IEA SHC Task 61 / EBC Annex 77

Integrated Solutions for Daylight and Electric Lighting

Subtask A:

User Perspective, Requirements

Coordination: Barbara Szybinska Matusiak, NTNU, Norway
email: barbara.matusiak@ntnu.no

Objective: Consolidation of available knowledge on user-, activity- and time-depending visual and non-visual ***requirements***.

Set up ***use cases*** in specific applications, reflecting typical temporal changes in the usage of these interior spaces.

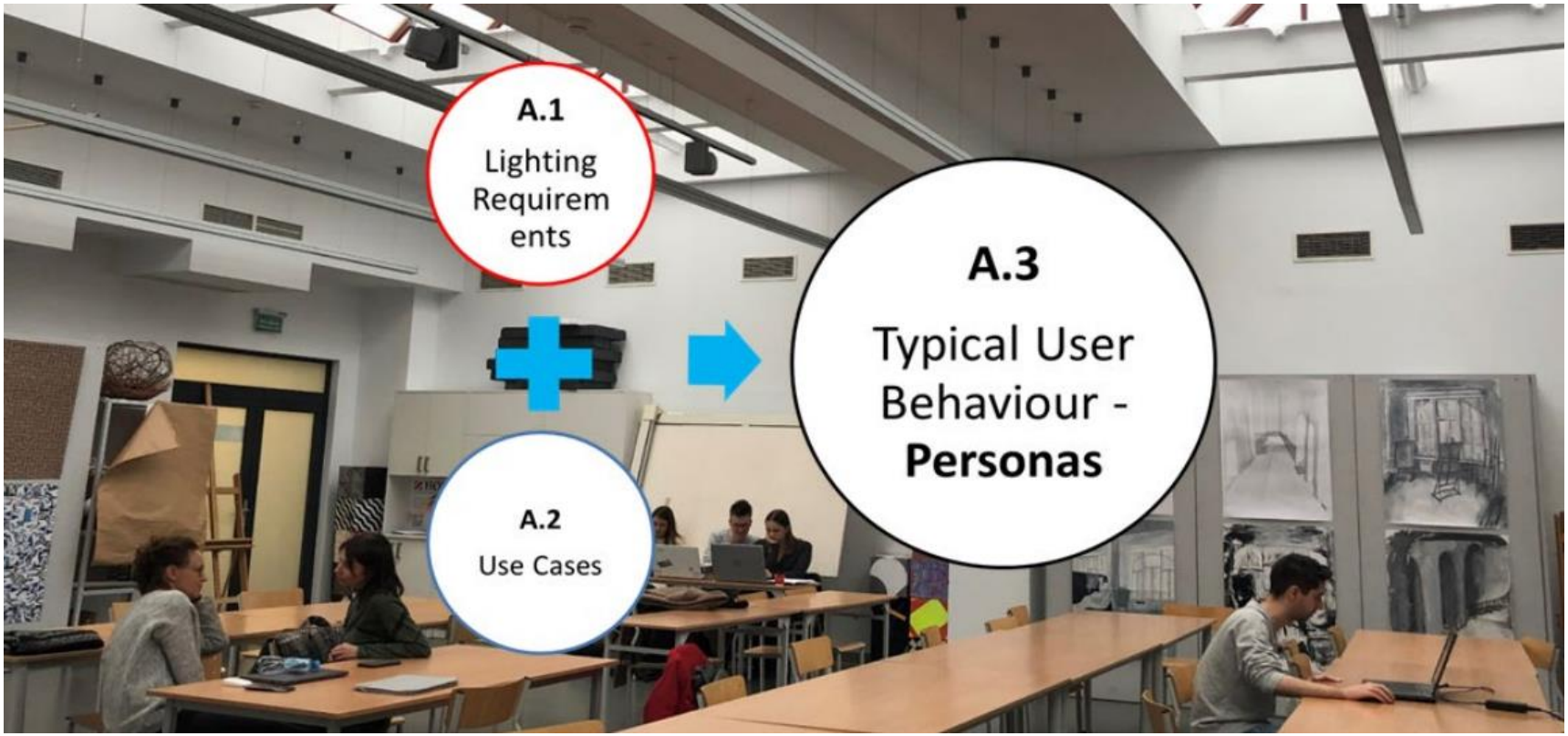
Aggregation in so called ***personas*** as representations of the behaviour of a hypothesized group of users in the defined applications.

