Impact of Light on Human Beings
Light and the human organism

Triple impact

1. Visual (seeing)
2. Emotional
3. Biological (setting the "internal clock")

Our "internal clock" (circadian system)

- ... is genetically internalised
- ... controls sleeping and waking phases, bodily functions and mood

→ Light synchronises the internal clock
Human performance curves

**Circadian rhythm** (approx. 24 hours): The performance curve
- climbs sharply in the morning,
- levels off at midday
- and reaches its lowest level at night.

**Infradian rhythm** (season): during winter months, for example, human beings are
- less fit,
- often in low spirits.
- If the low spirit persists, at risk of seasonal affective disorder (SAD).
Cells, organs and metabolism are blind to the outside world.

Organs/functions are synchronised with the environment by a master clock.

The pacemaker is the light. Information comes from the third photoreceptor in the eye (discovered in 2002)

The master clock control elements are messenger substances and hormones

Blue light is the most biologically effective. Wavelength: around 460 nanometres
Absence of light in the evening
- prompts our body to produce melatonin (sleep hormone), which makes us feel tired
- melatonin level falls in the morning

Daylight in the morning
- prompts production of the "stress hormone" cortisol, making us alert and focused
- stimulates the production of mood-elevating serotonin, making us feel fit and dynamic
Dynamic lighting harnesses the advantages of daylight

There is not always enough daylight available.

→ **Biologically effective artificial lighting brings the dynamism of daylight indoors**

**Programmed light settings support our natural biological rhythm:**
- daylight-white light has an energising effect (5,600 kelvin)
- warm-white light has a relaxing effect (3,000 kelvin)

**Advantages of dynamic lighting**
- Greater sense of wellbeing
- Enhanced performance and concentration
- Tailoring to individual needs
- Flexible use of space and workplaces
- Energy savings due to daylight-dependent control
Daylight sets the example

Nature provides parameters:

1. Natural distribution of light
   - planarity (modelled on the sky)
   - direction of light (from above and the front)

2. Natural spectrum (high blue content)

3. Dynamism
   - illuminance varies
   - colour temperature varies

![Graph showing activity and relaxation with colour temperature change](image)
Daylight sets the example

1. Natural distribution of light

*in nature:*

The sky acts as a planar light source, light enters the eye from above and from the front.

*in artificial lighting:*

- large area luminaires
- luminaires that radiate light directly and indirectly
- wall and ceiling washers that distribute all their light indirectly
- bright upper walls and ceiling as reflective surfaces
Daylight sets the example

2 Natural spectrum

*in nature:*

daylight spectrum with effective blue content

*in artificial lighting:*

- lamps with daylight spectrum
- lamps with corresponding blue content

3 Dynamism

*in nature:*

illuminance and colour temperature of daylight vary during the course of the day

*in artificial lighting:*

- intelligent control technology
- effective, dynamically controlled illuminance (500 to 1,500 lux)
- sensors for varying colour temperature as required (warm to daylight white)
Lighting design tips

Quality features
Meeting visual quality standards:
- Minimum requirements are defined in DIN EN 12464-1 „Light and Lighting – Lighting of Indoor Work Places“

Material characteristics and light colour
Optical control elements can change spectral composition. It is important here to:
- verify spectral characteristics
- verify ageing resistance on greater exposure to blue light
- pay attention to the transmission properties of plastic lens systems used with LEDs

Room environment and light colour
The impression a room makes is influenced by the colours of furnitures, walls and ceiling:
- dark colours reflect less light, reds and browns absorb blue light
- indirect lighting alone is not enough
Better light – lower cost

New lighting technologies = greater efficiency + more lighting quality

Energy-efficient lighting:
- daylight-dependent control (up to 35% energy saving)
- timers and presence sensors
- luminaires and light sources with high light output ratios
- dimmable light

→ The higher the degree of automation of a lighting installation, the more efficient it is.

Standards and laws
- EnEV (Energy Conservation Ordinance: Operating Energy Consumption of Lighting Installations)
- DIN V 15899 (Evaluation of the Energy Consumption of Rooms and Buildings)
Dynamic office lighting

Field trial: open-plan office, response and performance tests, control lighting, 4 weeks

Lighting and control:
- Large area lighting with warm-white direct light and daylight-white indirect light
- Dynamic light colour / illuminance control: stimulating morning mood to warm lighting atmosphere in the evening
- 1,000 lux und 8,000 kelvin have an energising effect during the performance „low“ in the early afternoon

Findings:
1. Employees are subjectively more alert and measurably more dynamic
2. Improved response time and productivity
Dynamic lighting in industry

Field trial: factory, manual production,
Previously static 500 lux (DIN EN 12464-1), 15 months

Lighting and control:
- Workplace lighting for individual and infinite regulation up to 3.000 Lux

Findings:
1. Greater sense of wellbeing due to biologically effective light
2. 48 of 49 assembly workers choose higher illuminances at all times even though 500 lux is a good level for the visual task.

Another study shows that the average assembly time for the same product is 7.7% under higher illuminance.
Dynamic school lighting

Field trial: school classroom, 3 lighting programmes, concentration, performance and behavioural tests, 10 months

Lighting programme 1:
- The combination of a colour temperature of 1,000 kelvin and 650 lux illuminance "activates" students in the morning

Lighting programme 2:
- 6,000 kelvin and 1,000 lux are combined to support "concentrated work"

Lighting programme 3:
- 2,700 kelvin und 300 lux provide a "calming" light

Findings:
1. Number of mistakes made falls by 45%
2. Reading comprehension and speeds increase by 30%
3. Restlessness decreases by 75% within 8 minutes
Dynamic retirement home lighting

Field trial: three dynamic lighting programmes, control lighting, 15 months

Lighting: 10 luminous ceiling modules, each with 12 lamps (4x 3,000, 4x 6,500 und 4x 8,000 kelvin)

Lighting programme 1: standard lighting raised from 300 to 2,000 lux
Lighting programme 2: 6,500 instead of 3,000 kelvin light colour in corridors; living/dining areas: 8,000 kelvin
Lighting programme 3: illuminance and light colour dynamically modified during the day

Findings:
1. Residents are more active during the day and sleep better at night (stabilised circadian rhythm)
2. Care staff are under less pressure and the need for sleeping pills decreases
Dynamic domestic lighting

Complete solutions for the home are not currently available

→ An agreeable lighting atmosphere should be ensured with good general and selective accent lighting

Waking up naturally with a light alarm clock:

1. 30 minutes before the wake-up time set, the clock raises the illuminance in a simulation of sunrise
2. Users are more alert, more energetic and get out of bed more quickly
3. Cortisol level is significantly higher than usual

Home light therapy:

- 20% of the population suffers from SAD
- Light therapy devices with daylight spectrum and high blue content (colour temperature: 6,500 kelvin / illuminance up to 10,000 lux)
Further information

Further information on the subject is provided

- In the booklet licht.wissen 19 „Impact on Light on Human Beings“ (48 pages).

- This and other booklets in the licht-wissen series are available as free pdf downloads at www.licht.de/en