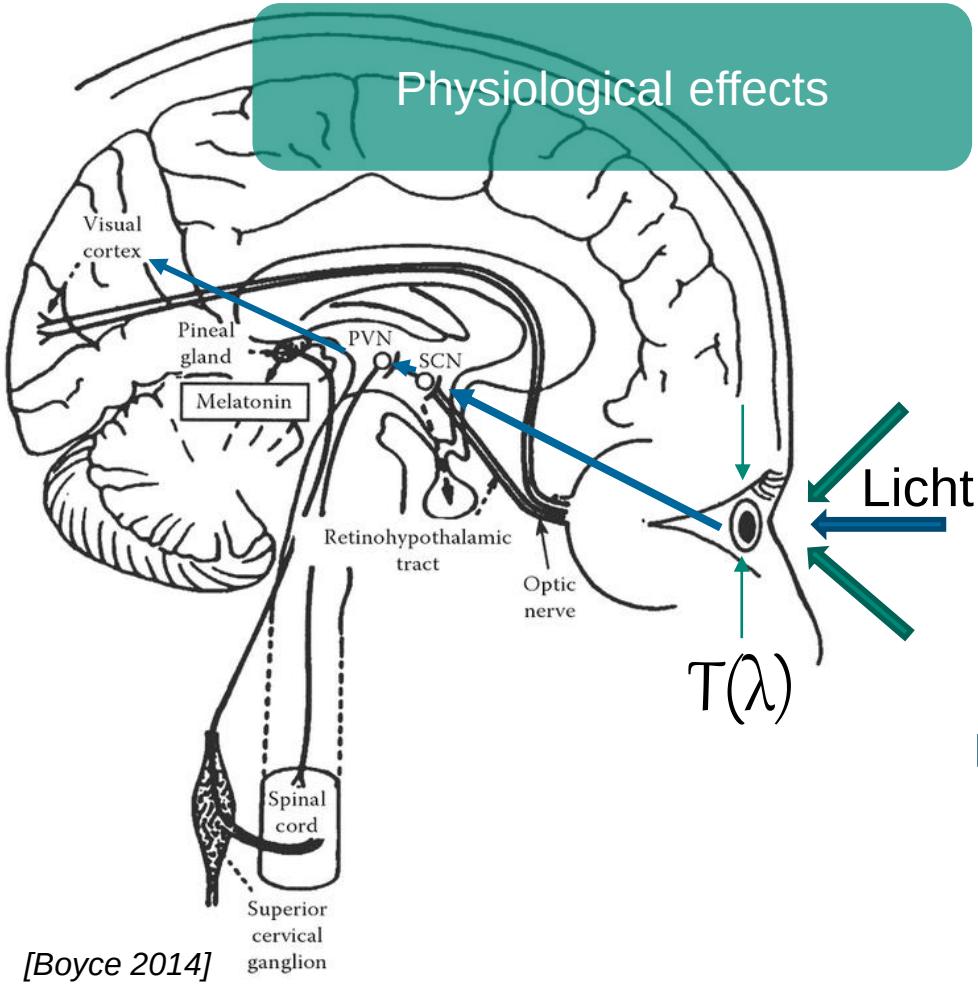
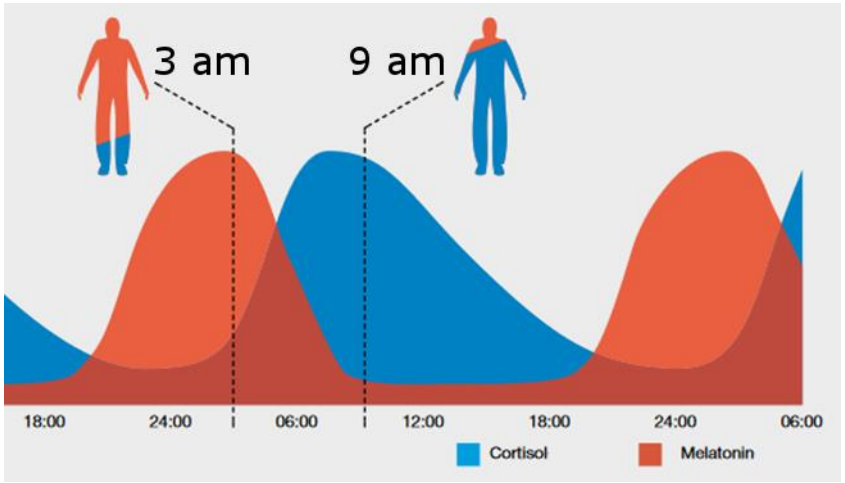
Physiological effects