Daylight vs electric light

Subtask A:

User Perspective, Requirements

Coordination: Barbara Matusiak, NTNU, Norway
Participation: Austria, Brazil, Italy, Japan, Norway and Poland



Starting from the lighting quality

Lighting quality is a concept that allows excellent vision while providing high comfort.

This definition of lighting quality focuses on humans, but it does not take into consideration aspects of light that has non-visual impact on human health and well-being.

- Visual perception
- Visual comfort
- Psychological effects (well-being)
- Non-visual effects (health)

Visual Perception

Visual acuity

Visual acuity is understood as the speed and accuracy of processing visual information, and is strongly influenced by lighting. Daylight is a very good source of light to support visual performance during the daytime.

Recent research strongly suggests that the amount of light affects children as they grow and determines whether they will develop **myopia** or not. Myopia, or short-sightedness, is the most widespread visual disorder affecting young people, it has reached an epidemic level in Asia and is increasing everywhere.

Some studies refer that the risk of myopia is lowered by exposure to daylight and increased by activities performed at short visual distances (close-up work). A person with little exposure to daylight has a fivefold risk of developing myopia.

Age

perception by touch

The visual recognition of object shape is different from haptic recognition in multiple ways: visual shape recognition can be superior to that of haptics and is affected by aging, while haptic shape recognition is less accurate and unaffected by aging.

Some researchers suggest that middle-aged adults' abilities to perceive and discriminate 3-D shape from motion are similar to those of younger adults. It appears, therefore, that the negative effects of increasing age on 3-D perception do not become substantive until the age of 65–70 years.

Emotional status

Since visual perception is an active process the emotional status and other background factors influence the visual perception, **happy participants can judge the room to be brighter than sad participants.**

Cultural differences

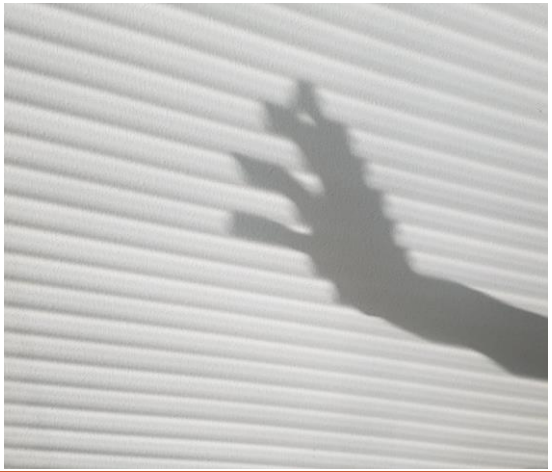
Cultural differences have been found, especially regarding the CCT. In some experiments aiming to investigate the effect of lighting on the perception of the atmosphere in a living room, using three types of light sources: halogen, fluorescent and LED lamps **a higher CCT source would make the room livelier for Chinese observers but less lively for Dutch observers.**

Visual Comfort

Flicker

Flicker may be divided into two types. One that is visual, i.e. it is possible to detect the flickering light with the eyes, and the other which is often named subliminal i.e. the flickering light is not consciously detected by humans, but the brain is registering the flicker.

Flickering lights can be uncomfortable to look at and can induce seizures in observers with photosensitive epilepsy. Subliminal flicker may cause **headache**, and **impaired cognitive performance**.



Glare

In a semi-controlled study in a test room with direct access to daylight and to an external view the researchers detected a tendency towards an **increasing tolerance to discomfort from daylight as the day progresses**.

It seems that glare sensation from electrica lighting also varies with time of the day. A laboratory study showed a tendency towards **greater tolerance to luminance increases in artificial lighting as the day progresses**. Additionally, the time interval between test sessions maters.

