

# *Healing with light*

*in a psychiatric context*

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A research-based lighting design concept proposed for  
treatment of eating disorder patients in Denmark



Master thesis  
MSc Lighting Design  
Pernille Bech-Larsen

«  
PHOTO 1  
FRONT PAGE  
SANAA, RYUE NISHIZAWA & REI NAITO,  
TESHIMA ART MUSEUM,  
IMAGE: VINCENT LEROUX

*“It was one of  
those March  
days when the  
sun shines hot  
and the wind  
blows cold:  
when it is  
summer in  
the light, and  
winter in the  
shade.”*

Charles Dickens  
Great Expectations



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Healing with light in a psychiatric context: *A research-based lighting design concept proposed for treatment of eating disorder patients in Denmark*

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## ABSTRACT:

The focus in this thesis revolves around the healing effects of light in a modern psychiatric context, with treatment of eating disorder patients as the primary aim.

The investigation of the topic includes research in symptoms and behaviour of patients with severe eating disorders. As patients are extremely sensitive and unstable, care professionals from Danish eating disorder facilities have been interviewed about the illness and treatment to avoid observation. A comprehensive study in the use of circadian lighting and light therapy in psychiatric treatment is implemented to explore context and comorbidity.

Investigations of lighting design in new psychiatric facilities are included in a Danish state of the art section as well as current lighting standards. Criteria for a lighting design developed with eating disorders in mind is formed based on these findings.

In conclusion, a research-based lighting design concept has been proposed, for a 24-hour treatment facility, including a customised circadian lighting schedule.

Hypotheses are to be tested and evaluated in an upcoming clinical trial in Spring 2018.

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« PHOTO 2  
HOUSE IN UTSUBO PARK, TADAO ANDO

## ***Abstract***

The focus in this thesis revolves around the healing effects of light in a modern psychiatric context, with treatment of eating disorder patients as the primary aim.

The investigation of the topic includes research in symptoms and behaviour of patients with severe eating disorders. As patients are extremely sensitive and unstable, care professionals from Danish eating disorder facilities have been interviewed about the illness and treatment to avoid observation. A comprehensive study in the use of circadian lighting and light therapy in psychiatric treatment is implemented to explore context and comorbidity.

Investigations of lighting design in new psychiatric facilities are included in a Danish state of the art section as well as current lighting standards. Criteria for a lighting design developed with eating disorders in mind is formed based on these findings.

In conclusion, a research-based lighting design concept has been proposed, for a 24-hour treatment facility, including a customised circadian lighting schedule.

Hypotheses are to be tested and evaluated in an upcoming clinical trial in Spring 2018.

## ***1.1 Introduction***

Research in lighting design is a fairly new discipline. It is a field that is still lacking evidence and evaluation of methods and the amount of previous results and data is thus limited. When approaching lighting design (LD) and related research in connection to severe eating disorders (ED), the pool of data is even smaller and the aim of studies vary based on the background of the researcher. It is to be presumed that the broad spectrum of professional backgrounds involved, (doctors, psychiatrists, psychologists and lighting designers) approaches the topic differently to a very high degree, as each profession takes different factors in ED treatment into consideration. The effect of light therapy on ED have only been investigated in limited ways and never with LD in mind, as lighting design research is a very recent way to approach this.

The objective of this study is to investigate the healing possibilities of light and how light affects the human body and mind. From a broad study of the healing effects of light, the focus will be on different studies within psychiatric illnesses, and from this potentially initiate future cooperation between LD and psychiatric treatment. Finally, findings will be evaluated according to symptoms and behaviour in Anorexia Nervosa (AN) and Bulimia Nervosa (BN), to approach possible overlaps in comorbidity and treatment.

Since 1903, where the Danish physician Niels Ryberg Finsen (Niels Ryberg Finsen - Biographical, no date) won a Nobel Prize for his treatment of tuberculosis using ultraviolet light, light has been a known treatment form for various diseases. Names as heliotherapy, photo therapy and sun light therapy became common and well-known as treatment forms. In 1930, Dr. Auguste Rollier, who was the most famous heliotherapist of the time, found that sunbathing early in the morning, combined with a nutritious diet, produced the best effects. By the year 1933, sunlight had proved to be a beneficial treatment for more than 165 different diseases. In relation to this, Dr. Rollier found that the healing sunrays were ineffective if his patients wore sunglasses.. (Rollier, 1921)

Connecting the treatment to the photoreceptors in the visual system, and by this the Suprachiasmatic nucleus (SCN). This links his research to the biological clock, and to the 2017 Nobel Prize winners (Physiology or Medicine) Jeffrey C. Hall, Michael Rosbash and Michael W. Young "for their discoveries of molecular mechanisms controlling the circadian rhythm". (The Nobel Prize in Physiology or Medicine 2017, no date) This joint effort provided ground-breaking findings of how the internal clock is connected to our everyday exposure to daylight and artificial light, potentially leading to discoveries within Circadian Lighting (CL). LD for offices and health sector has become more acknowledged world-wide in the later years and currently dynamic lighting for circadian stimulation is being implemented in modern health care in Denmark.

Current implementation of LD and CL in the Danish health care sector has only been evaluated to a minimal extend or not at all. In the implementation process of integrating LD in the new super hospitals, the main focus has been on improving sleep quality. This applies for both patients and the professional staff.

Until now, research in circadian lighting has shown positive outcomes in fields as Dementia, Seasonal Affective Disorder (SAD), jet lag, stabilising daily rhythm in night time workers and hopefully future research will show benefits in treatment of related illnesses. Alzheimer, bipolar disease, depression and anxiety are already in the scope and by initiating a study of patients with severe eating disorders, it is anticipated that lighting design can play a role in the future treatment.

Eating disorders (ED) is a group of serious mental illnesses, all related to body weight and food intake. All forms of eating disorders are possibly dangerous, but severe AN has the highest mortality rate. Patients struggle with this nutrition and control based anxiety, that can seem incomprehensible to outsiders, but facts state that more than 70% of ED patients will never fully recover and the treatment is to this day very experimental (Anoreksi, prognose - Patienthåndbogen - sundhed.dk, no date). Currently, the only common denominator is to use cognitive therapy and to shape the treatment until something works. (Interview E, 00:22:09)

Every time something is designed, the end user should be in focus, so understanding the disease became an important objective in the process of working with the lighting design. People have different needs, depending on age, cultural background, state of mind and internal body clock and this also applies to ED patients. (Zavada et al., 2005) Different segments will react in different ways, so it was especially important to learn, and understand the mindset and behaviour of people struggling with ED. The more you learn about ED, the harder it is to understand how something as instinctive as eating can become ones worst enemy and in some cases, be mortal.

*"Everything you can imagine is real"*

*Pablo Picasso (footnote\*\*)*

This short sentence can be interpreted as both freedom and prison. When your imagination is used for freedom and creativity, all is good, but as liberating as this statement might seem, a person that suffers from anxiety may have a different take on the freedom of believing in their imagination than Pablo Picasso, when he said this.

When you believe that food is your enemy and spend every second of the day trying to control your calorie intake and everything you put in your mouth, your imagination can become a prison. When ED gets out of hand, this control issue will start affecting more than weight loss. Soon, the general state of health will be challenged emotionally, somatically and cognitively.

Professionals describe dealing with ED in different ways, but a sentence like “the ED tells the patient” is reoccurring ways of describing anxiety and control issues. (Interview H, 00:05:20, 00:09:20, 00:18:47) On top of this voice, ED is connected to a line of comorbid illnesses, such as depression (50-75%), menopause, ADHD, OCD, anxiety, diabetes, self-harm, personal disorder (33%), Bipolar (4-6%) (©Sundhedsstyrelsen, 2016). Treatment in ED is not focusing on what is comorbid disease and what is part of the ED, as it can be hard to distinguish in severe cases, but generally treatment is focussed on both somatic and cognitive state of the patient.

Light therapy has only been tested to a low degree in connection to ED, even though it is a non-invasive treatment form. Side effects reported in studies within other patient groups have mainly been connected to Bright Light Therapy (BLT), resulting in headaches and nausea. (Pail et al., 2011; Jurvelin et al., 2014)

Previous findings suggest that food intake and state of mind could be connected. If LD or light therapy can make a small difference for AN and BN patients, then the following investigations will hopefully shed some light on this.

## **1.2 Research case:** *Psykiatrisk Center Ballerup, Center for spiseforstyrrelser*

In a new 24 hours housing facility for patients with severe ED in Psykiatrisk Center Ballerup (PCBA ED) a line of experiments with CL is currently planned for Spring 2018, as part of a Lighting Metropolis cooperation between Aalborg University (AAU), Region Hovedstadens Psykiatri and Zumtobel. AAU will be in charge of CL scenarios and collecting data, HSP will be in charge of the clinical tests and Zumtobel will deliver fixtures for the eating area.

The new PCBA ED facility consist of five consecutive buildings designed by Rubow Architects, starting with an open day centre and ending in a 24-hour facility with twelve rooms for patients with ED stage 1-3. This building is numbered 55 and will be referred to as "PCBA ED 55".

PCBA ED 55 is not an intensive care unit, which differs in the freedom of the hospitalised patients, how they are allowed to move around in and outside the facility.

According to the protocol for the future research project "The effects of artificial lighting on symptoms of eating disorder" the objective will, among others be focussed on "exploring if and how artificial lighting affects symptoms of eating disorders (ED)". Practically, the study will consist of three lighting scenarios, each will run for duration of one month. During the three periods, all movement of the patients will be tracked via specialised PIR sensors, allowing privacy for the patients and following ethical guidelines. The study will investigate if CL will have an effect on the behaviour and symptoms of the patients. (Sjögren, Mullins and Triantafyllidis, 2017)

## **1.3 Vision**

Inspired by the upcoming research project, this thesis will seek to determine if there is any reason to expect that the lighting design, and especially CL will show any effect on the emotional, cognitive or somatic symptoms in PCBA ED 55 inpatients. By investigating the positive effects of light in the treatment of a range of psychiatric diseases, the hope is to be able to determine if lighting design can add to the treatment of AN and BN.

*"What if **light therapy** could make a positive contribution to the non-invasive treatment process of severe eating disorders, by **calming** the inpatients and ED related anxiety, **accelerate** the healing process by stabilising the circadian rhythm and **reducing** the hospitalisation time, creating a **personalised and comforting** environment, while sustaining the demands of a **professional** work environment? "*

## ***1.4 Research question***

Based on the coming research project in PCBA ED 55 and the lack of knowledge on the topic, this master thesis will investigate the effects of light therapy in ED treatment.

As a tool to work with the PCBA ED 55 facility and engage the different characters of the spaces, the initial objective of this thesis is to answer the following research question:

*“Can lighting be used as part of the treatment (**healing**) of severe eating disorders in a 24h facility, calm the patients (**atmosphere**) and still support a professional work environment (**function**)?”*

The lighting design is considered to add:

- **Healing:** *When it is a tool for a faster healing process by enhancing rest, sleep, motivation and minimise comorbidity by intentionally stimulating the human biological clock.*
- **Atmosphere:** *When it is calming and comforting for the patients emotionally and aesthetically, by stimulating the anxiety and positively affects the mood and overall wellbeing.*
- **Function:** *When it supports the professional functions of the staff throughout day and night with minimal disruption of their sleep, giving the staff a better work environment.*

## ***1.5 Methodology***

The nature of this thesis is to evolve around a future research project. Being a pre-project for a future clinical study with the patients in PCBA 55, actual tests and final measurements will be part of future investigations. This combined with that fact that the finishing of the building is still in process, prevents actual test in this preface. As a consequence, the tools and methods used in this thesis are more analytical than practical.

Through a mixed methods-approach, combining the findings from an extensive literature review, state of the art investigations, interviews, observations and qualitative measuring methods, a lighting design concept including circadian lighting, for the new PCBA ED 55 facility will be suggested.

Different methods have been used in order to obtain information within this narrow topic. As previous results concerning lighting and ED are limited it has been a necessity to find useful information through alternative channels. Initially, focus and importance was understanding the nature of ED as a mortal and mental disease. To be able to understand the behaviour and state of mind of ED patients, a line of expert interviews was carried out with qualified professional personnel such as nurses and psychological therapists within the ED field. A visit to the current ED facility in PCBA provided knowledge on the current situation, both concerning daily schedule, architecture, spaces, eating facilities and lighting design.

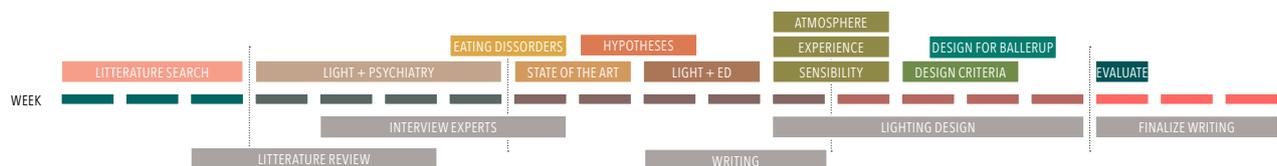
When the patients move into the newly build facility, it will be completed with healing architecture, designed with focus on ED patients. These new building could play a role in the results from the study of the circadian lighting. In this context, a brief investigation of Danish state of the art, within healing architecture with circadian lighting has been carried out. Taking the lack of evaluation in CL systems into consideration, this section is merely a brief introduction to other facilities.