[Boyce 2014]



[Ilicht.wissen-07' 2012]

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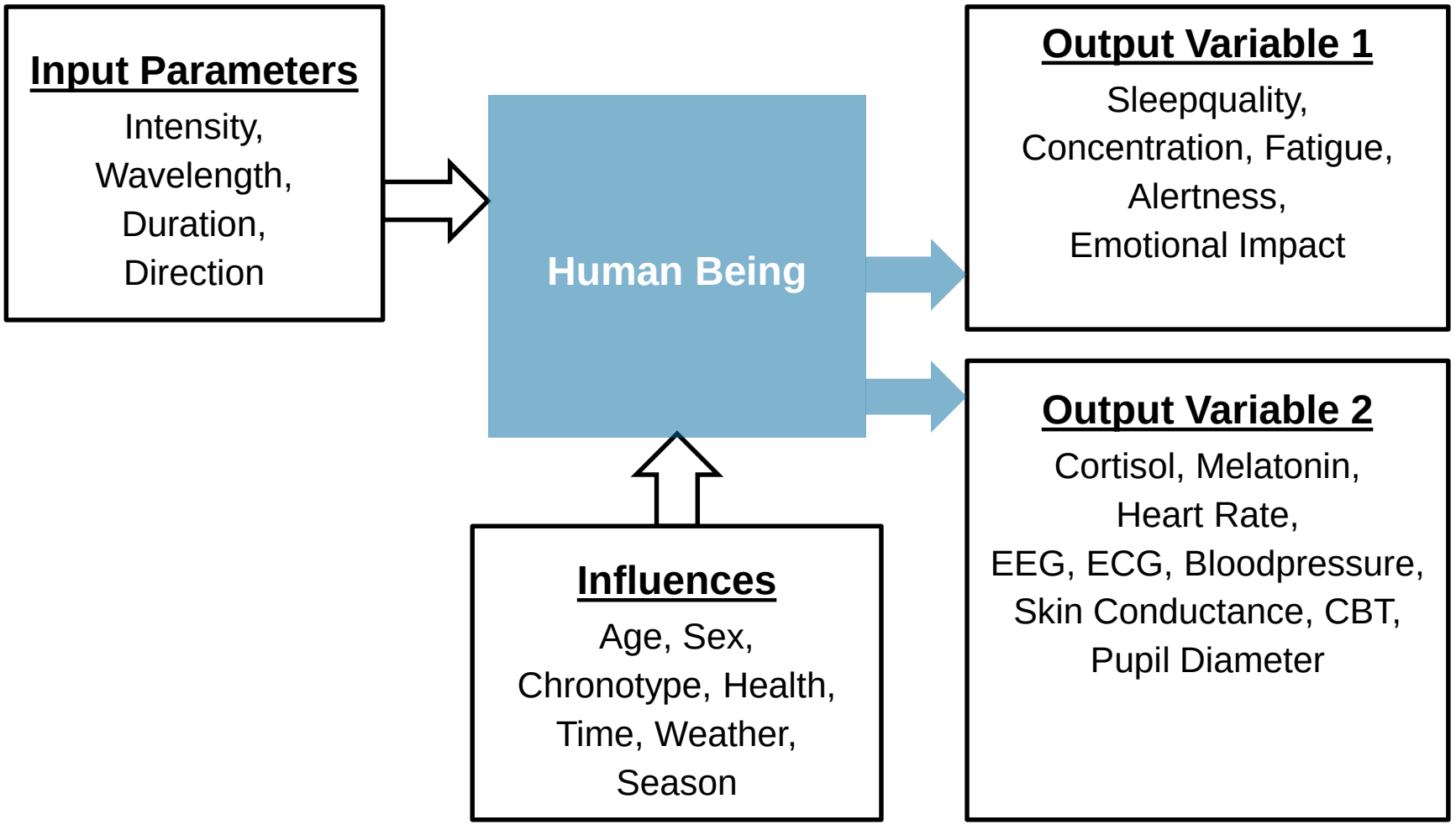
Psychological effects