The temporal variation of glare response was found to be also influenced by the **difficulty in extracting information** from the visual stimulus.

Moreover, statistically significant and substantive evidence was detected of a **direct effect of fatigue and caffeine ingestion**, and **an inverse influence of food intake, on reported glare sensation**.

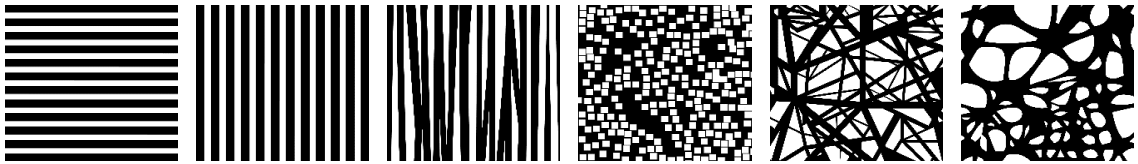
The factors that almost certainly do not influence discomfort glare perception are

the gender and **optical correction** of the observer

Contrast

The human visual system is more sensitive to contrast than to the absolute luminance, therefore humans can perceive the world similarly regardless of the huge disparities in illumination levels over the daytime and space.

Façade geometry and associated sunlight patterns have **significantly influence subjective responses**. Analyses showed differences mostly between the Irregular and Regular patterns, with the former being evaluated more positively.

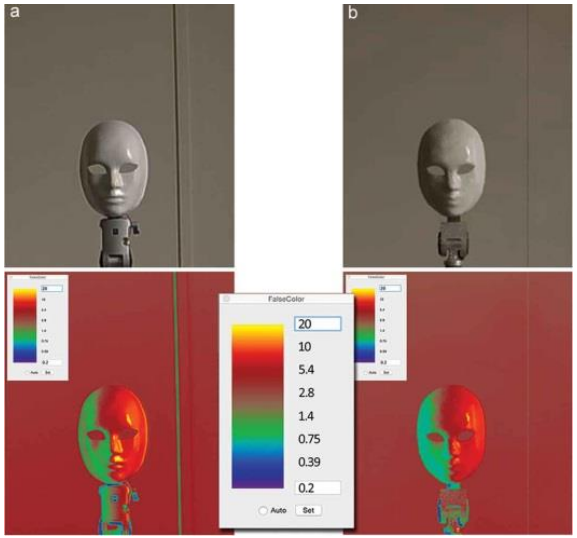


Façade and sunlight pattern geometry affected also heart rate. Participants showed a larger decrease in heart rate while exposed to the Irregular condition compared to the regular Blinds.

Contrast

In another study the researchers found that Luminance-based measures are useful for evaluation of visibility of objects contour as well as shape and details of objects. The analytical comparison showed that the **contrast measurement** or **luminance ratio** between luminance of the object and luminance of the background, are good predictors for contour distinctness of the observed 3D objects.