The character of the study will, to a high degree be analytical, as this thesis will concentrate on existing research, combining lighting design and ED treatment. A process of self-evaluation on the hypotheses developed, based on the findings from this thesis, will conclude this thesis. Future results from the upcoming study can provide further information on the evaluation of the hypotheses and a final conclusion as future work and ways to apply the research will be discussed.

## 1.6 Process overview

The structure follows the thesis process working through the different steps (Graphic 1 w. timeline) in order to understand the complexity in ED and how to address this with light.

Graphics, sketches and images will form the visual guidance throughout the thesis process. The final LD will be formed as a concept and design principles for working with LD in ED treatment. A list of illustrations can be found after the references.



Graphic 1: Thesis proces

## ***2.1 Background***

The initial research question will form the foundation for this literature review, "focusing on the effects and influence that natural and artificial light can have on the human body". As research connecting light and ED is limited, the main objective will be to map out the known effects of light on the human body and subsequently connect this to AN and BN.

In terms of establishing a ground of knowledge and insight on the topic, being able to elaborate on the initial problem statement, relevant areas concerning light therapy, mental illness and research in circadian rhythm (CR) has been investigated. The focus will be to map out positive findings from research in light therapy, establishing common ground.

By investigating current research in the use of light in therapy and recent studies with patients connected to a variation of illnesses, findings can be linked to symptoms and behaviour in ED and overlaps can be discovered. Diurnal conditions like Jet Lag and sleep deprivation has also been taken into consideration.

The following literature review will thus provide knowledge within essential research areas of lighting in psychiatry. Definitions of CR, biological clock, neural and hormonal definitions will be elaborated on, as well as ED, symptoms and behaviour. Cognitive, emotional as well as somatic effects that can be connected to ED will be emphasised.

## 2.2 Search strategy

In the following, a thorough search methodology was initiated but the lack of material resulted in a search of a higher degree of variation based on reference lists and keywords.

Google Scholar + AUB Library search engine:

- a) *Psychiatry AND lighting*
- b) *Psychiatry AND eating disorders*
- c) *Psychiatry AND (light treatment) AND (eating disorders)*
- d) *Psychiatry AND lighting AND (eating disorders) -*
- e) *(Bright light therapy) AND (eating disorders) +*
- f) *(Vitamin D3) AND (eating disorders)*
- g) *Sleep AND (eating disorders)*
- h) *Light AND Body AND mind*
- i) *(Light therapy) AND (eating disorders)*
- j) *Circadian Lighting AND (eating disorders)*

As a result of the narrow field of ED and light in treatment methods, it was not possible to gather enough information from the above-mentioned methodology. A new search strategy was applied, where a line of relevant keywords were explored. Later on, additional relevant literature were gathered through references from the found material.

**Keywords and search terms:** *Chronotype, Endocrinology, The Blue hour AND Melatonin, Heliotherapy AND Eating disorders, Phototherapy AND Eating disorders, Body temperature, Circadian rhythm, Body clock, diurnal, light therapy, blue light, bright light therapy, mental illness AND light therapy ...*

As the literature search was expanded, the breadth of knowledge did as well, resulting in a shift in focus. In the following literature review, a line of external circumstances has been sought out and elaborated on.

## 2.3 Circadian Rhythm

The daily sleep/wake cycle, is popularly known as the CR and part of the chronobiology, covering all biological rhythms that takes part in all natural cycles. These cycles are repeated over and over again like (a day) daily, (the tide) tidal, (the four seasons) seasonal, (a year) and annual. Circadian originates from "Circa" "Diem" and means more or less "about a day".

It is very easy to manipulate the CR, as this rhythm is endogenous and easily adjusts to our habits and environment. The flexibility makes jetlag a temporal condition. Daylight is a very successful manipulator as this is highly effective of stimulating the Suprachiasmatic Nucleus. Strong stimuli like daylight, food, muscle activity and social contact can work as circadian time givers. They are popularly named as "Zeitgebers", as they can synchronise our CR and circadian hormone cycles. In addition, it also stimulates mood, energy, metabolism, sleep and recovery depending on exposure to daily cycles of natural light. (Schibler et al., 2003; Wirz-Justice, 2006; West, Simonson, et al., 2017)

When the CR is being disturbed by exterior factors it can cause a disturbance in the biological clock. This is often connected to sleep deprivation, problems focusing and can be connected to jetlag or shift work. As a diagnosis it is called Circadian Rhythm Sleep Disorder. (Wirz-Justice, 2006) *"Shift Work Type: insomnia during the major sleep period or excessive sleepiness during the major awake period associated with night shift work or frequently changing shift work"* (American Psychiatric Association. and American Psychiatric Association. Task Force on DSM-IV., 2000)

CR and healthy sleep is a "hot topic" at the moment, following important findings and the recent Nobel Prize. People are in general getting more aware of how light and darkness affects their sleep and mood. Especially on avoiding and filtering out the blue light from computer screens and the self-emitting screens on tablets and smart phones. TED talks (Russel Foster, Why do we sleep?) and news articles about sleep, stress and the relation to light and Melatonin is slowly becoming part of healthy and stress-free living. (Friedman, 2017)



**Table 24.2-12**  
**DSM-IV-TR Diagnostic Criteria for Circadian Rhythm Sleep Disorder**

- A. A persistent or recurrent pattern of sleep disruption leading to excessive sleepiness or insomnia that is due to a mismatch between the sleep-wake schedule required by a person's environment and his or her circadian sleep-wake pattern.
- B. The sleep disturbance causes clinically significant distress or impairment in social, occupational, or other important areas of functioning.
- C. The disturbance does not occur exclusively during the course of another sleep disorder or other mental disorder.
- D. The disturbance is not due to the direct physiological effects of a substance (e.g., a drug of abuse, a medication) or a general medical condition.

Specify type:

**Delayed sleep phase type:** a persistent pattern of late sleep onset and late awakening times, with an inability to fall asleep and awaken at a desired earlier time

**Jet lag type:** sleepiness and alertness that occur at an inappropriate time of day relative to local time, occurring after repeated travel across more than one time zone

**Shift work type:** insomnia during the major sleep period or excessive sleepiness during the major awake period associated with night shift work or frequently changing shift work

**Unspecified type**

*Figure 1: DSM-IV-TR Diagnostic criteria for circadian rhythm sleep disorder (American Psychiatric Association. and American Psychiatric Association. Task Force on DSM-IV., 2000)*



### 2.3.2 Hormones related to circadian rhythm

The circadian rhythm is connected to a line of hormones that regulate different processes in the human body according to variables as body temperature, sleep/wake, satiety, stress and event happiness (#Figure2+3). A short introduction to important regulators will follow.

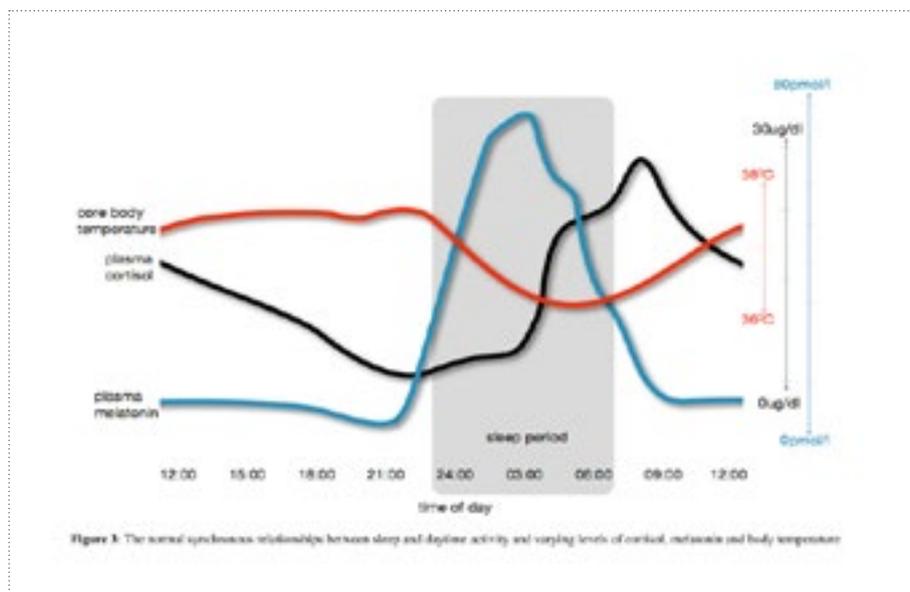


Figure 3, mammalian hormone levels (Hickie, I. et al, 2013)

#### 2.3.2.1 Melatonin (sleep)

Melatonin regulates the biological clock [section 2.3.1] that is controlled by the suprachiasmatic nucleus (SCN) turning different hormones on and off. The sleep-hormone Melatonin is produced by Corpus Pineale, closely connected to SCN producing higher levels in the dark hours of the day and low or non-detectable blood levels during daytime. (sundhed.dk, 2017)

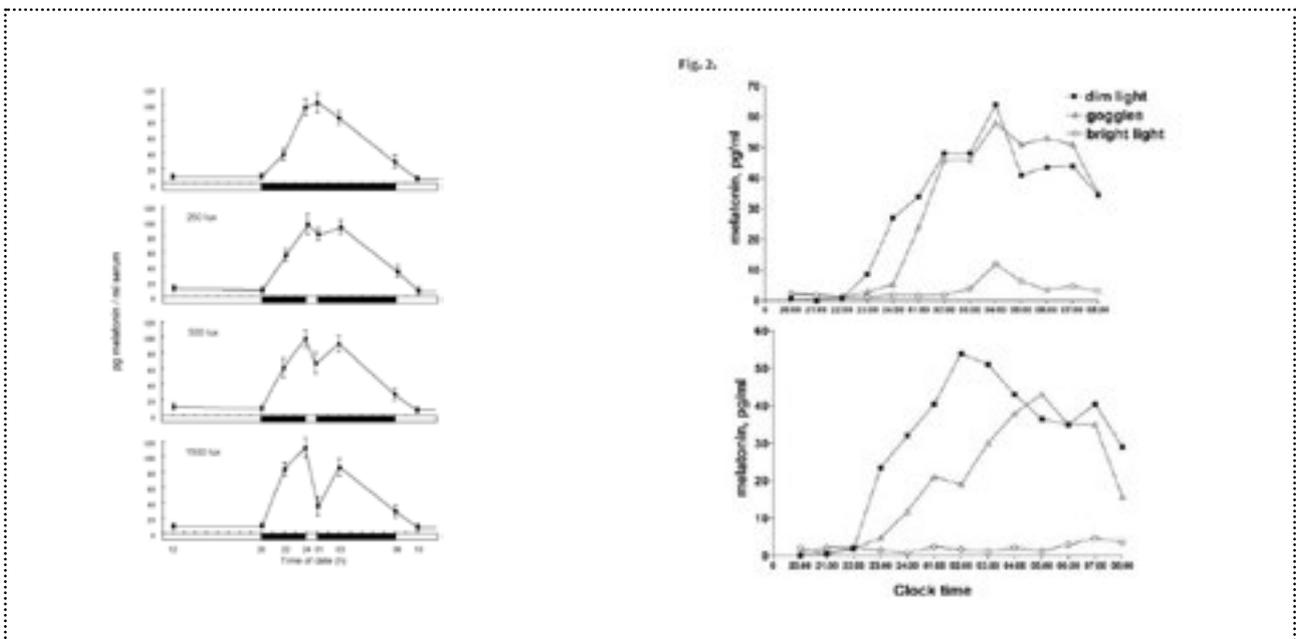
People with phase shift advance or delay can benefit from BLT [section 2.6.1] regulating the Melatonin segregation or as medication.

Low levels of Melatonin occur in depression, but Mortola et al, found that Melatonin segregation rhythms are not differing from normal persons, to patients with AN and BN, without signs of depression. (Mortola, Laughlin and Yen, 1993) Fasting in healthy adults showed lower night-time Melatonin levels, but AN shows conflicting results. (Kennedy, 1994) Findings suggest no significance in the reduction of nocturnal Melatonin, so low weight will not affect or disturb the Melatonin rhythm. In AN, not restrictive (with b/p) elevated Melatonin levels could suggest that it is regulated by the activity in neurotransmitters connected to this.

Connecting sleep depression and shift-work, and by this Melatonin to cancer is an important focus, as the biological clock is highly effected by artificial light at night (ALAN). Breast cancer in female night shift workers, has been studied among nurses and strong connections were argued. ALAN should be of high importance when designing night lighting for health care environments.