FGLT

Motivation: Effect of Light on the Human Body



Models to evaluate Circadian Stimulus (CS)

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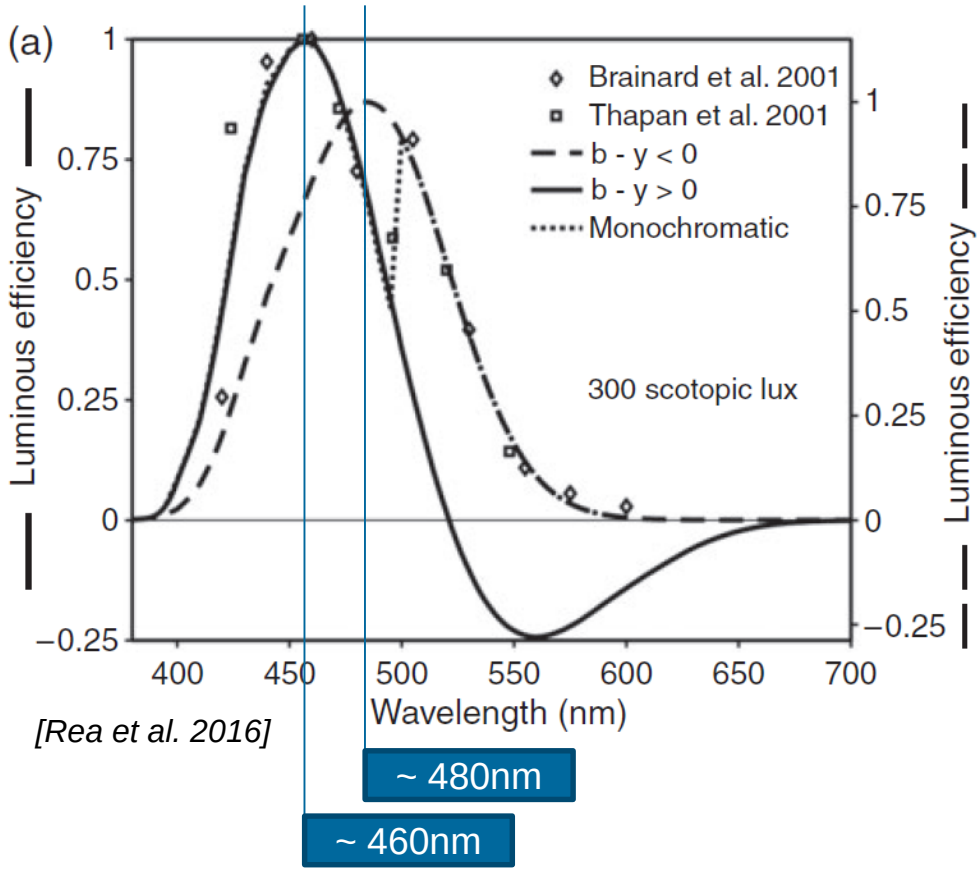
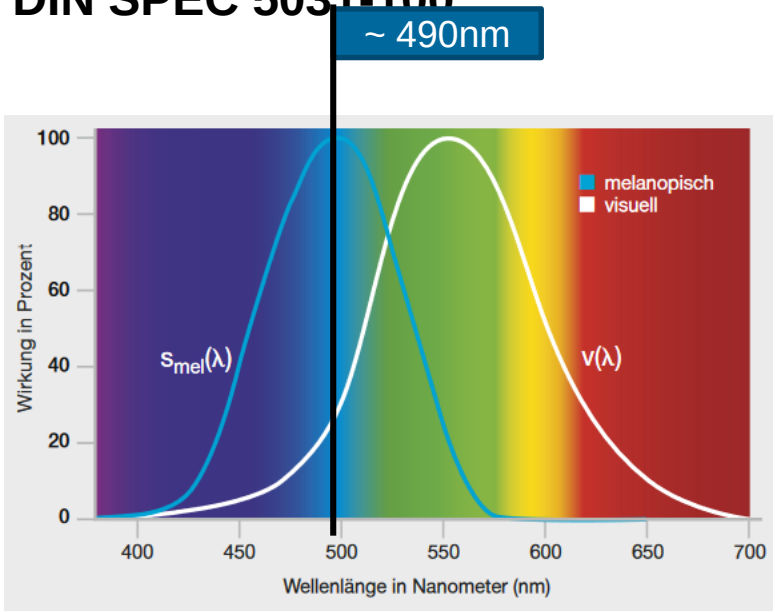
Rea et al. 2016