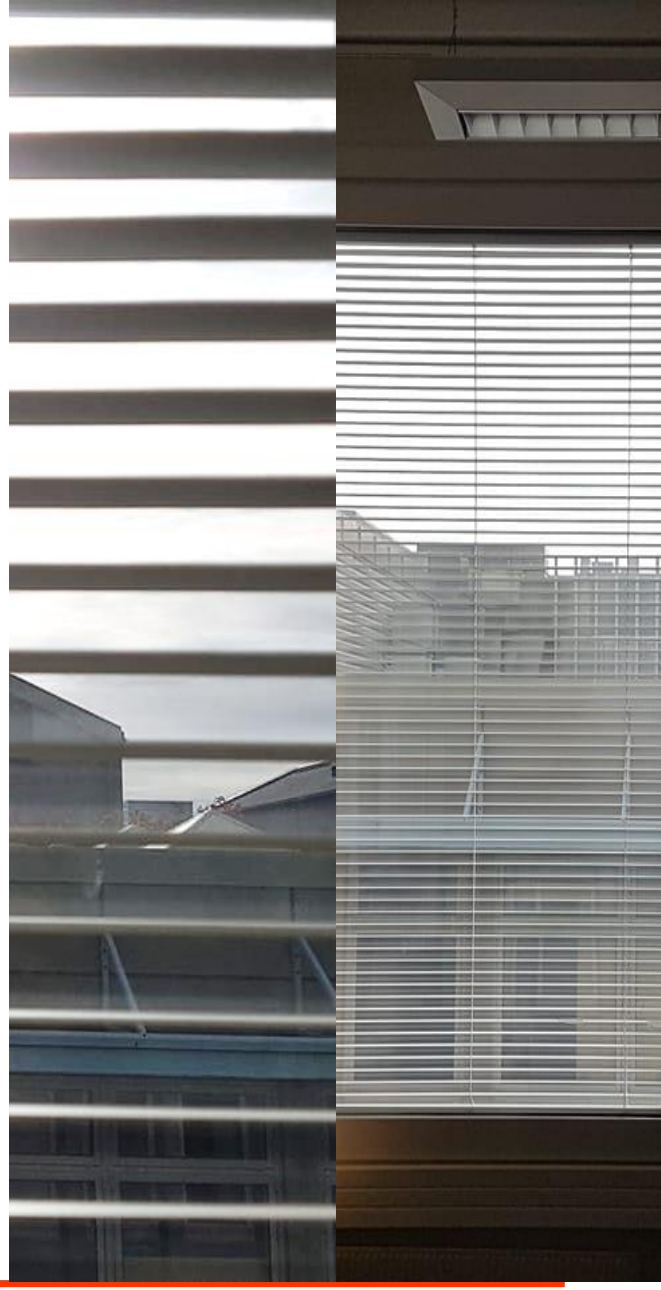
The result shows that the contrast plays an immense role for our understanding both shape and colour.



Spatial frequency

One source of visual discomfort is when images have spatial frequencies that deviate from the frequencies typical for natural scenes, especially if they give strong stimulus at the medium frequencies at which the visual system is most sensitive.

The visual system is optimized to encode images of natural scenes.



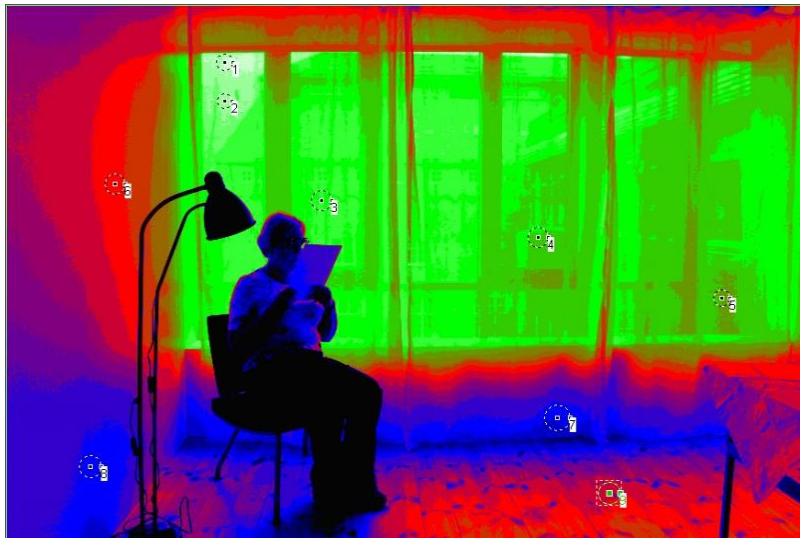
Psychological effects of light (well-being)

Behavioural effect of light

Most people prefer to follow a daylight cycle instead of a constant level of light.

Preferred lighting levels are **significantly higher** than today's indoor lighting standards and **correspond to levels where biological stimulation can occur**.

Good holistic lighting, has significant effect on pupil’s learning progression.



Quality of the view out

People should have access to windows giving good view out in terms of

-information about the outdoors,

-restoration from tiredness or stress (greenery important here)

-aesthetical experience (nice and well-kept buildings and trees)

Perceived quality of interior space – daylight

The size of windows should not be minimized as this not only limit the view, but also has negative effect at the perceived quality of the space, specifically on: **spaciousness**, **openness**, **pleasantness**, **excitement**, **legibility** and **coherence**.