Effects of different brightness and wavelengths on Melatonin are still being investigated, but tendencies towards avoiding strong blue light are dominant. (Schernhammer et al., 2001; Pauley, 2004; Figueiro and Rea, 2010; Cho et al., 2015) In a study By Wright et al, 204, where "Two long wavelengths, 595 nm (amber) and 660 nm (red) and three shorter wavelengths, 470 nm (blue), 497 nm (blue/green), and 525 nm (green) were compared with a no-light control condition." significant results suggest that the human circadian system reacts stronger to shorter wavelengths. (Wright, Lack and Kennaway, 2004) Low wavelength light can be succesfully blocked by orange tinted goggles. (Kayomov et al, 2005)

Interest in the role that light plays in the nocturnal melatonin segregation and production is growing. Linking the biological clock to light, sleep and mental illness, can open new areas for investigation of the effects of "healing light". (Figueiro, Rea and Bullough, 2006)



«  
 Figures 4 illustrates how bright light effects Melatonin levels (Reiter et al, 2007)  
 »  
 Figures 5, blocking low wavelength light with goggles (Kayomov et al, 2005)

### 2.3.2.2 Melanopsin

The Melanopsin system controls the biological clock, as the main Zeitgeber for SCN, through short wavelength light entering the eye. In the human eye, the Melanopsin level is adjusted in correlation to the light intake, sending a message to the SCN, that controls which hormones are released to the body. (Xue et al., 2011)

Melanopsin also is found in the iris of mice and primates, rats and chordates. (Chellappa et al., no date; Drouyer et al., no date; Xue et al., 2011; Halper, 2016)

### 2.3.2.3 Serotonin (Happy)

Seotonin works as a neurotransmitter in the brain, if the Serotonin levels are low it can point to bad immune function and lead to depression. Seasonal Serotonin dysregulation shows correlations between SAD and BN, but not AN. (Kennedy, 1994; Tasegian et al., 2016) Serotonin is popularly known as the happy hormone because of its relaxing effect and sense of wellbeing. Antidepressants like Prozac works by speeding up this process.

### 2.3.2.4 Orexin (hypocretin)

Orexin is regulated by SCN like Melatonin and is a protein regulated by orexin-neurons, keeping track of the human sleep/wake balance, food intake and energy metabolism (Figure 6). A study comparing Orexin A (OXA) levels in untreated girls with AN to healthy girls, shows significantly higher OXA levels in AN but no correlation with Leptin. (Bronsky et al., 2011) (Figure 6)

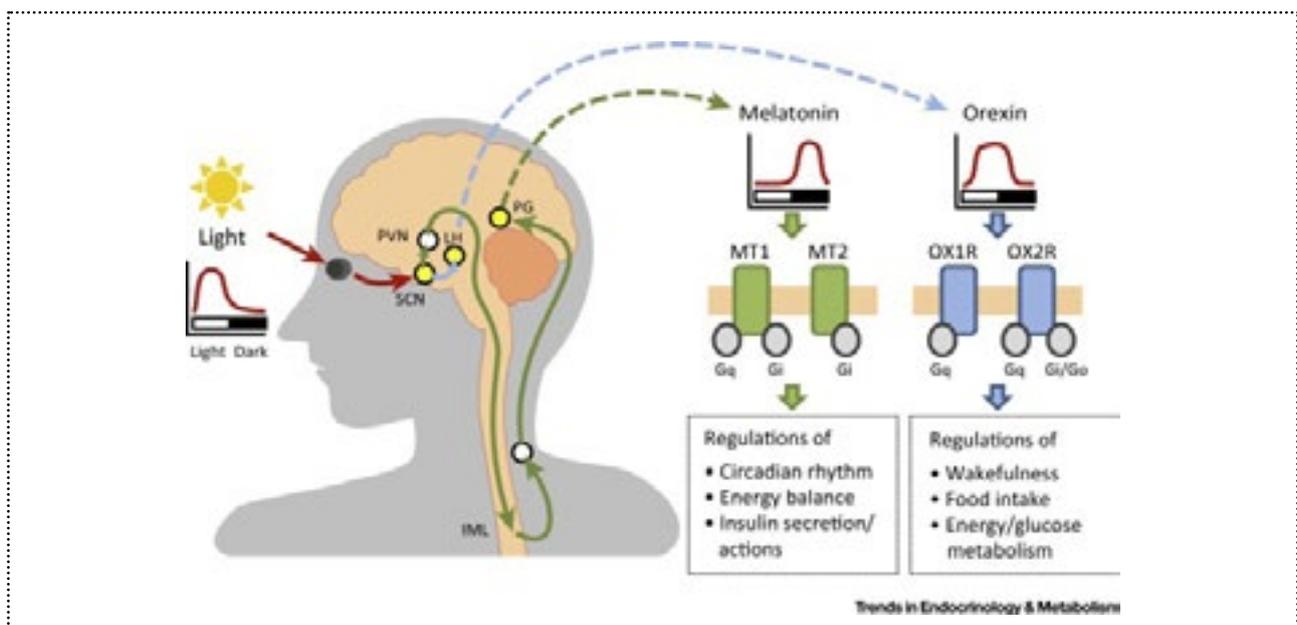


Figure 6, SCN Orexin regulation of Glucose (Tsuneki, H. et al, 2016)

### 2.3.2.5 Cortisol (stress)

Cortisol is known as the stress hormone. This hormone influences the metabolic system, and is circadian regulated by the hypothalamus. This means that the concentrations are high during the day and low during night. Cortisol can be acutely released when the body is under great stress, e.g. anxiety attacks, loss of sleep and exposure to bright light. The stress-hormone Cortisol is released opposite to Melatonin. (Jung et al., 2010)

### 2.3.2.6 Leptin (satiety)

Leptin is known as the satiety hormone or starvation hormone and is produced by the fat-cells in the body. Main function is regulating appetite and signalling the hypothalamus when the body is starving or had enough, making it the main regulator of energy and calories. Friederich R. et al, suggest that the Leptin levels in AN are significantly high compared to normal test-persons, contributing to a constantly inappropriate message of being full. In BN, leptin levels are significantly higher explaining the need to binge and purge. (Frederich et al., 2002) Leptin levels are connected to Cortisol and Insulin and will in healthy humans change over the course of the circadian rhythm (Radić et al., 2003).

## 2.4 *Suprachiasmatic Nucleus*

In investigating the healing effects of light, first and foremost it is important to understand how the mammalian body is affected by natural and artificial light.

When light reaches the eye, the photosensitive cell layer in the retina is activating the photo pigment called Melanopsin [section 2.3.2.2]. This is known as the Ganglion layer. The Ganglion cells in the eye are highly photosensitive and react to light but contribute only little to the human sight. They have long fibres that are connected to the optic nerve and the input reaches as far as to the Suprachiasmatic nucleus (SCN), which is a tiny area within the hypothalamus, consisting of neurons that control the CR.

SCN is known as the central body clock in mammals and transmits the information from the ganglion cells to the Pineal gland, which is located in another section of the brain, called the Epithalamus. When the Ganglion cells detect darkness, they report this to the pineal gland and it starts producing the hormone Melatonin to make the human body drowsy, resulting in feeling an urge to rest or sleep. CR indicates that mammals have an autonomous pattern of sleep/wake or activity/rest. This pattern relates more or less to the rotation of earth and is ~24.18 among healthy adults, as the circadian pacemaker has an internal period ranging in 23.5-24.7 hours. (Czeisler et al., 1999) To maintain an appropriate CR, this needs to be reset accordingly. Light is the most powerful Zeitgeber, and findings suggest that it requires daily ocular exposure to the natural 24-hour light cycle, to reset this pacemaker to 24-hours. (Pechacek, 2008)

## **2.5 Blindness** *and circadian rhythm*

Totally blind people often have free-running circadian rhythms that are not entrained to the 24-hr day/night cycle. In these blind free-runners (BFRs), circadian phase drifts each day, causing recurrent insomnia. Properly administered melatonin can advance the circadian rhythms of BFRs, and most of them can be entrained to the 24-hour day/night cycle. (Czeisler et al., 1995)

## **2.6 (Artificial) Light** *in psychiatric treatment*

The term "Light therapy" is used in this thesis as an umbrella for the different variations of artificial healing light: Bright Light Therapy (BLT), Blue Light Peaks (BLP), CL, Sensory Lighting for Therapy, Seasonal Light Schemes etc. This does not include daylight or dynamical daylight sensors.

### **2.6.1 Bright Light therapy**

BLT has been known in psychiatric treatment for the longest time, earlier known as phototherapy or heliotherapy. It can be prescribed by a doctor or psychiatrist and consist of a light box mimicking the bright light of day. Using full-spectrum light, polychromatic polarised light or using only specific wavelengths can create the desired light. A prescription can dictate a certain time of day, like morning or evening and a specific timeframe for looking into the light box. Both sunlight and bright artificial light can suppress human melatonin segregation, so BLT is like sitting in the sun and works by mimicking the sunlight that strikes the retina in the eye. (Parry and Maurer, 2003) (Krysta et al., 2012)

BLT is frequently used to treat seasonal affective disorder (SAD), a type of depression that occurs at the same time each year, generally in the fall or winter when there are fewer hours of daylight. It can also be used to treat other types of depression as well as various sleep disorders by phase shifting for advanced or delayed circadian phase. The effect of BLT on depression shows more significant results in seasonal than non-seasonal depression. The dose of BLT is usually 10000lx for a period of 30min or 2500lx for a period of 2 hours. (Tonello et al., no date; Wetterberg, 1990; Blouin et al., 1996; Terman et al., 2001; Baxendale, O'Sullivan and Heaney, 2013; Jurvelin et al., 2014) 10000lx are equivalent to the natural light approximately 45min after sunrise.

Side effects are rare but include eyestrain or visual disturbances, headaches, agitation or a strange feeling, nausea, and sweating. These side effects are generally reversible by decreasing the duration of time one spends exposed to the lights. In a case with young pupils in an elementary school in

Malmö, one classroom is exposed to bright cold light throughout the day. In the beginning, many pupils complained, but after a period, only two pupils remained affected by the BLT, the teacher explains. Most pupils are pleased with the new bright light conditions, contributing to better concentration and alertness she explains. They do not believe that it is the light that causes the causes headaches and migraines in the two pupils. (#Appendix1, email from teacher)

Trans cranial bright light (TBL) is a new way of receiving the light treatment, as new research (Jurvelin et al., 2014) provides evidence that the light can be obtained not only through the retina, but also through the thin tissue in the ears. TBL is different, because you can walk around with it, as a pair of LED-headphones. The results from Jurvelin et al, 2014 suggest antidepressant and anxiolytic (decreasing anxiety) effects on patients with SAD, but more research is required in the field. Patients experienced side effects as headaches, nausea and insomnia. (Jurvelin et al., 2014)

### **2.6.2 Circadian lighting**

A final definition of CL has not yet been defined and there is no current standard available. (Syddansk Sundhedsinnovation, 2012) Positive effects have been related to CL, but as a direct consequence of various studies, limited evaluation and different lighting settings, no standard has been established. Evidence for a biological dawn and dusk in the human circadian timing system has not proved to have any significant effect on non-seasonal depression, but can help dementia patients navigate time. (Wehr, Aeschbach and Duncan, 2001)

Variables such as lux levels, correlated colour temperature (CCT), standards, transition time and quality of the fixture can determine the CL. Exact wavelengths for peak sensitivity has yet to be defined, as blue and green wavelengths are currently battling. (Wright, Lack and Kennaway, 2004; Figueiro and Rea, 2010; Münch et al., 2014)) Future evaluation could establish best practise and seek out the differences between tuneable white CL and RGBW CL.

Another factor is that transition time has no significant standard. This a thing that is naturally dependant on location and weather conditions. According to ocular adaption of contrast and increase in light, slow transitions could be easier on the eye. Further research is needed on the topic and on the effect short/long transition time has on the SCN. Findings suggest a higher level of suppression, if the transition is from very low illuminance levels to significantly higher as in Chang et al, 2011. (Smith, Schoen and Czeisler, 2004; Chang, Scheer and Czeisler, 2011)

Barosso A et al 2014 proposes a set of metrics, that can be used in comparative analysis of circadian lighting conditions in patient rooms. Focusing on the following metrics: contrast, bright mean level, bright clustering, dark mean level, dark clustering and circadian variation. These metrics can be used in future tests and investigations in PCBA ED 55. (Barroso, Simons and De Jager, 2014)

### 2.6.3 Non-psychiatric effects of light

Other uses are seen in dermatology, as the layers of the skin is susceptible to light of various wavelengths. Vitamin D [section 2.7.1], which is segregated when UVB reaches the skin and BLT can be used as treatment in cases with severe acne, psoriasis and dermatitis. Epidermal thickness and melanization are important factors for UV wavelengths less than 300 nm, whereas the attenuation of UVA (320–400 nm) and visible radiation is primarily via melanin.