[Rea et al. 2016]

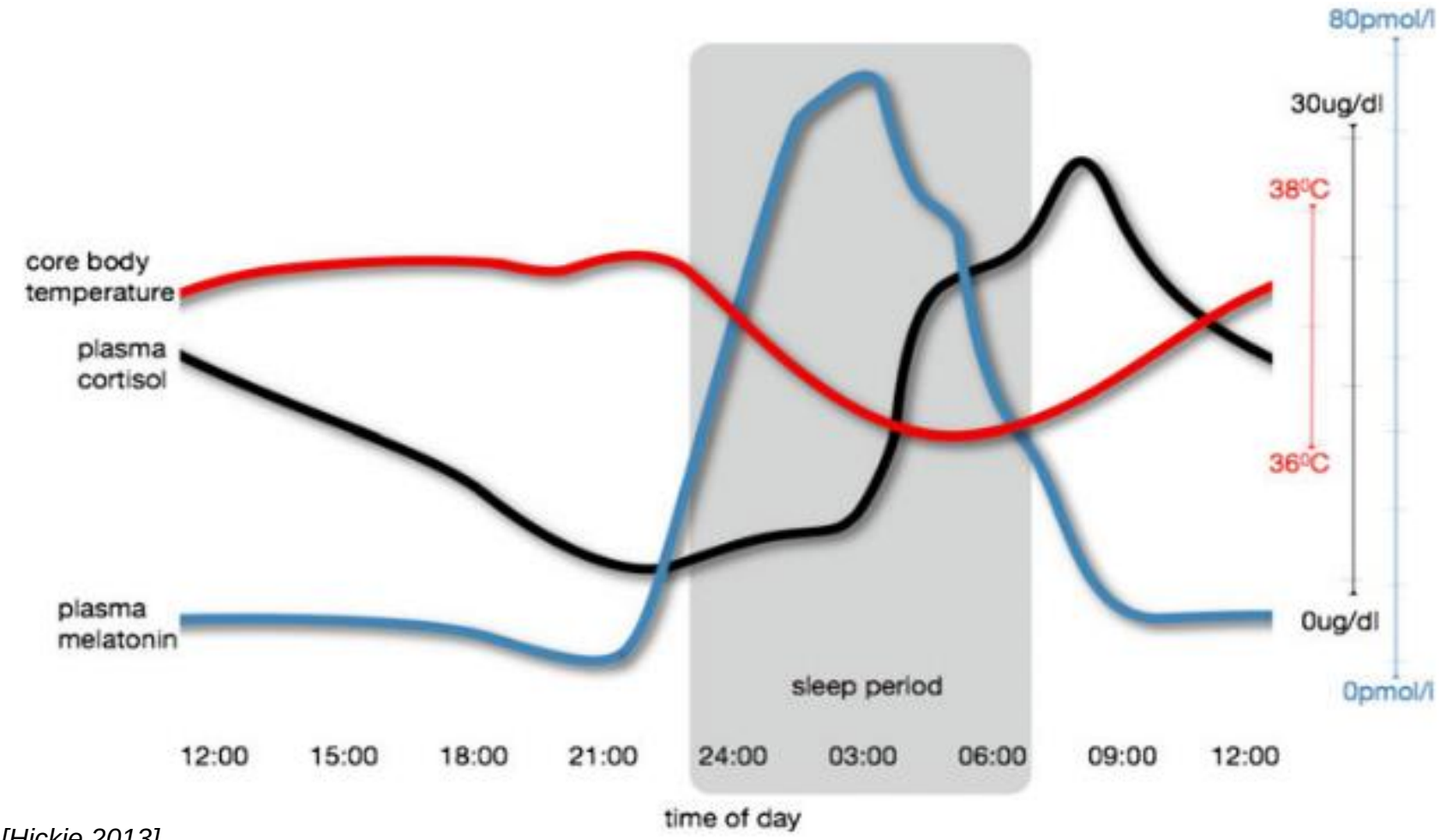
DIN SPEC 5031-100



[licht.wissen19]

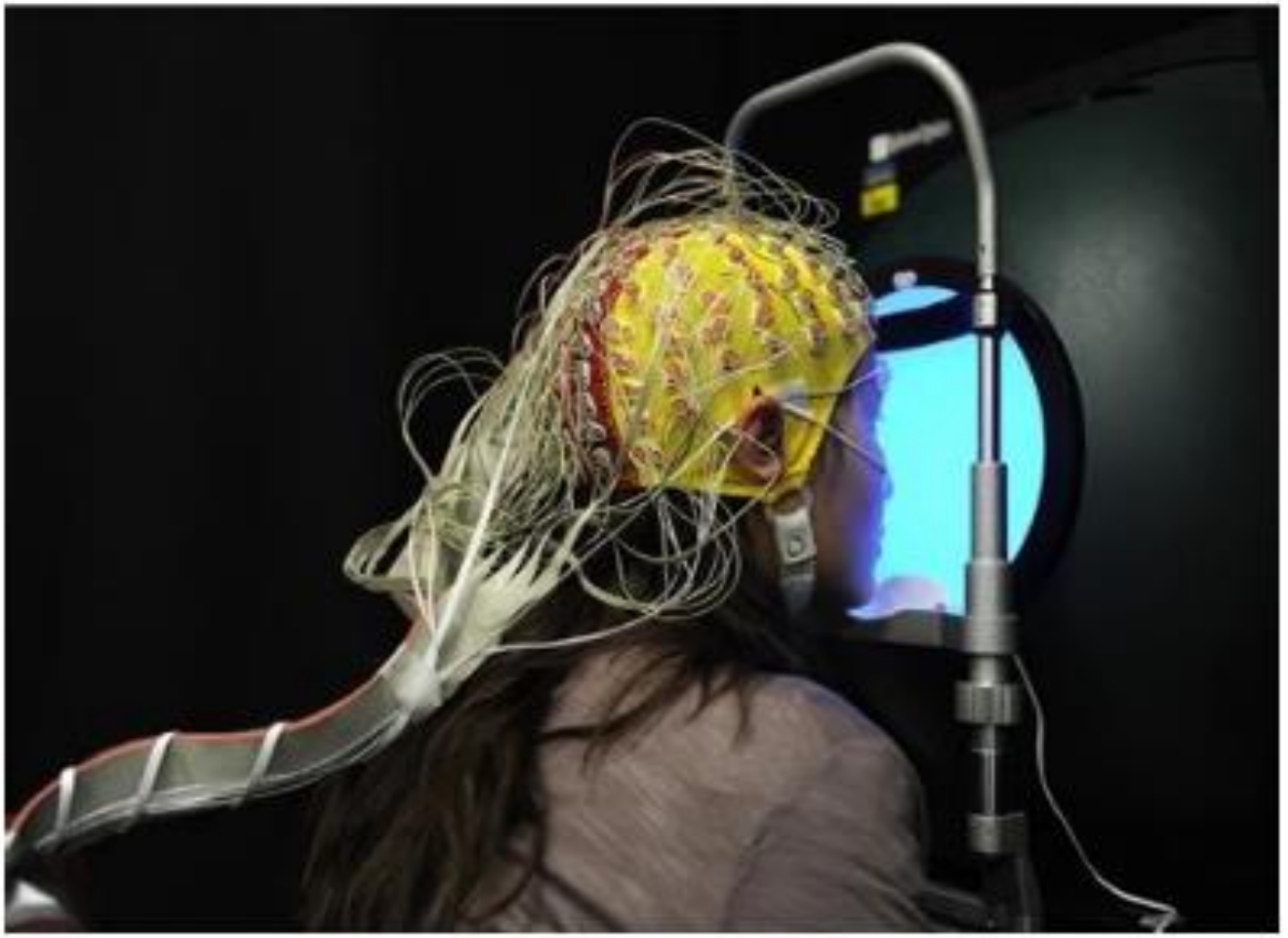
$$a_{mel,\,v} = \frac{\int_{\lambda_u}^{\lambda_o} X_\lambda(\lambda) \cdot s_{mel}(\lambda) \cdot d\lambda}{\int_{\lambda_u}^{\lambda_o} X_\lambda(\lambda) \cdot V(\lambda) \cdot d\lambda}$$