Figure 1: WR – D1


Figure 2: WR – D2


Figure 3: WR – D3


Figure 4: BR – D1

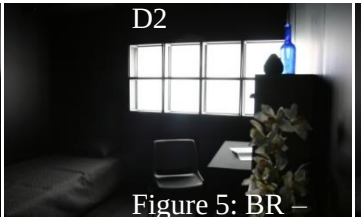


Figure 5: BR – D2

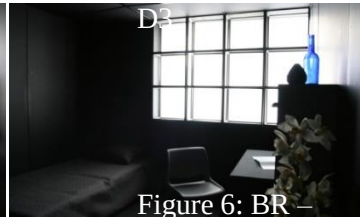


Figure 6: BR – D3

Perceived quality of interior space – electric light

Lighting has clear impact on the two underlying dimensions: **liveliness** and **coziness** of the space. In general, the increase of luminance makes the space appear livelier.

Non-image forming aspects (health)

The ipRGC is not the only photoreceptor that has an impact on photo entrainment. Both rods and the three different types of cones seems to influence the photo entrainment. As a consequence, a spectral distribution where **all wave-lengths are represented** seems to be important

We must divide the non-image forming effects of light into two: **long-term** and **acute** effects. Furthermore, the previous exposure to light with certain spectral composition and intensity is also of great importance.

Direct, acute effects of increasing the intensity of polychromatic white light has been found to increase subjective ratings of alertness in a majority of studies, though a substantial proportion of studies failed to find significant effects.

Prior light exposure influences the sensitivity of the ipRGCs.

The phase-response curves presented until now are consistent in showing that light exposures in the late evening phase-delays the circadian clock and light exposures in the late night and early morning phase advances the circadian clock.

There are differences related to chronotype, age and gender. There are also changes in chronotype over time. Girls and women seem to be significantly more morning oriented than boys and men. Younger children are more morning oriented and become rapidly evening oriented during puberty, while the more attenuated turn towards morningness occurs from the age of 20 years. Then from the ages 25 to 30 morningness-eveningness remains rather stable.