(Anderson and Parrish, 1981) Green light through the eyelids at night is right now being tested as treatment for a type of blindness (proliferative diabetic retinopathy) that occurs in diabetes patients, where the rod cells are dark-adapting. (500-nm light) (Sivaprasad and Arden, 2016)

### 2.6.4 Chrono-nutrition

According to Anna Wirz-Justice (Wirz-Justice, 2006) each organ in the body has a biological clock and each organ has a Zeitgeber that can reset this. Even though the SCN is the master pacemaker and to a high degree controlled by light stimuli in the dark hours, the liver clock is controlled by food intake, as applies to heart, kidney, and pancreas. Food does not, however control the SCN or have any effect in this matter. (Schibler et al., 2003; Tahara and Shibata, 2013)

Chrono-nutrition covers the maintaining of a food schedule coordinated with the daily rhythm of the human body – referring to the time of ingestion as an important player in the well-being of human beings. (Asher and Sassone-Corsi, 2015) Research with mice and rodents show tendencies towards that food calculated food-intake could affect our biological clock. (Tahara and Shibata, 2013) The research explores how timed meals can contribute to maintaining human health and simultaneously contribute to changes in the human internal clock system. This suggests that the biological clock is not only controlled by the brain, and that scheduled food intake can affect the body through the Food-Entrainable Oscillator (FEO) clock in the pancreas, providing information for brain and liver clocks.

In terms of food timing, Tahara and Shibata reports that scheduled food intake during only light hours caused higher weight gain in rodents than ingestion at night. Mice held in dim light conditions during the night, showed an increase in daytime food intake causing weight gain compared to mice in normal light/dark conditions. Conditions with bright light (LL) and dim light (DL) were tested in comparison to regular light/dark (LD) conditions and both LL and DL showed a reduced glucose tolerance and weight gain over time, compared to LD. (Fonken et al., 2010) Low levels of light at night shows results indicating a disrupted food intake timing thus leading to obesity.

Meal timing affects more than glucose tolerance and our urge to snack. A range of psychological processes are also connected to Chrono-nutrition: core body temperature, sleep/wake cycle, performance and alertness. The central clock, located in the hypothalamus, is a structure called suprachiasmatic nucleus (SCN) (e.g. I.N. Karatsoreosa, R. Silvera,b, no date; Tahara and Shibata, 2013)



### ***2.6.5 Artificial light in night-shift work***

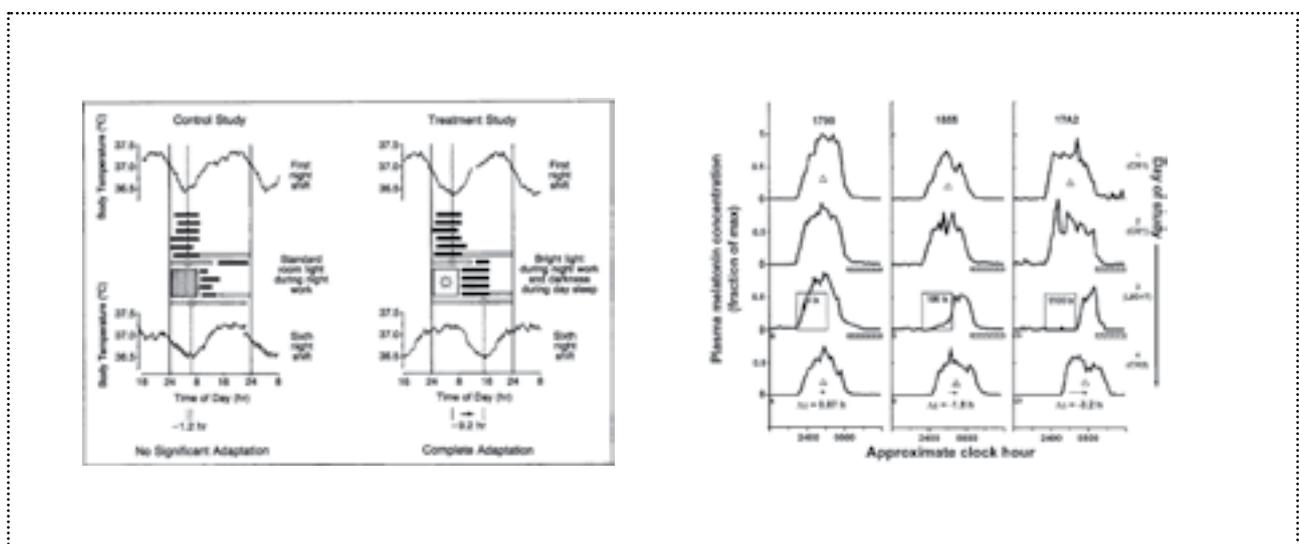
Being exposed to artificial light at night (ALAN) is not considered to be positive in any way. Exposure to light suppresses the melatonin production in the human body, creating shifts in the circadian rhythm and leading to reduced sleep quality. Long-term exposure to ALAN (more than 15 years), for at least 3 nights pr. month, proves to increase the risk of cancer (breast and prostate) in night shift workers. Research shows an increased risk of breast cancer in nurses over time (Schernhammer et al., 2001). Reiter et al, 2007 explains that the cancer risk and possibly other health risks might be related to

PHOTO 3  
AABENRAA PSYKIATRI,  
WHITE ARKITEKTER

NIGHT SHIFT LIGHTING  
BY CHROMAVISO

the suppression of Melatonin as a direct effect of ALAN. (Reiter et al., 2007) In addition, obesity is also one of the consequences of ALAN and research in rotating night-shift work entails a higher risk of cancer development. (Tahara and Shibata, 2013)

Pros and cons of light in different spectrums has been assessed in relevant research. (Webb, 2006) For female workers, a potential risk of developing breast cancer and colon cancer has been investigated and show a developed risk over time. (Pauley, 2004; Figueiro, Rea and Bullough, 2006; Cho et al., 2015)



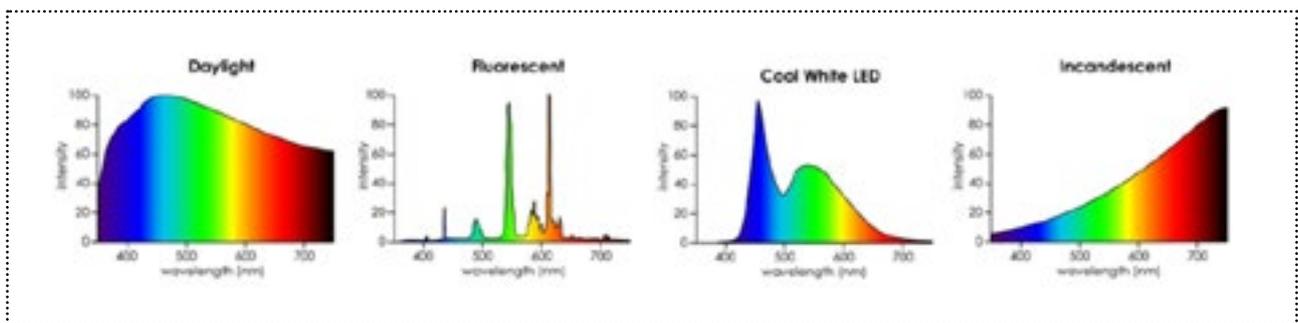
Shift-work has also been prone to advance the risk of developing a mood disorder, but workers that experience quick returns (less than eleven hours between shifts) had less work/rest adaptation and showed a more positive connecting. Quick returns showed no relation to anxiety and depression (Eldevik et al., 2013) Symptoms of depression in night shift workers may be connected to the direct well-being and a direct consequence of the shift work as a stress-factor in the everyday lives of this population

The circadian cycle is divided in sleep/wake also referred to as the subjective day and subjective night, meaning the phase in the CR considered time to sleep or to be awake, this should be coordinated with the illuminated part of the day, but ALAN can turn this around in night shift work over a longer period. (Jewett et al., 1997; Duffy, Zeitzer and Czeisler, 2007) Findings from Duffy et al, 2007 indicate that the response to phase-delay decreases with age. Sleep and wakefulness are found to be highly sensible to bright light exposure at night time. Czeisler et al, 1990, found that early morning light can produce an advance and evening light can produce a delay of the normal circadian temperature cycle. (Figure 7) In Contrast, being exposed to bright light during the subjective day only adds a slight stimulus. This means that bright light may have a positive effect on the normalisation of body temperature and daytime sleep in night shift work. (Czeisler et al., 1990) (Figure 7)

« Figure 7, body temp related to BL according to subjective day (Czeisler et al., 1990)

» Figure 8, Melatonin concentration and brightness exposure (Zeitzer et al., 2000)

In "Lighting and Human Performance II: Beyond Visibility Models Toward a Unified Human Factors Approach to Performance" chapter 5-5, Boyce et al reviews "the factors determining the effectiveness of light exposure" and 5-6 "the consequences of trying to work in circadian night". (Boyce and M.Rea, 2001) Linking illuminance levels to Melatonin depression. Significant results from Zeitler et al, 2000 showed surprising results in this matter, by indicating that 90% stimulus can be experienced at an illuminance of about 550lx. But half the saturation response is found at exposure to about only 100lx. In figure 8, the phase-shift delay in 3lx exposure shows little to no delay, 11% Melatonin suppression. As expressed, the exposure to dim light 106lx resulted in 88% suppression, while 9100lx resulted in total suppression of 98%, while the shifts of -1,8 is nearly half of the experienced shift of -3,2 in the brightest light condition. (Figure 8) (Zeitler et al., 2000) A threshold for minimum phase-shift is needed, but Melatonin segregation is clearly effected by illuminance even in exposure to dim light.



### 2.6.6 Blue light

Blue light is a term of speech with no specific definition, other than the suppression on the production of Melatonin in the brain. In the electromagnetic spectrum, a small portion is visible to the human eye, from about 390-700nm. Blue light is situated from 450-495nm (606-668THz) also known as short wavelength light. As light with shorter wavelength has proved to be more effective than longer wavelengths in suppressing nocturnal melatonin, the term Blue Light is popularly known from resent findings connecting sleep to the use of smart phones, computers and tablets, as such devices emit optical radiation at short wavelengths, very close to peak sensitivity of Melatonin suppression. Even causing effect on some blind patients. (Czeisler et al., 1995)

The resent use of LED light (Bauer et al., 2017) introduced a new circadian regulator to offices, health care facilities and schools, as the peak in short wavelength light is higher in LED's than they are composed by RGB light. Compared to incandescent and fluorescent tubes they have a much higher peak in blue light as figure 9 with Spectral Power Distribution (SPD) spans illustrate. (#Figure 9) (Natural light is fundamentally different than artificial light - Sunlight Inside, no date)

The duration of exposure was compared to light level in a study by Wood B. et al. suggesting that the effect on nocturnal Melatonin levels from self-il-

*Figure 9, spectral distribution of artificail light sources compared to natural daylight, (Natural light is fundamentally different than artificial light - Sunlight Inside, no date)*

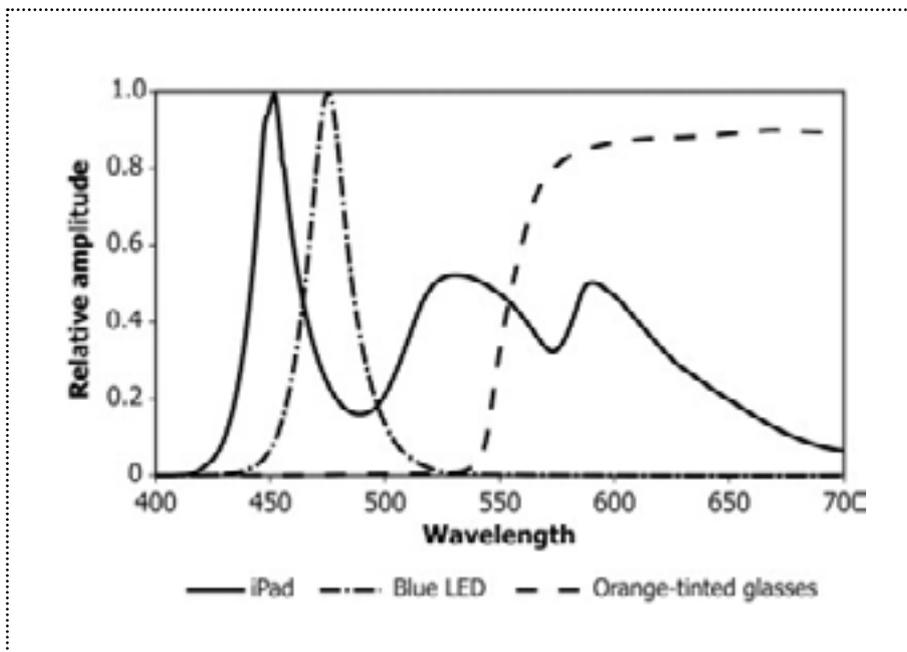


Figure 10, SPD transmittance of the orange-tinted glasses compared to the SPD of iPad and blue LEDs (Wood et al., 2013)

luminating screens with Blue diodes emitting 40 lux of 470-nm caused more significant disruption in the circadian rhythm after two hours of use, than after only one hour, compared to zero. (Figure 10) shows the spectral transmittance of the orange-tinted glasses compared to the SPD of iPad and blue LEDs used for the experiment. (Wood et al., 2013)