Circadian Rhythm of Human Beings



[Hickie 2013]

Electroencephalography (EEG)

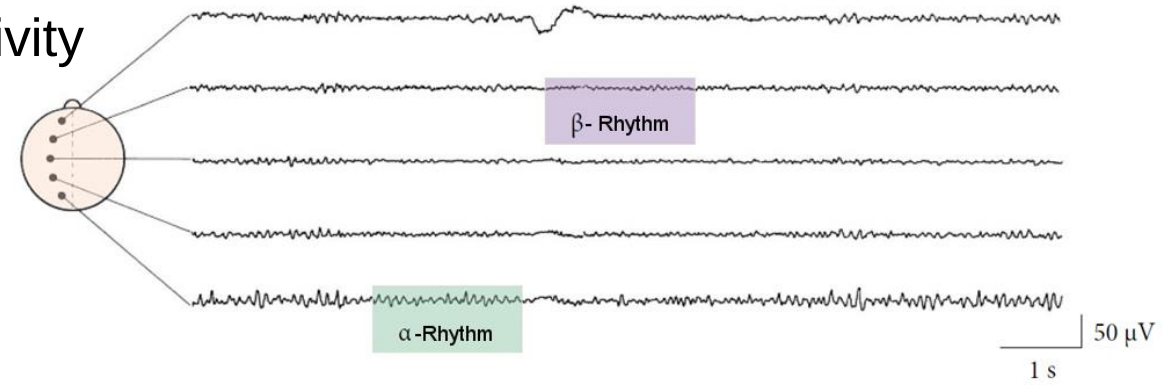


[Münch 2015]

EEG

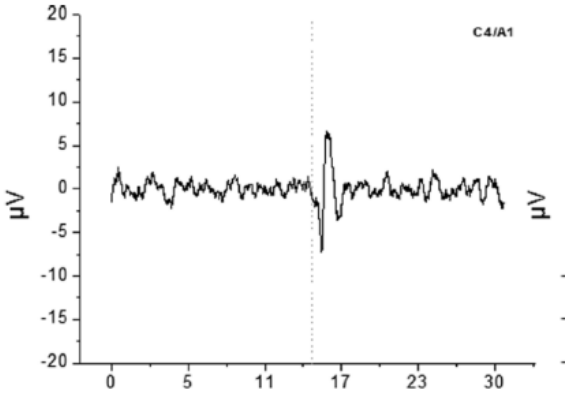
- Synchronous Activity

Name	Frequency
Delta (δ)	0,5 – 3 Hz
Theta (ϴ)	4 – 7 Hz
Alpha (α)	8 – 13 Hz
Beta (β)	14 – 30 Hz
Gamma (γ)	31 - 60



