

Nonvisual effects of light

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Visual and nonvisual effects of light

MIND

VISION

HEALTH

How light influences human being?

EMOTIONS

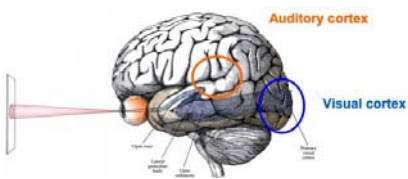
FEELING

MOOD

Visual effect of light

Visual effect are connected with:

- Cons and Rods in eye;
- Visual nerve system;
- Visual cortex in brain.



Visual and nonvisual effects of light

MIND

VISION

HEALTH

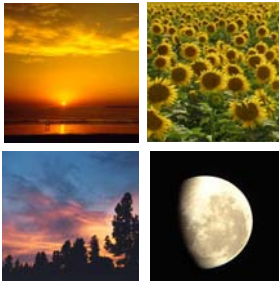
How light influences human being?

EMOTIONS

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Most important: Rhythms



The human body runs on cyclic programs:

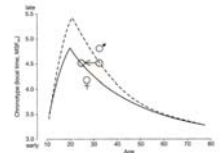
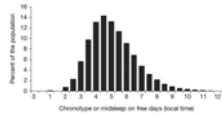
- Ultradian rhythms span only a few hours.
- Circadian rhythms are geared to day and night.
 - night.
- Infradian rhythms have cycles longer than
 - 24 hours.

Most important: Rhythms



- All organisms have their own rhythms.
- We have the rhythm of day and night anchored in our gens.
 - Regular sleep and waking phases are maintained even if they are not stimulated by daylight.

Chronotypes



- The genetically programmed rhythm for human beings is normally around 24,2 hours.
- For some people, the cycle is shorter than 24 hours;
- For others, it is considerably longer.
- On the basis of these differences, people are divided into „chronotypes“.

Chronotypes



- Chronotypes are identified mainly by their sleeping habits.
- Many people are early risers – “larks” wide awake at the crack of dawn. Their internal clock has 23 h cycle.
- Other are “owls” and need more time to face the new day. Their internal clock runs significantly slower (26 h).

Rhythm and age

- **Infants and toddlers:** ultradian rhythms of three or four hours' duration.
- **Teens:** go to bed late and sleep longer.
- **Around 20:** sleep requirements decrease to 7-8 hours.
- **From 30 onwards:** the quality of sleep steadily declines.
- **At 70:** our sleep/wake rhythm gets increasingly out of sync with external rhythms.



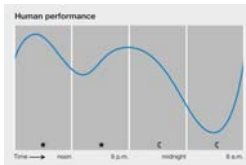
Seasonal differences

- Our chronobiological rhythms are also influenced by summer and winter.
 - In the dark months we tend to be less fit, we have difficulties concentrating and our responses are slower. We also eat more.
 - The seasons also have a psychological impact – seasonal affective disorder (SAD, in Germany up to 10% of adults)



Circadian Rhythm

- Circadian rhythm influences more than just a sleep/wake phases:
 - Heart beat
 - Blood pressure
 - Core body temperature
 - Hormonal regulation
 - Metabolic functioning



Resynchronization

- To keep with the sun's 24 hour rhythm, our internal clock needs occasional resynchronization (twice a day?).

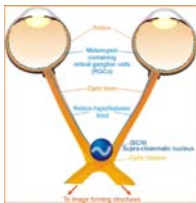


- Light acts as pacemaker for our internal clock

How it works?

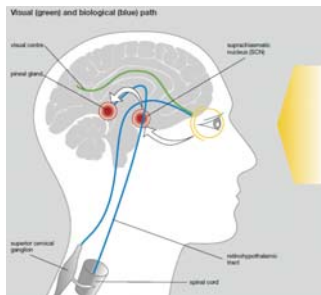
Suprachiasmatic nucleus (SCN):

- SCN acts as a master clock for cell activity by using synapses and neurotransmitters to synchronize the various clocks in the body.



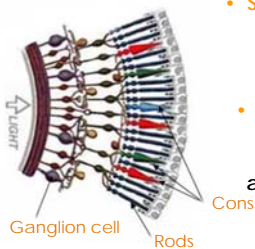
- It does this by activating or inhibiting enzyme and regulating the production or prevention of hormones.

How it works?



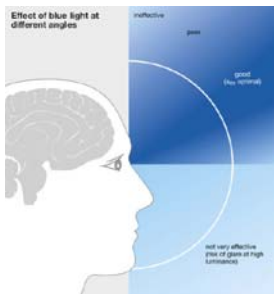
- SCN consists of two brain nuclei the size of a grain of rice. They are located above where the two optic nerves cross. Each one is comprised of thousands of nerve cells whose circadian rhythms are "set" daily by daylight.

Third photo-receptor



- Scientists in 2002 discovered a third photoreceptor in the retina (ipRGC).
- Its function is not visual.
- It is a special ganglion cell, distributed over the entire retina being more frequent and sensitive in lower part of eye.