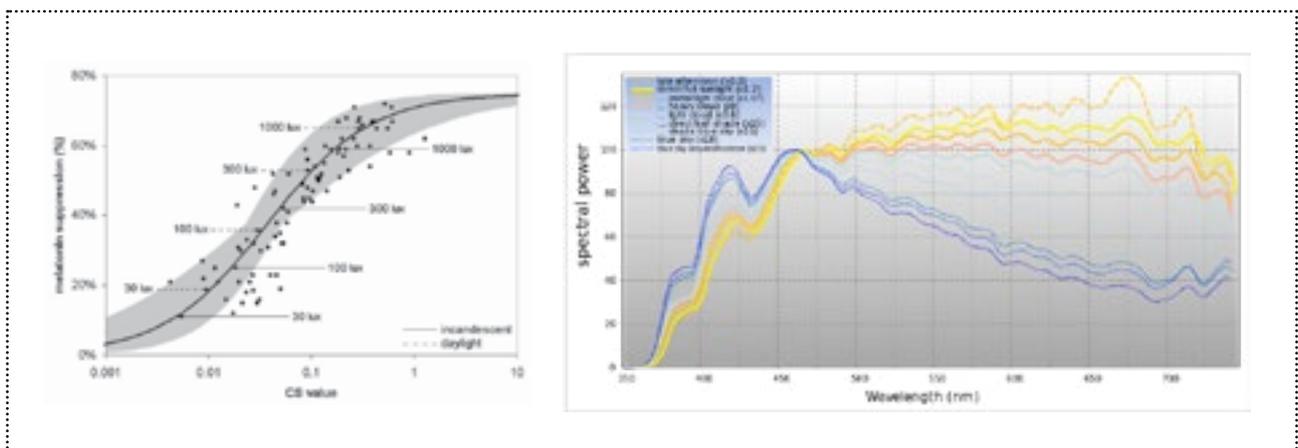
The attention on the sleep related problems caused by self-illuminating screens and the still rising demand for screen based work has lately resulted in a line of research based programmes developed to will filter out the short wavelengths from screens. Programmes like f.lux<sup>2</sup> can to some extend function as the orange-tinted glasses in Figure 10, while the dynamic website fluxometer.com can detect the percentage of Melatonin suppression from the current screen conditions. (Gooley et al., 2011)

Negative effects are not only connected to insomnia, on the long run, people with suppressed Melatonin levels and trouble sleeping could also be more prone to developing depression later in life. (Chellappa et al., no date; Pauley, 2004; Webb, 2006; Zaki et al., 2011; Münch et al., 2014; Halper, 2016; West, Simonsen, et al., 2017)

Positive use of short wavelength light, outside phase shifting, has been seen in treatment of neonatal babies and patients with sensitive skin to avoid the UVA, UVB and UVC from natural daylight (Boyce, Hunter and Howlett, 2003)

## 2.7 (Natural) Light in psychiatric treatment

Being exposed to natural light is important for wellbeing, both psychiatrically and somatically. Hypothetically it is healthier to be outside in the natural light, than inside in artificial light, as natural light, temperature and humidity provides us with an understanding of both season and time of day on top of the exposure to natural light. Natural light levels will vary according to the weather conditions, but even on an overcast day, the light levels will be much higher and have a higher influence on the SNC and circadian rhythm. (#Graphic illustration of weather condition and illuminance) Living in the Northern hemisphere it is crucial to get a daily dose of Vitamin D [section 2.7.1] to stay healthy and fight SAD during the dark winter months. (Boyce, Hunter and Howlett, 2003; West, Jennum, et al., 2017)



Some CL schemes mimic the natural sunrise and sunset in simulated dawn/dusk transitions according to the daily schedule and not according to season in order to imitate the “optimal” length of day and reset the biological clock. Findings suggest that this approach shows better results in seasonal depression like SAD than in non-seasonal depression. (Terman et al., 1989; Wehr, Aeschbach and Duncan, 2001; Fontana Gasio et al., 2003)

The difference in natural and artificial light is connected to more than intensity and Correlated Colour temperature (CCT). Natural light is dynamic, the nature of the light will change over the course of a day according to time, season, weather conditions and location. When natural light and artificial meet in a space, something happens to the atmosphere and aesthetics of human perception. (Volf, 2011) Hypothetically this can be mimicked by dynamic daylight sensors, adjusting the artificial light to the outdoor daylight conditions, but Figure 11 illustrates how different the human response

«  
Figure 11: melatonin response compared to CS value of natural and incandescent light (Rea and Figueiro, 2016)

»  
Figure 12, Spectrum of sunlight; direct, overcast, and indirect (blue sky) Wikimedia commons

is to natural illuminance and artificial illuminance from incandescent. (Rea and Figueiro, 2016) In the middle of the day, daylight is bright and rich in blue, stimulating the SCN, while sunset emits softer light and is dominated by orange and red perceived as relaxing and calming. (Figure 12) These changes happen because the sunlight is filtered by the atmosphere, naturally changing the angle of the sun according to the location, time and weather conditions.

Seasonality in natural light is connected to longitude as the length of day and exposure to natural light is very different in Northern Europe compared to countries closer to the equator. As biological rhythms are a big part of the human functional system, this has a proven effect on the natural sleep/wake rhythm, mood and energy level. Circadian and infradian rhythms shape our lives and the way we behave: Days, weeks, months and years are rhythms we frequent without even thinking about it. A hypothesis could be that when living in the North, it is quite possible that following the seasons is a natural part of our annual rhythm.

### **2.7.1 Vitamin D**

Vitamin D3 can be obtained through food and nutrients and directly from the sun, dividing it into two groups: Calcitriol (D3) – metabolic system (kidneys) and Soltriod (Vitamin D3) from sun and food. This will affect your sleep time, calcium + phosphate intake and by this your bone strength. It is one of the non-visual effects of light and the human body can self-regulate the intake, thus the level of Vitamin D will exceed healthy levels.

Vitamin D is not absorbed from the sunlight but is a process in the skin. The synthesis is a response to ultraviolet light UVB rays from the sun (290-315nm). (Stumpf and Privette, 1989; DeLuca et al., 2013; Tazzyman et al., 2015) These wavelengths should be effectively blocked by most glass types, but earlier in architecture the glass was allowing some UVB to enter the indoor space, as a direct effect of bringing daylight inside the house. Volf, 2013 states this ability as part of an unhealthiness factor of the window (p. 85). (Volf, 2013) Infrared rays do however penetrate most glass coatings, as you can feel the warmth from the sun. If the skin receives no direct sunlight and in addition you don't eat supplementary foods to compensate, you can become deficient in Vitamin D accelerating negative effects on health and wellbeing, as ageing, high blood pressure, diabetes, kidney disease etc. (Caprio et al., 2017)

### **2.7.2 Connection to nature**

Biophilia has been connected to wellbeing and research in biological stimuli for hospitalised patients has shown positive response to hospitalisation time. (Ulrich, 1984) [section 4.2.1] Findings suggest that work motivation, satisfaction and productivity has been linked to the ability to view nature from the work station. Windows with view can thus be a positive contribution to wellbeing in staff as well as patients in the health care sector. (Boyce

and M.Rea, 2001; Frandsen et al., 2009; From and Lundin, 2010; Kamali and Abbas, 2012; Arkitekterne, 2013; Nickl-Weller and Nickl, 2013) Findings suggest that roof top gardens have therapeutic effects on staff and patients in a review by the American Medical Colleges association. (Hospital Roof Gardens Soothe Patients and Staff, no date) View to nature enables the visible proof of seasonality and can provide for a relaxing moment of looking away from the desk or computer screen. According to the anatomy of the eye, the most relaxed condition occurs when looking into infinity. This condition is rare, from a workplace, but a simple shift in vision will help the eye relax and enhance better focus and concentration.

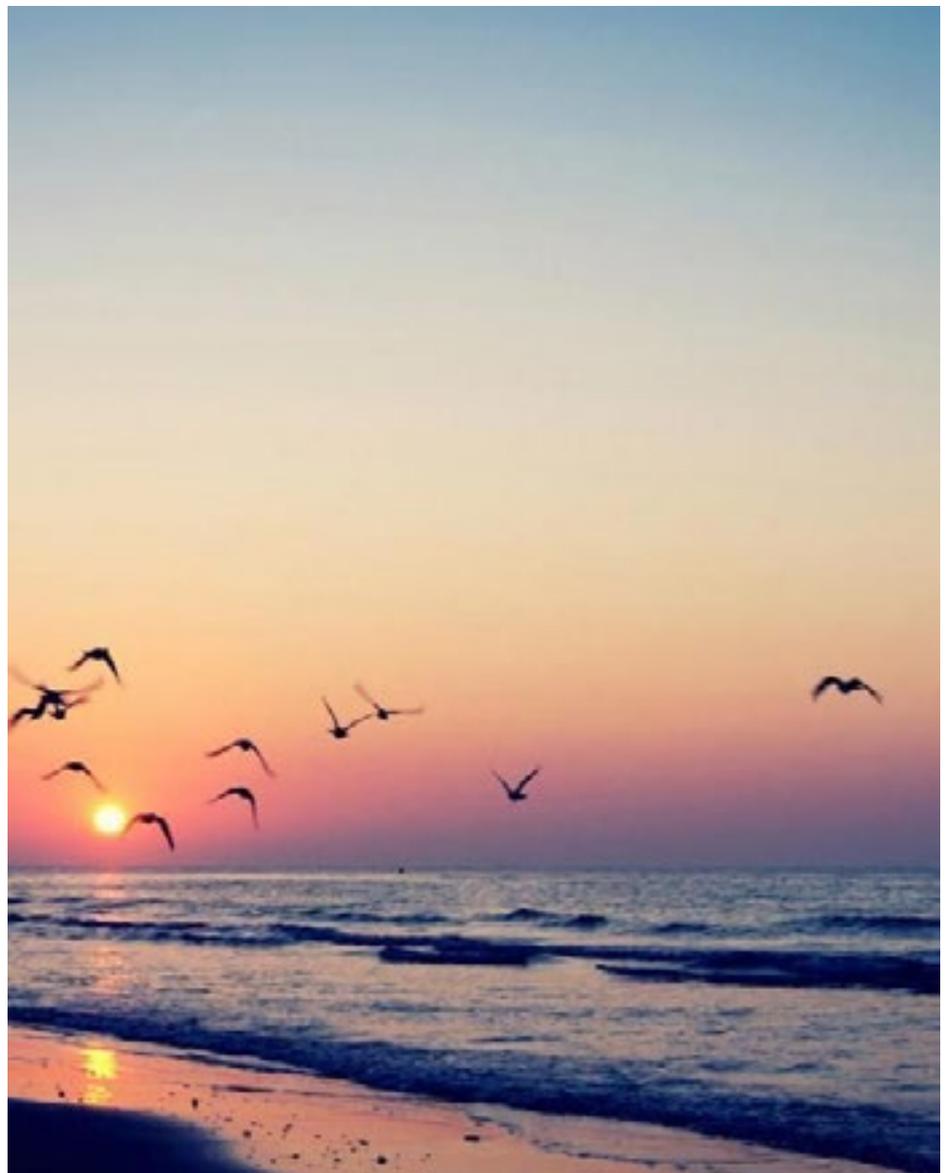


PHOTO 4  
SUNSET  
IMAGE: PINTEREST  
\*\*

## 2.8 Atmosphere

The biological effects of light in the space can somehow be measured on the body. How the mind reacts to different light scenarios is much harder to measure, but through observations, interviews and tests this can be verified through thorough philosophy and qualitative research.

In "Atmosphere in hospital wards", Stidsen investigated how something as simple as the height of the light source can affect the atmosphere in hospitals. Stidsen describes the connection between space and body and puts emphasis on the body as a part of the space. The person in a space is thus part of the experience and the way the atmosphere is perceived. It then becomes a given to including oneself as part of the experience. (Stidsen, 2013, p. 91)

She elaborates on the two different explanations of atmosphere from wikipedia and The Oxford Advanced Learner's Dictionary, "The term can be understood as the atmosphere between people or the emotional experience of a situation or space" making it hard to determine the exact meaning and qualities.

*"The feeling or mood that you have in a particular place or situation; a feeling between two people or in a group of people"*

*Oxford Advanced Learner's (Hornby and Turnbull, 2010)*

*"Atmosphere is an immediate form of physical perception and is recognised through emotional sensibility. Architects and designers use the notion of atmosphere to argue that architecture and space is designed and built for people to use and experience."*

*(Wikipedia)*

Working with psychiatric patients, this can possibly add to the bad mood within the hospital. Meaning that, when the patient is having a bad day, then that becomes part of the perceived atmosphere and surroundings. The atmosphere in a hospital can be experienced when two patients meet or as an immediate feeling or emotion of the physical aspects of a space. This links atmosphere to three criteria: self, others and architectural space.

When designing for a space with 24-hour patients, it is important to bear in mind that the wrong solution might cause illness and even discomfort. The last is hard to measure, but the word atmosphere can be perceived as a measurable point, qualitatively speaking. The essence of atmosphere will be explored through the findings and understanding of Gernot Böhme, Maurice Merleau-Ponty, Peter Zumthor and the Danish researcher Lone Stidsen.