[Schandry 2011]

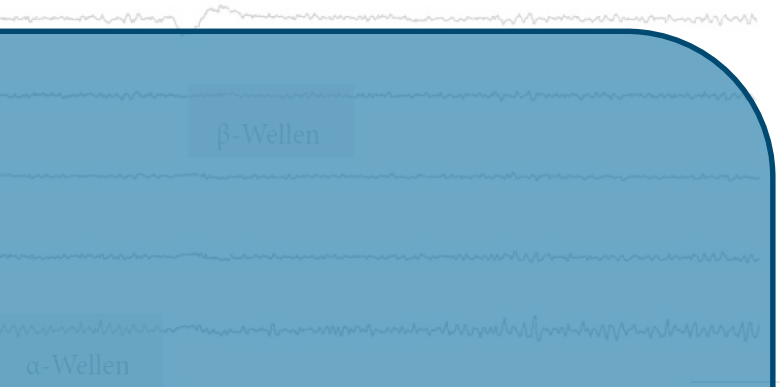
- Event-related Potential (ERP)



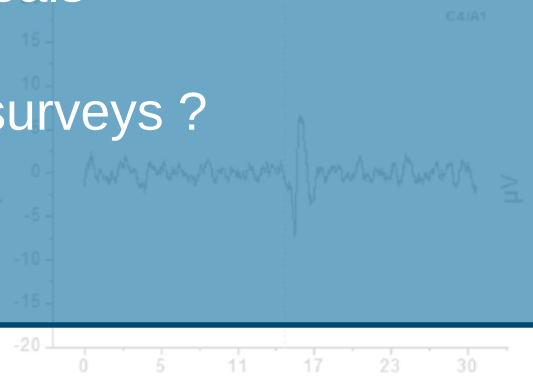
[Zeitzer 2014]

EEG

- Physiological effects:
  - Cerebral signal
    - Alertness
    - Stress
  - Activating different brain areals
- Correlation with psychological surveys ?



[Schandry 2011: Biologische Psychologie]

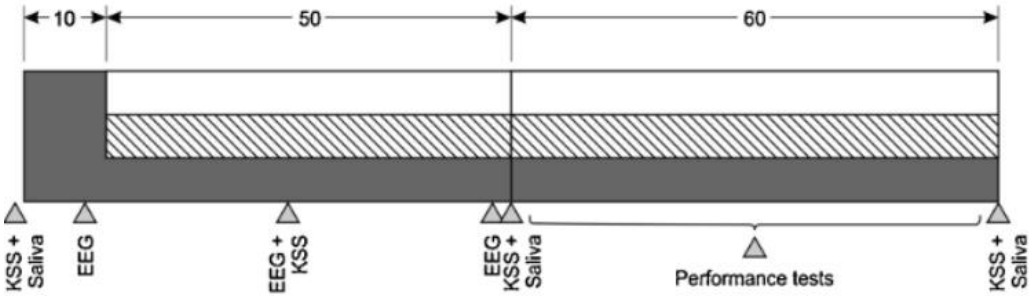


[Zeitzer et al. 2014]