Third photo-receptor



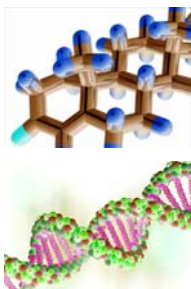
- Third photo-receptor (ipRGC) contains **melanopsin**, a light-sensitive protein .
- Melanopsin is most sensitive to the **blue light of the visible spectrum (460 nm)**.

Light acts as pacemaker



- The crucial cues for the SCN are provided by light.
- **ipRGC** send signals through the retinohypothalamic tract, which connects them directly with the **SCN**, the **pineal gland** and the **hypothalamus**: control center of the autonomic nervous system.

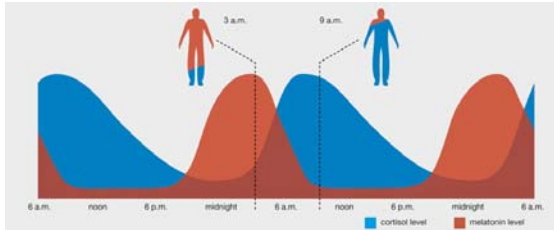
Hormones and genes



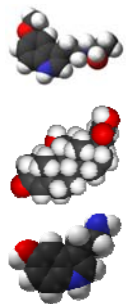
- Digestion, mood, sleep – human beings are governed by complex biochemical processes.
- Hormones and genes regulate when food is easily digested, when performance peaks, when sleep is at its deepest, when our body regenerates

Hormons: internal clock's messengers

Circadian rhythms are determined particularly by melatonin and cortisol because they impact on the body in opposite cycles.



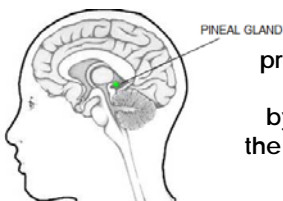
Hormons: internal clock's messengers



- **melatonin** – makes us feel drowsy, slows down bodily functions and lowers activity levels to facilitate a good night's sleep,
- **cortisol** – increases blood sugar, suppresses immune system, aids in fat, protein, and carbohydrate metabolism,
- **serotonin** – regulate mood, appetite, sleep, as well as muscle contraction

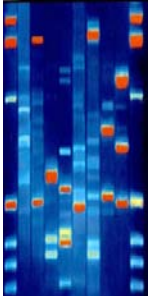
Hormons: internal clock's messengers

- In the evening, the pineal gland secretes melatonin, which makes us feel tired.
- In the morning, the level of melatonin in the blood then ebbs.



- The first sunlight promotes this genetically conditioned rhythm by additionally inhibiting the hormone's production.

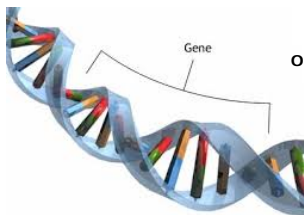
Genes react on light



- 51 % of all human genes reacts on environmental cues: light, temperature feeding times ...
- Regulatory genes have protein sleeves, which can be „removed“ by environmental cues (light) to express genes.

Clock gene

- Very important for maintaining the body functionality.
 - Impacted by depression.
- Shift and disruption lead to only marginally operation of 6 regions in brain, leaving only 2 intact: Hippocampus, Amygdala.
 - Light may reactivate these 6 regions.



Biological darkness



- Today life is less connected with natural rhythms:
- shifts and windowless buildings.
 - artificial lighting turning night into day.

Biological darkness



- But even where lighting is fully compliant with standards, the dynamism and biological effects of daylight are missing.
- “Biological darkness” impacts on human beings by disrupting their internal clock.

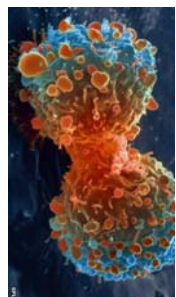
Biological darkness



Consequences:

- Heart diseases
 - Diabetes
 - Depression
 - Obesity
- Alzheimer's
- Parkinson's
- Cancer

Biological darkness



- Too much light = not enough melatonin.
- Melatonin influences our sleep but also DNE regenerations and tumor suppression.
- Some cancer types like breast cancer and ovarian cancer are more common at night-shift workers?

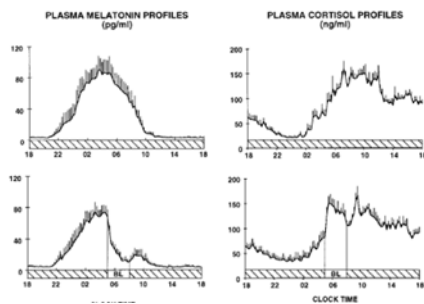
Direct effects of light



Beside
• Circadian effects,
which affect the daily rhythm

light also has
• direct (non-circadian)
effects, which have direct
impact on welfare and not
always affect the daily
rhythm.

Direct effects of light



Direct effects of light



- Direct effects include:
- light at night: reduces melatonin level and so disturb sleep;
 - bright light during day: decreased sleepiness and fatigue;
 - bright light in the morning: very quickly increases the level of cortisol;
 - temporary increased brightness in a room: increases alertness.

Direct effects of light

Not only luminance but also color of light:

- warm-white light: relaxes;
- day-white light: stimulates work.