Böhme addresses the atmosphere in light, colour and sounds in "Atmosphere as the Fundamental Concept of a New Aesthetics". He links atmos-

phere to environmental qualities and categorisations of different atmospheric qualities as inviting, scary, melancholic etc. Not stating if atmosphere is dependant of the space or the person experiencing the space. (Bohme, 2006)

*“Atmosphere is indeterminate above all as regards their ontological status. We are not sure whether we should attribute them to the objects or environments from which they proceed or to the subjects who experience them. We are also unsure where they are. They seem to fill the space with a certain tone of feeling like a haze”*

*(Böhme, 1993, p. 114)*

In the philosophical approach by Merleau-Ponty in the “Phenomenology of Perception”, the atmosphere is connected to the body. How the body is not only present in a given space, but inhabits it with its presence. He fur-



PHOTO 5  
SAN TELMO MUSEUM  
EXTENSION  
NIETO SOBEJANO  
ARQUITECTOS,  
SAN SEBASTIÁN, SPAIN  
\*\*

ther expresses how the coloured spectrums we meet in a space affects our movements and spatial thinking. (Ponty, 2013, pp. 140, 217)

Tonino Griffero, 2014 talks in "Atmosphere: Aesthetics of Emotional Spaces" about the sensory perception of atmosphere as "*means grasping a feeling in the surrounding space*" in his investigation of atmosphere. He states that we are never not in an atmosphere, and human atmospheric perception he refers is a symptom of human as "*holistic and emotional being-in-the-world*". (Griffero, 2014)

In "Space, Place and Atmosphere. Emotion in Peripheral perception and architectural experience" Juhani Pallasmaa approaches the topic in an architectural context by enhancing the experience of the body in the space. Explaining that when human beings dream or read a novel, we do not imagine spaces and atmospheres in 2D and without spatial awareness. (Pallasmaa, 2014, p. 239)

Another architectural take on atmosphere from Peter Zumthors "Atmospheres", where he talks about the mind and body in connection to 9 items. The body of architecture (I), Material compatibility (II), The sound of space (III), The temperature of space (IV), Surrounding objects (V), Between Composure and Seduction (VI), Tension between Interior and Exterior (VII), Levels of Intimacy (IIX) and finally, The light on Things (IX). (Zumthor, 2006)

*"We perceive atmosphere through our emotional sensibility - a form of perception that works incredibly quickly, and which we humans evidently need to help us survive. The big question is "What is the magic of the Real"? The Body of Architecture, Material Compatibility, The Sound of a Space, The Temperature of a Space, Surrounding objects, Between Composure and Seduction, Tension between Interior and Exterior, Levels of Intimacy, The Light on Things."*

*Peter Zumthor (Zumthor, 2006)*

Emotional sensibility, something very unique and human can be extremely hard to define. As we talk about atmosphere and emotional sensibility, the effects of lighting must be accentuated as a tool for both. It is hard to define sensibility and atmosphere, but even if there is no scientific proof, light has an ability to carry memories and emotions, just as smell and touch. Allowing for the emotional qualities of the space to be interpreted by the visitor, as characteristics such as homely and cosy can be determined by heritage and culture.

It is important to take atmosphere into consideration, as the effect and stimuli from the surroundings, materials, connection to staff and natural lighting can have a big impact on hospitalisation time. (Ulrich et al., 2004; Redding et al., 2017) This is why the combination of space and lighting design is even more important, when people are hospitalised in the same health care buildings 24-hours a day for an unknown period of time.



« PHOTO 6:  
PERFORMANCE ARTIST ECHO MORGAN  
IMAGE: JAMIE BAKER  
\*\*

## 2.9 Summary

### on Literature Review

In the following summary, different light related terms of influence will be highlighted including a brief comparison of ED related challenges that might be relevant for further investigation. All the separate areas will be reviewed in a collected manner and an overview of relevant areas will be outlined for further investigation.

Below is a sum-up of the important findings about healing light, from the literature review:

**Light therapy:** BLT, sensory rooms, art therapy etc.

**Light and the body:** both natural and artificial light trigger a line of symptoms and reactions within the body, that we need to stay healthy

**Light in psychiatric treatment:** depression, bipolar, dementia, Alzheimer

**Effects of circadian lighting:** when patients have trouble sleeping, pulses of light in regulated colours according to the time of day can have a positive effect.

**Experience of lighting:** atmosphere, memories and wellbeing

**Bright Light Treatment:** Strong use of light, can regulate the internal clock and works on seasonal depression, jet lag etc. as a substitute for the missing sunlight.

**Blue Light:** short wavelength lighting

**CCT:** Kelvin temperature is connected to the way we experience the room temperature

The healing effects of light can be measured both quantitatively and qualitatively, dividing the expected effects into two groups:

#### **Somatic:**

How the given light stimulates the human body and measurable functions (quantitative)

- Variables: Hormone levels, body temperature, digestion
- Result: Energy levels, sleep, circadian rhythm

#### **Emotional and cognitive:**

How the given light situation makes a person feel and react (quantitative)

- Observations: behaviour, mind-set, mood, stress, anxiety, feeling
- Result: atmosphere, stimuli, sensibility

## 3.1 Eating disorders

Eating disorders are separated into five categories Anorexia Nervosa (AN) (11/12 female), Bulimia Nervosa (BN), Binge Eating Disease (BED), Ortoreksi (obsessed with health and quality of food) and Megareksi (obsessed with developing muscles, working out and following diets, mainly male).

In Denmark, most of the focus is on AN, BN and BED. According to LMS (Landsforeningen mod spiseforstyrrelser og selvskade) about 5.000 people suffer from AN, 30.000 from BN and 40.000 from BED. Other numbers show that only about 5000 patients are hospitalized and treated professionally (3000 AN and 2000 BN and BED). (Landsforeningen mod spiseforstyrrelser og selvskade, no date)

AN is the deadliest form of ED and 60% of the Danish patients suffer from AN symptoms. There are in research a very strict distinction between AN and AN-R patients, AN-R referring to anorexia restricted starvation and dieting. In research, all purging patients are considered Bulimic, in addition 25% of BN patients converted from AN, so the treatment numbers may need some detailed division of symptoms, to understand them properly. Patients within different ED behaviour share some of the core psychopathology features like over-evaluating eating, shape and weight. Attitude and behaviour in the two main disorders, BN and AN, can be compared in terms of body checking, restricting food, vomiting, use of laxatives and level of over-exercising. Some cases of AN can be more focused on controlling the food intake than on weight and overall shape, this is different from BN. (Fairburn, Cooper and Shafran, 2003, p. 519)

### 3.1.1 Current ED treatment

ED patients are divided into six stages, 1 being the most severe and 6 being the best case. During treatment, patients work themselves up from 1 to 6, before they are considered healthy and fit to live by themselves. All types of ED suffer from a very low recovery rate and require long-term periods of hard work for the patient. The treatment has not developed much over the years, with no significant evidence for improvement of AN treatment. The last big break-through being the re-invented of cognitive therapy 1970's by Aaron T. Beck and Albert Ellis.

*”There was no convincing evidence that the outcome of anorexia nervosa improved over the second half of the last century. Several prognostic features were isolated, but there is conflicting evidence. Most clearly, vomiting, bulimia, and purgative abuse, chronicity of illness, and obsessive-compulsive personality symptoms are unfavorable prognostic features.”*

*(Steinhausen, 2002, p. 1284)*

Current Danish treatment guidelines for AN by October 2016 include learning how to relate to the reality around you, common sense, including the close family and therapeutic conversations. The strategy in AN is personalised and BN treatment include cognitive behavioural therapy and BN and BED use psychoanalysis and psychotherapy. (Interview E, 00:22:09-00:22:58) There are no current statistics or treatment for patients with Ortoreksi and Megareksi in Denmark. (Sundhedsstyrelsen, 2016) (Ingen målbar forbedring i behandling af anoreksi og bulimi - ViOSS - Videnscenter om spiseforstyrrelser og selvskaade, no date)

ED is connected to high sensitivity and high risk of anxiety attacks and as a relief, acupuncture and relaxation therapy has a potential. BN patients could potentially benefit from BLT for depression and massage. (Fogarty, Smith and Hay, 2016) Patients with BN and BED show improved symptoms with biological antidepressants. Studies with AN patients show disappointing results, and though pharmacological treatment of ED shows improvements with binge frequency in BN and BED it is still an undeveloped field. Light therapy in the morning showed improvement in seasonal bingeing in BN. (Mitchell, Roerig and Steffen, 2013) Studies of the effect of light therapy on BN shows superior benefits of using bright light over dim red light (Braun et al., 1999) while Blouin et al, 1996 found that the effect of bright white light showed similar effects as dim light on the affective symptoms and food intake in a double-blind study. (Blouin et al., 1996)

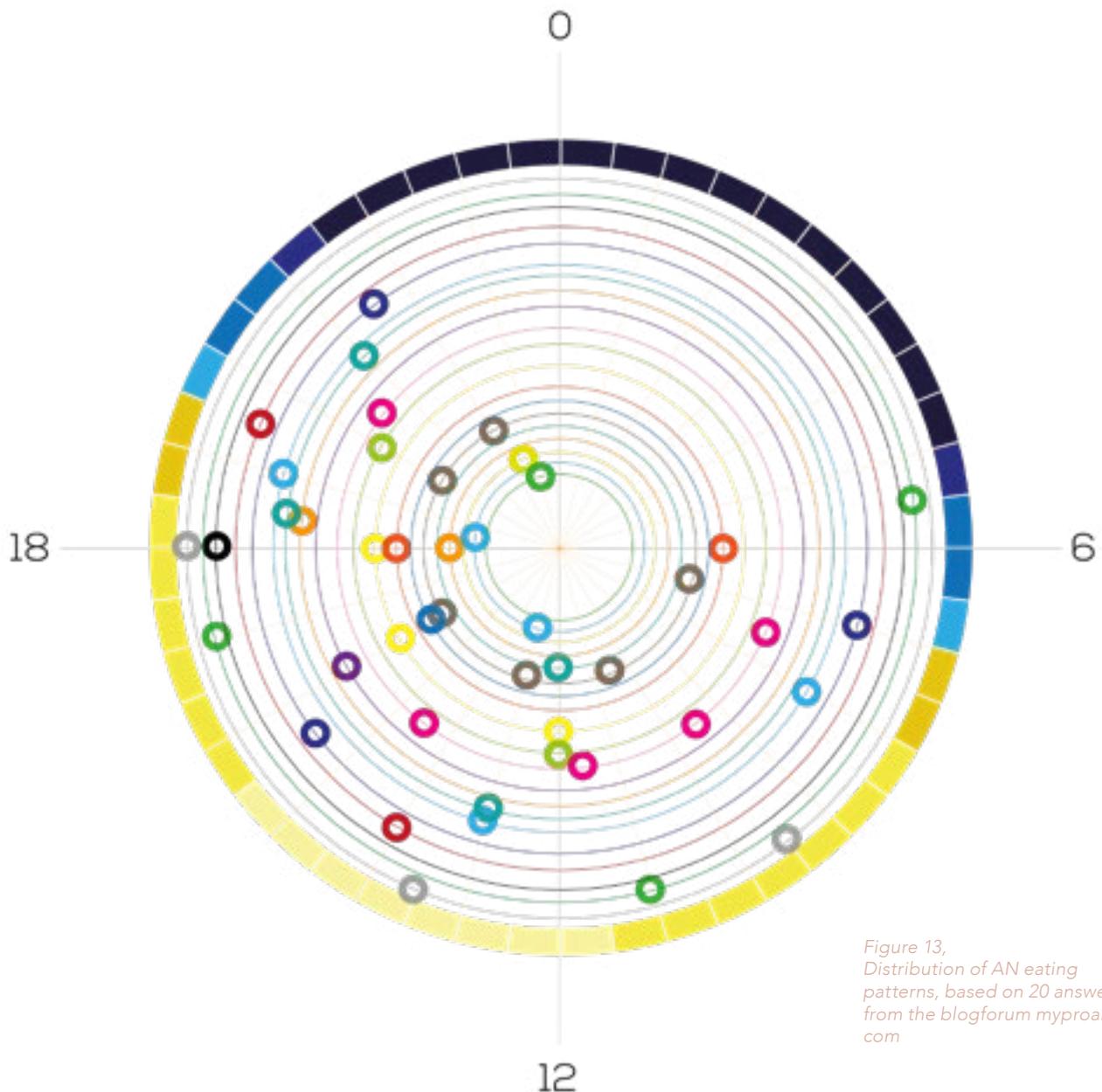
Lam et al, investigated seasonality in ED patients with BN, after Berman et al, 1993 established evidence of clinical overlap between SAD and BN. BN and BED symptoms has been related to SAD and light therapy with positive result on seasonality symptoms. (Berman, Lam and Goldner, 1993; Lam et al., 1994, 2001; Lam, Goldner and Grewal, 1996) As AN symptoms are limitedly connected to seasonality, other areas has been explored. Krysta et al, 2012 found that BLT could improve depressive states in patients with AN-R. (Krysta et al., 2012) In a study on circadian rhythmicity and body temperature in ED patients, synchronisation of hunger rhythms, body temperature rhythms and antidepressant effect, BLT showed positive effects. Body temperature was improved and normalised for AN patients, BN patients showed normal body temperature levels before the study. (Yamamoto, Papezov and Veveřa, 2008) Findings from Beauchamp et al, 2016 suggest BLT for ED patients with night-eating syndrome. In connection to AN, BLT is suggested for positive improvements of mood and eating, though timing and response is not yet established. (Beauchamp and Lundgren, 2016)