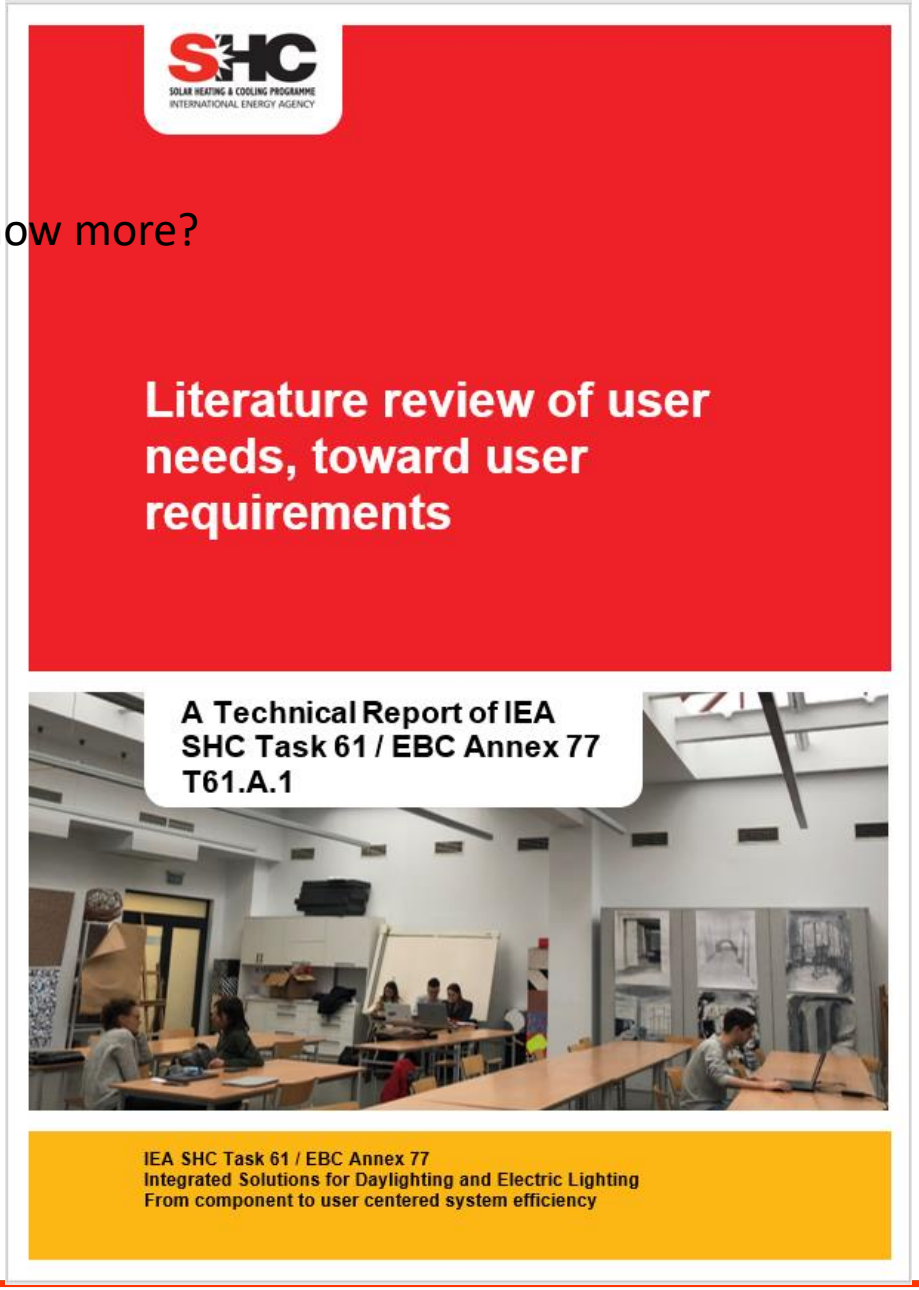
Elderly people display a higher risk for disturbed circadian rhythm. One of the possible causes of disturbed circadian rhythms and sleep in the elderly may be impaired photic input to the circadian clock. Age-related changes in lens density are known to reduce the transmission of short-wavelength light, which has been shown to be most effective in suppressing nocturnal melatonin. Also, changes in the neurophysiological pathways may be of importance.

Adolescents living in brightly illuminated urban districts had a stronger evening-type orientation than adolescents living in darker and more rural municipalities. This result persisted when controlling for time use of electronic screen media, intake of stimulants, type of school, age, puberty, time of sunrise, sex, and population density.

	Daylight		Electric light	
Parameter	Measure	Standard value	Measure	Standard value
Workplace illuminance General	Target illuminance of daylight provision from windows	≥ 300 lux on the working place level ≥ 50 % of the yearly daylight hours ≥ 50 % of the space area	Mean E_h on the desk	Together with daylight ≥ 500 lux
	Spaces with skylights	as for windows but ≥ 95 % of the space area		
Workplace illuminance Visual demanding	Daylight provision from windows	≥ 750 lux on the desk ≥ 50 % of the yearly daylight hours	Mean E_h on the desk	1 000 lux
Workplace illuminance homogeneity General	Minimum target illuminance of daylight provision from windows	≥ 100 lux on the working level in room ≥ 50 % of the yearly daylight hours ≥ 95 % of the space area	Uniformity U_o (E_{min}:E_{mean}) on the desk	≥ 0.6
Workplace illuminance homogeneity Visual demanding	No measure	*Low level of uniformity on the desk by daylighting is mostly accepted*	Uniformity U_o (E_{min}:E_{mean}) on the desk	≥ 0.7
For more parameters, see the report IEA Task 61 SA 1.1 Literature Review of User Needs, Toward User Requirements.				

Figure 2: A part of a table showing integrated lighting recommendations.

Do you want to know more?



Thank you!