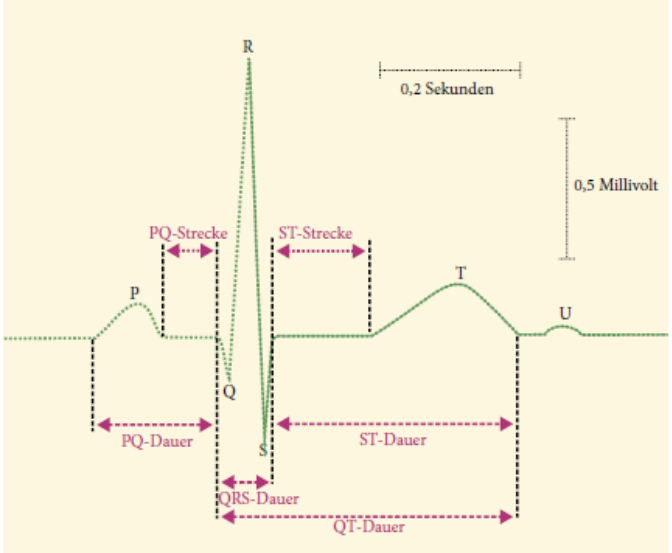
EEG – Synchronous activity

- **Alerting Effects of blue and red light at afternoon**, *Sahin et al. 2013*
  - EEG synchronous activity: Alpha-Theta and Theta waves significant lower after red light exposure
  - KSS is not significant (but similar behaviour as EEG)

- **Daytime light exposure**, *Sahin et al. 2014*
  - 3 Conditions:
    a) dim < 5lx
    b) 631nm 213lx (1.1w/m^2)
    c) 2568K, 361lx (1.1W/m^2)
  - Results:
    - 631nm → significant higher reaction time und performance
    - white: → significant reduced Alpha power (red only at afternoon)
    - No influences on Melatonin and Cortisol



Heart Rate & Heart Rate Variability



[Schandry 2011]

- Elektrocardiogramm (ECG) measures potential arousal of the heart on body surface
- Measuring:
  - Electrodes (e.g. Limb leads)
  - optical (e.g. at wrist or earlope)
  - Chest strap

Heart Rate Variability (HRV):

Frequency analysis:

HF (high frequency): Parasympathic activity

LF (low frequency): Symphytic and parasympathic activity

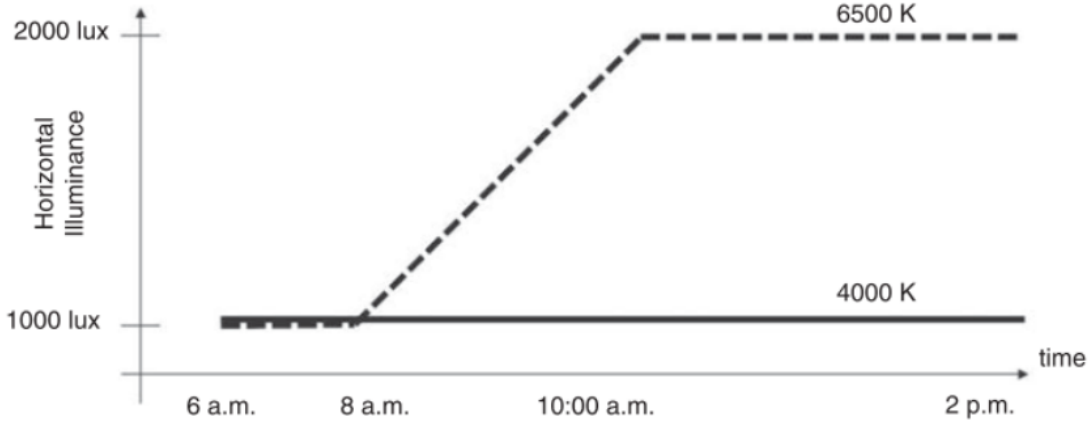
VLF (very low frequency): Stress indikator

Heart Rate Variability

Examination of dynamic lighting:

***Canazei et al. 2014*:**

- HRV: HF higher at dynamic lighting
  VLF attenuated during winter



[Canazei et al.]

Stefanie et al. 2016:

- No significant differences for mood and wellbeing (dynamic & static)
- Indication of higher physiological acitvation through dynamic light

Conclusion

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- Physiological influences/reactions of light stimuli recognicable in biosignals
- Not necessarily a correlation with psychological perception
- Potential for dynamic light research
- Complexity of human organism and factors of influences have to be handled with care

Thank you for your attention!

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