### **3.1.2 Anorexia Nervosa vs. Bulimia Nervosa**

Investigations in the effects of light therapy on anorectics are limited. This can be connected to the fact that there is no current evidence of seasonal change in AN and in particular in AN restricted type (AN-r). Patients suffering from BN and BED have shown higher rates of seasonality and SAD

can to a higher degree be connected to both conditions, why more knowledge is available on this area. This literature review is limited from including BED, but will look into the binge/purge (b/p) connected to seasonality in BN. (Lam, Goldner and Grewal, 1996; Braun et al., 1999)

AN differs from BN in more ways than the non-purging behaviour. Findings from the global seasonality score (GSS) test on the Seasonal Patterns Assessment Questionnaire (SPAQ) show no significant scores of seasonality in AN compared to BN. Seasonal change was in addition less in categories as energy, mood and weight than with BN patients. AN patients also have lower seasonal mood and appetite variation than purging AN patients. (Fornari et al., 1994)



In relation to sleep patterns, ED is not connected to insomnia, but insomnia could potentially lead to ED symptoms. Patients with ED experience sleep disruption where patients with night-eating syndrome (NES) have risk of phase delaying as a consequence of late night eating. (Lacey et al., 1976; Allison, Spaeth and Hopkins, 2016) AN patients with b/p symptoms experience greater sleep disturbance than patients with AN-R, comparing patients without ED to ANb/p and BNp, ED patients experience higher levels of sleep-disturbance. (Tanahashi et al., 2015)

Evidence of NES in AN is not as significant but highly associated with BN. (Eiber and Friedman, no date; Martins et al., 2012; Allison, Spaeth and Hopkins, 2016; Coutinho and Brandao, 2016) Evidence in NES in connection to AN patients is still scarce.

From findings at myproana.com (Forum and Community, no date), eating patterns of girls in the online forum with AN has been mapped out. In [section 3.1.3] (Figure 13) a pattern slightly suggests that the girls tend to eat from late afternoon and until night. It is important to note that the graph does not show how many calories they eat, as many girls only drink a cup of black coffee or tea for a meal.

Signe (interview D, 00:03:10) explained that this is very normal and serves as a reward, from being in control all day. The hours in the late afternoon and evening is the time to go to the refuge and comfort themselves after a long day of controlling food intake, steps and calories burned.

Patients have high energy levels in the morning and evening, because the ED counteracts sleeping and laying down for rest. (interview H, 00:09:20, 00:18:45, 00:20:15)

Findings connecting ED, night time food intake and poor sleep could suggest longer treatment periods, as many comorbid diseases could come from sleep deprivation and depression. This indicates that addressing and improving the CR in ED patients could potentially effect the healing process. (Lombardo et al., 2015)

### **3.1.3 Schematic overview of AN eating**

AN eating behaviour was explored through blog search on an online community for girls with ED. (Forum and Community, no date) By investigating profiles of 20 girls with available information of eating behaviour, the available information was collected and inserted in a graphical overview showing a slight tendency in afternoon or evening food intake. The chart does not include the size of the meal or take BMI of the girl into account, thus some meals might be a coffee with milk. Late night food intake can be connected to NES or a reward and others might be living with parents or a boyfriend that does not know about the ED.

## 3.2 ED Comorbidity

ED is a very serious mental illness with mortal consequences, if not treated in time. The majority of patients experience urges of self-harm and anxiety. Comorbidity is hard to diagnose in the most critical stages of the illness, because AN can be channelling self-destructive behaviour, easily interpreted as comorbidity. According to a recent report, comorbidity in ED includes: depression (50-75%), menopause, ADHD, OCD, anxiety, diabetes, self-harm, personality disorder (borderline) (1/3), Bipolar disease (4-6%) and dysthymia. (Anoreksi, prognose - Patienthåndbogen - sundhed.dk, no date; © Sundhedsstyrelsen, 2016) Research in comorbidity shows that AN patients develop comorbid diseases after the AN. Whereas, in BN there is a tendency towards patients developing comorbid diseases before they experience symptoms of BN.

### 3.2.1 BMI

ED patients are evaluated on body mass index (BMI), determining when you are sick enough to get a hospital bed and when you are fit to be discharged. BMI is calculated as total body weight (kg) divided by the square of height (m). The number says nothing about fat distribution, bone structure or other factors and the focus on this number, can sometimes lead to patients feeling neglected by the system. (Interview D, 00:08:05, 00:09:45)

In a report about the Danish health conditions, BMI is used as the definition of over- and underweight people in the Danish population. The percentage of underweight people dropped from 4,6% in 1987 to 2,6% in 2010, with a dominant in females 16-24y. (Christensen et al., 2010)

Being disposed to mental illness is not significantly connected to low BMI, but mental illness can, according to a report developed by the Danish Health Council, cause underweight in long-term patients. Mentally conditioned underweight is however concerned a symptom of ED. Underweight is defined as a BMI < 18,5 by The World Health Organisation (WHO). (Christensen AI, Davidsen M, Kjølner M, 2010)

### 3.2.2 Mental health

A report from 2005 about mental health in the Danish population, from The Danish Health Authority establishes a high occurrence of mental illness in people with trouble sleeping within the last 14 days (Christensen AI, Davidsen M, Kjølner M, 2010, p.9). The same report connects depression and anxiety, but not SAD.

It concludes that mental illness is occurring in one 1 of 10 Danes and 5% of the adult population is suffering from anxiety and/or depression. (Christensen AI, Davidsen M, Kjølner M, 2010, s. 42) Mental illness is furthermore connected to stress over a longer period. Connecting mental illness to BMI, shows no significance (s.48-49) but a tendency among underweight men

and overweight and underweight women is connected to mental illness. In Denmark, psychically conditioned underweight is especially connected to young people with eating disorders and especially young women. (Christensen AI, Davidsen M, Kjølner M, 2010)

No findings suggest a tendency towards SAD being significantly high in ED patients, while some studies suggest that bingeing in BN and BED patients could be affected by seasonal change, increasing during winter. AN patients have a harder time gaining weight during winter, because freezing will require more calories for warming up the body. (Interview D, 00:06:10, 00:14:44) (Interview H, 00:06:05)



PHOTO 7  
SIGNE GRØNNEBÆK,  
ANOREKSIGNE.DK  
\*\*

### 3.2.3 Selfharm

Self-harm behaviour (SHB) or non-suicidal self-injury (NSSI) is a mayor issue when dealing with ED patients and strongly serotonergic (connected to the release of Serotonin). Cucchi et al, 2016 found positive association between NSSI and ED, being more prevalent in BN or AN patients with b/p behaviour. Treatment methods included skills training, emotional coping and distress tolerance in a study of BN and NSSI. (Cucchi et al., 2016) (Muehlenkamp et al., no date) Findings from Steiger 2004, even suggest a stronger serotonergic connection between BN and destructive behaviour than between BN and b/p. (Steiger, 2004)

In 2015, a study by "Videncenter om spiseforstyrrelser og selvskade" (VI-OSS) found that 11% of the adult Danish population (18-80y) had deliberately tried to perform self-harm once or more. Gender differs within this group, with three times as many females (16% females and only 6% of males). 32% belong in the youngest group (18-25y) where only 3% are 41 years or older.

The study found no correlation between light therapy and SHB or NSSI. Hypothetically, SHB could be related to depression and experiments with BLT could be possibly beneficial.

## **3.3 Discussion**

To answer the initial research question, possible links between ED and light therapy has been analysed and explored through expert interviews and findings from the literature review. The following review discusses possible overlaps in triggers, symptoms, behaviour and comorbid diseases, in conclusion findings have been connected in a circular diagram allowing for triangular connections of the abovementioned.

As patients with severe ED is a sensitive group, the main source of information came from expert interviews, one interview with a long-term anorectic woman, and a lecture with three personal stories of struggling with bulimia and anorexia, respectively, as patients and as a relative. It is thereby important to note, that most hypotheses are based on experiences from care personal and psychologists in combination with research based findings, hence the topics of the following discussion originate from the scarce amount of knowledge collected and obtained in the process of this thesis. Some hypotheses could be investigated in the future as the character of this study suggest.

### **3.3.1 ED + Circadian rhythm**

Patients with AN normally have problems connected to sleep as it can be hard to sleep when experiencing a combination of hunger and anorectic thoughts. (Interview H, 00:09:20) In connection to this, sleeping burns no calories resulting in high energy levels morning and evening. Afternoons are often more relaxed. (Interview H, 00:20:15) Afternoon rest is often suggested in treatment. Dysregulations in Melatonin rhythms could be connected to daytime sleepiness. [section 2.3.2.1]

Findings from [section 2.6.4] Chrono-nutrition suggest that the strict eating schedule for ED inpatients have some impact on the internal liver clock. Treatment including carefully composed and personalised nutrition could influence the circadian rhythm.

### **3.3.2 ED + Melatonin**

Findings from Brambilla et al 1988, found higher levels of nocturnal Melatonin in AN-patients compared to healthy subjects and obese subjects. Stating that 8 out of 12 AN subjects had disruptions in their circadian Melatonin rhythms. (Brambilla et al., 1988) Ferrari et al 1990, found a relatively lower body temperature in anorectics compared to obese patients. The mean "Circadian profile" in AN-patients was parallel to the healthy control group, but with higher levels, and with a significant increase in plasma cortisol circadian Melatonin. (Ferrari, Fraschini and Brambilla, 1990)

There is no apparent relation between weight and Melatonin release, but Kennedy et al 1989, found a correlation between the depression state and the Melatonin levels in BN and AN-patients compared to healthy age compatible subjects. Cortisol levels were on the other hand not relatable to the depression state. (Kennedy et al., 1989) Depression is related to the Serotonin/Melatonin segregation, disturbing CL and potentially causing daytime sleepiness. This Melatonin disturbance accounts mainly to BN and AN with b/p behaviour, (Kennedy, 1994) this can be related to night time eating in BN. If sleep is related to ED anxiety attacks in some patients, melatonin levels could be suppressed by cortisol, making it harder to rest and sleep.

According to (Interview E, quote) (Trine) small doses of melatonin at night is used in children and young ED patients. This suggest that circadian lighting (CL) could add to the night time calmness of the patients. (Interview F, 00:05:14)

### **3.3.3 ED + Circadian lighting**

Poor sleep quality is related to both AN and BN. Previous studies with BLT in BN suggest that patients with BN could benefit from CL to a higher degree than AN [section 2.6.2]. Findings in the connection between ED and Melatonin segregation [section 3.3.2] supports designed CL for enhanced sleep quality at the right time of day. (Interview E, 00:11:50)

Night eating syndrome (NES) is connected to bingeing in BN and AN-patients with late night food intake. This impacts the sleep quality, leading to a reduced REM-sleep period and/or insomnia. (Eiber and Friedman, no date) Nocturnal binge behaviour in BN and BED is connected to late serotonin segregation, as a reward after a long day, but it only happens in the private and not during hospitalisation. (Interview E, 00:13:39, 00:22:47) The same nocturnal behaviour in AN can lead to BN and according to expert E, this is normally a step in a good direction. (Interview E, 00:20:49-00:21:55)

Light therapy is a none-invasive treatment form and no findings suggest that BLT or CL could cause negative effects in ED, aside from adding more energy to the patients resulting in more compulsive exercise. According to findings from (Brambilla et al., 1988; Ferrari, Fraschini and Brambilla, 1990) the focus should be on stabilising Melatonin rhythms in patients with disruptions, delays or no peaks, as the majority of the tested AN-patients had regular but elevated circadian Melatonin patterns.

### 3.3.4 ED + Sensitivity

High sensitivity in nose, skin and temperature and observations from (Interview E, 00:06:28, 00:07:02) could suggest a high light sensitivity with connection to strong light and especially bright/glary/direct light. (Interview H, 00:13:50) If ED patients are more prone to sensitivity, quick transitions and high contrast could potentially feel highly uncomfortable. (Interview E, 00:24:18) This could also hypothetically create a better response to CL and transitions.

In findings from Jewett et al 1997, *"the timing of background room light modulates the resetting response to bright light"* suggesting that contrast and transition time could be related, (Jewett et al., 1997) thus high sensitivity to bright light could lead to higher CL sensitivity.

### 3.3.5 ED + Body temperature

Recent findings in CCT and Kelvin-temperatures and connection to the experienced temperature in a room could suggest that warm light (low K) should be used in common areas and private rooms. This could be beneficial for the severe freezing sensation in ED patients, but Bennet & Rey, 1972 present evidence that the heat/cold experience related to CCT is positively connected to effects, but argues this effect to be strictly intellectual, thus having no effect on actual thermal comfort. (Bennett and Rey, 1972) Thermal comfort might differ depending on activity, gender and culture. In a London study about perceived room temperature and energy optimisation, room conditions with bright white light (4000K) reported more comfortable than 2700K and 6200K. (Huebner et al., 2016)

Focus on proper materials are also important, as white tables get colder than wood, creating problems for patients, as it is too cold for them to touch. (Interview E, 00:25:25) As white materials reflect more light than wood, this can add disturbance for sensitive eyes. This suggests that wooden surfaces could add thermal comfort for patients in furniture interaction and create a more relaxed visual environment.