Light as drug



Nature uses light to trigger different (healing) processes in our body (genes express or stay silent).

We will use light in a same way in a future (light on prescription)

Direct effects of light on health

Direct effects of light include also effects on our health:



- Wound healing
- Immune response
- Muscle coordination

e.g. patients in daylight rooms with view to outside spent in average 2,7 days less in hospital.

Light and health



Seasonal affective disorder (SAD), a mood disorder that occurs in the darker months of the year, can be successfully treated with light.

Daylight spectrum therapy devices



- Smaller devices for home use.
- Time monitored lamps.
- Sufficiently bright.
- Taking human pupil into consideration.

Technical requirements for therapy devices



- 8.000 to 10.000 cd/m²
- Large luminous surface area.
- High color temperature >6500 K.
- Illuminance at the eye level >2000 lx.
- Large portion of blue light.
- No UV light.

Light and health



Light can also be used as a therapy for other diseases:

- neonatal jaundice
- inflammation
 - edema
 - pain relief
- healing of wounds.

Light and health



Not only visible light influences human health but also infrared (IR) and ultraviolet (UV) light:

- we feel IR light as heat
- UV light causes some chemical reactions: browning, formation of vitamin D, accelerate exchange of substances in the muscles.

Light and health hazard

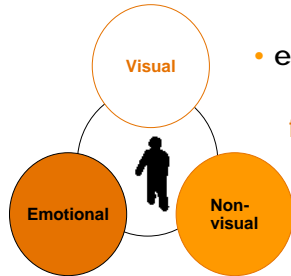


UV light

causes also negative effects: sunburns, injuries of the eyes (conjunctivitis – acute inflammation of the conjunctiva, which is 10 times more sensitive to UV light as skin).

Therefore it is necessary to protect the eyes from UV light with a wavelengths below 315 nm.

Emotional effects of light



Light:

- enables our **vision**,
- regulates the **functioning** of our body, and also
- influences our **emotions**.

Light and emotions



Where would you feel better?

Light and emotions

Light also affects the welfare of people:



- Good lighting increases attention and activity which contributes to improving job skills.
- Bad lighting make us feel uncomfortable and our willingness to work will fall

More than just vision



Today we know that lighting is much more than just providing good visibility of the observed objects.

How to make it biologically and emotionally effective?

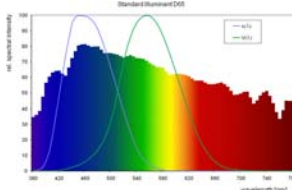
Biologically effective lighting



In many cases daylight can be used for interior lighting part of the day. For the rest we use artificial lighting.

Daylight is biologically effective so the artificial lighting should complement the daylight in interiors and not to compete with it.

Biologically effective lighting



- Needed parameters:
- **Illuminance** (500 lx to 1500 lx)
 - **Planarity** (ceiling and walls)
 - **Direction of light** (from front and above)
 - **Color temperature** (daylight or more (8000 K))
 - **Dynamism.**

Biologically effective lighting

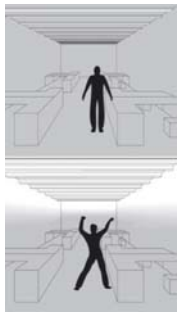


Biologically effective lighting should mimic daylight:

Dynamic lighting control:

- changes in illuminance,
- changes in color;
- changes in direction

Biologically effective lighting



Biologically effective lighting should mimic daylight:

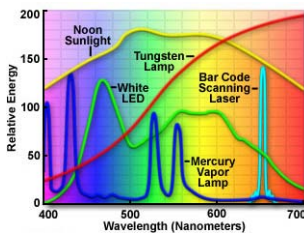
Natural light distribution:

- Light from above and from the front.
- Large area luminaires or reflecting ceiling and walls.

Biologically effective lighting

Biologically effective lighting should mimic daylight:

Natural light spectrum:



- The biologically effective range is the blue spectrum around 460 nm.

Some lighting design tips



Lighting features:

- It should meet all visual requirements (EN 12464).
- Attention should be given also to luminous distribution.
- No glare or other disturbing effects.

Some lighting design tips



Color of light:

- Dynamic if possible: colder during the day, warmer at evening.
- If not dynamic than according to use of interior: colder for work, warmer for relaxation.

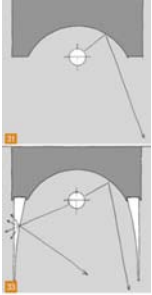
Some lighting design tips



Spatial distribution of light:

- Large area luminaires.
- Indirect luminaires which illuminates ceiling and upper part of walls.
- Ceiling and wall washers.

Some lighting design tips



Materials:

- Optical control elements of luminaires (louvers, enclosures, prisms) should not change the spectrum of light.
- Also the colours of interior can change spectrum (red and brown absorb blue light).

At the end

- Light affects not only our vision but also our functionality, health and welfare.
 - Daily contact with outside world (daylight) is important for our internal clock.
 - Biologically effective lighting has a positive influence on the overall human functioning.

... and now:

Questions?