Research in body temperature, ED and light therapy is limited. Yamamoto et al, 2008 showed an effect on rhythm synchronisation of temperature and hunger. In addition, *"phase advanced rhythm was delayed and phase delayed rhythm was advanced"* and BLT normalised body temperature rhythms in both AN patients and BN patients with disruption. Future research on effects related to food-intake-rhythms in ED were suggested. (Yamamoto, Papezov and Vevera, 2008)

Body temperature is controlled by the SCN and may contribute to phase setting of circadian escalators as proteins, detoxing connected to important circadian Zeitgebers. Findings from day-time feeding of nocturnal rodents suggest that food timing can influence the circadian rhythm over body temperature. The body temperature is strongly influenced by food intake, but both activity, rest and feeding and can sustain circadian clock gene activity. (Schibler et al., 2003)



PHOTO 8  
MORNING LIGHT THROUGH A CURTAIN  
NINA HOLST  
\*\*

### **3.3.6 ED + Morning light**

Common practice in BLT involves early morning treatment, proven effective on resetting CR and phase shifting in people with Circadian phase delay. (2.6.1) Natural light has proven more effective than artificial light boosts in the morning, but fresh air is not part of current morning routines. (Interview F, 00:16:40) Only smokers that go for a morning cigarette before breakfast are regularly exposed to natural light and fresh air in the morning. The morning and the first meal can be especially tough, because getting out of bed equals eating the first meal - and the aspect of physical activity is not recommended. A pre-breakfast walk is therefore not optimal in current treatment. The majority of people with ED prefer to exercise to a high degree and according to (Interview D, 00:01:20) it is popular to do so in the morning to feel like the day is off to a good start and deserve the first meal.

Going outside for some fresh air on days where the weather conditions allow for it. Attending a short morning stretch, slow walk or easy yoga routine could add to quality of life for patients and make the morning routine easier. Group walks (30min) with staff are regularly organised twice a day for stage 1 patients. Depending on weather and outside temperature. (Interview H, 00:06:05, 00:07:10)

### **3.3.7 ED + Side effects**

Surroundings, meals and activity in treatment is very restricted and extremely controlled, allowing for customised lighting schemes. Previous findings show no reason to expect that CL will have any effect on the AN, but suggest some effect in BN and maybe BED. Obesity and binge eating has been connected to phase delayed chrono-patterns. (Tahara and Shibata, 2013) Circadian lighting is waves of light, varying in colour/CCT and intensity/lumen over the course of a day. Potential side effects from are not general, but headaches and nausea are reportedly reoccurring. (Eiber and Friedman, no date; Jurvelin et al., 2014) As this is common side effects of underweight and ED, it can be hard to discover increased discomfort in the patients, (Interview B, 00:11:26) (Interview C2, 00:04:42) which makes it difficult to determine whether the BLT/CL courses negative effects. It should be possible to detect and determine positive effects. CL and light therapy in general are non-invasive and should be tested.

### **3.3.8 ED + Seasonality**

Depression and anxiety are two of the comorbid diseases in severe ED. (Interview C, 00:09:30-00:10:30) Nothing suggests that ED patients develop SAD symptoms more than healthy Danish people, but one subject explained that more difficulties gaining weight during the Winter, than during Summer. This problem occurs mainly because the body burns more calories when it is cold, as it needs padding to keep the organs safe and running, but also because she feels that her mood and eating are closely related. She is very sensitive to the sun and to getting energy from being outside during the day. (Interview D, 00:06:10, 00:14:44, 00:15:08) One of the experts experienced some symptoms of seasonality and SAD in young patients, but it is not something they draw attention to. Noting that summer allows for more outdoor activity, that can positively affect ED patients' mood. (Interview E, 00:10:02) SAD symptoms are more regular in BED and BN than in AN, and both behaviours can become more extreme during winter.

There is no evidence suggesting that seasonality is connected to ED to a higher degree than the standard in Danish population. (Danmarks statistik, 2016)

### **3.3.9 ED + Personal disorder**

The two, often described faces of ED draws attention to borderline, personal disorders, (Interview D, 00:09:08) bipolar disease (BP) and schizophrenia (SF) that are other psychiatric diagnoses with a sudden change in mood stability and personality. (Interview F, 00:06:30) These symptoms are not recognised as "comorbidity" as it is hard to tell symptoms of severe ED and symptoms of the comorbid mental illnesses apart. (Interview C2, 00:10:09) Current findings from bipolar disease (BP) and schizophrenia (SF) show promising results from light treatment. (Jagannath, Peirson and Foster, 2013) A possible future connection can be made.

Known side effects and thus consequences of dealing with a mental illness can occur in many different ways, both as small side effects and as bigger mental issues following the disease. In mental illness and to a high degree in ED it can be hard to determine what is comorbid disease and what is part of the illness. (Interview C, 00:09:49) (Interview F, 00:04:21)

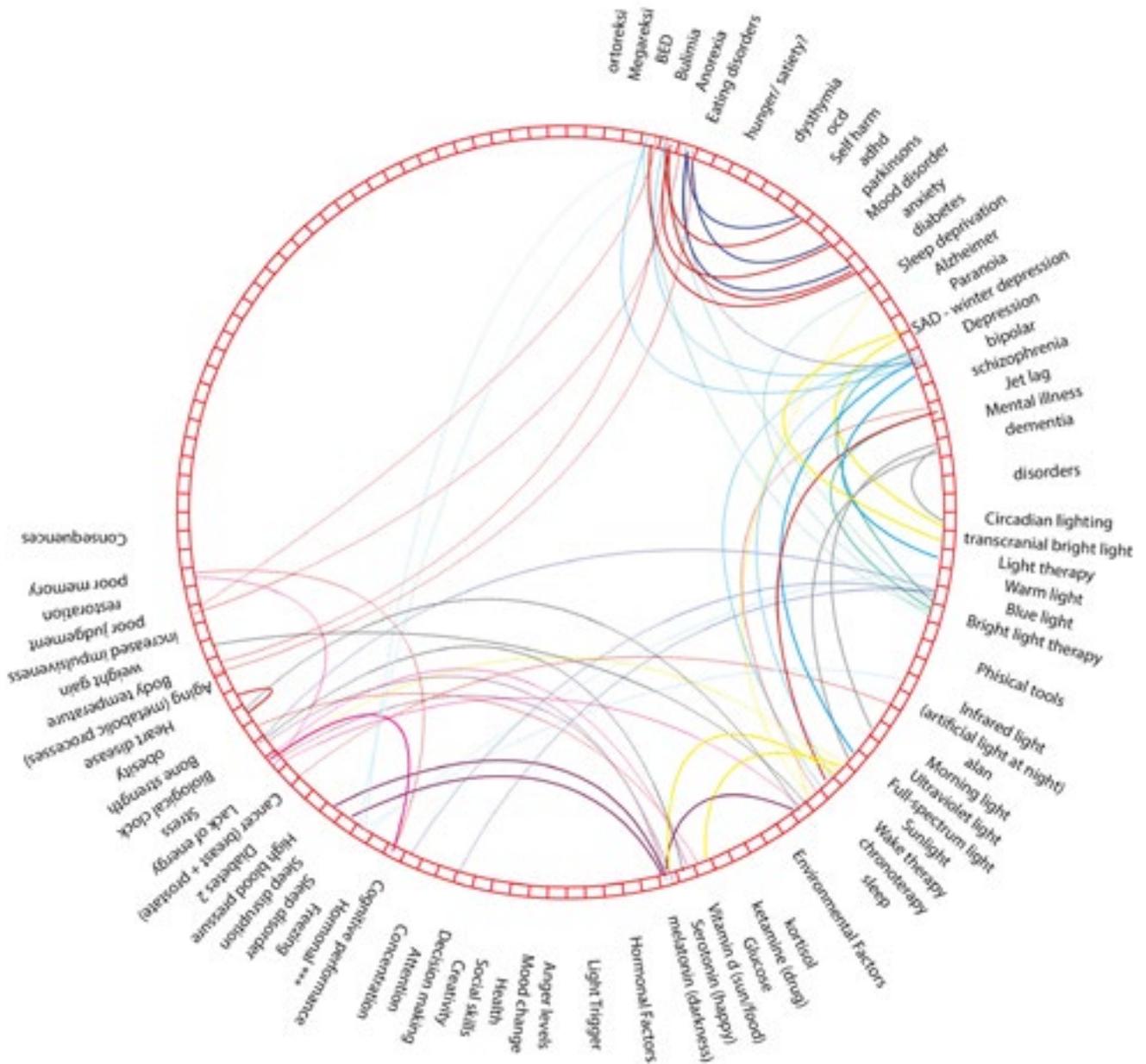


Figure 14, Mapping wheel

### **3.3.10 ED + Control**

Anxiety attacks in ED can among others be connected to being alone or with a group in situations including: food intake, sitting still after eating and sleeping. Cortisol levels and anxiety attacks could be related. One AN patient (Interview D, 00:09:08) states that she does not experience ED/AN as a psychiatric disease, but as a drug she cannot quit, but says that others might refer to "it" (the ED) as an inner demon. (Interview F, 00:06:16) The control aspect in ED is concentrated solely to food intake and exercise. All ED patients are voluntarily hospitalised, signing a contract that all aspects of control are stripped away while they undergo treatment. (Interview C1, 00:01:25) (Interview F, 00:35:30)

In private spaces, they can find calm and refuge. Dimming possibilities or controllable light sources as Philips hue are suggested in private rooms, to give back some kind of control over the atmosphere in private rooms.

### **3.3.11 ED + Body Check**

Hall ways can be used for body checking and comparing "soft spots". This is especially problematic when new girls are admitted and they look more sharp and bony. (Interview E, 00:20:21) Big heavy curtains that can be "drawn" at night, is suggested, to create a cosy atmosphere instead of institutional blinds. (Interview D, 00:20:05, 00:21:47) (Interview E, 00:18:49-00:20:05) similar problem in Glostrup. (Interview H, 00:25:20, 00:27:20) One of the experts suggest that the transparency is not only bad, as it can be used as part of the healing process. Linking body check to conversations about the body.

### **3.3.12 ED + Natural light**

Patients find sunlight and the heat from direct sunlight to be bad, they have an instinctive desire to take down the blinds during summer and in general they avoid sitting in the sun. This behaviour is connected to calorie intake, as the body burn more calories when freezing. (Interview H, 00:14:30)

ED patients like being outside and outdoor activity and one expert experienced that the arrival of spring created a positive mood in some patients. (Interview F, 00:16:16)

ED patients have issues with bone strength, especially AN-patients have weak bones due to calcium and BMD (bone mineral density) which can be optimised by Vitamin D3 intake, from food and sunlight. (Interview D, 00:15:08) (Interview F, 00:26:50) Low levels of Vitamin D can also cause depression. ED patients could potentially benefit from the non-visual portion of the light spectrum, as wavelengths below 400nm (ultra violet) can start Vitamin D production and wavelengths above 700nm (infra-red) provides warmth to the body. (Parry and Maurer, 2003; Webb, 2006) Sauna and infra-red saunas can help on maintaining thermal comfort during winter. (Interview D, 00:14:44)

## 3.4 Summary

Research within the field of light and ED is still extremely limited. In #Figure 14, investigations in side effects, symptoms and various mental disorders has been compared and mapped.

Common triggers from ED has been implemented in the overview to see where they occur in other psychiatric contexts. This was done, to get an overview of the findings, and a few connections occur as dominant in relation to mental illness and light therapy. This can be used to hypothesise on how lighting design can be beneficial in the treatment process.

Short summary on important overlaps in ED and positive outcome of light therapy from the discussion:

**Control:** *Common for all ED patients is the desire for control. What they eat, when and where. When they feel out of control, they can turn to self-harm.*

**Daily rhythm:** *ED patients have an urge for scheduling and knowing what happens and when, hence control aspect. Sleeping is bad and ED patients feel the need to stay active during night.*

**Body temperature:** *Due to low BMI, ED patients have trouble staying warm, also during summer. The body uses energy and calories to stay warm. Cold surfaces and wrong materials can add to this.*

**Sensitivity:** *Patients are extra sensitive to smell, touch and some have reported that glare is highly disturbing, assuming that they could also be extra sensitive to light and especially glare.*

**Freezing:** *Infrared waves and the sun can help the girls getting a feeling of warmth and direct sunshine indoors.*

**Sleep:** *ED patients can sleep, but some sleep shorter. If they wake up at night it can be a symptom of an experience, low body weight or rules. ED patients have a small tendency of eating their biggest meal in the evening and nocturnal behaviour. Obsessive exercise and self-harm can occur during night. AN-R shows normal Melatonin levels. Some ED patients have CR phase disruption.*

**Anxiety:** *Eating is a highly uncomfortable situation for ED patients, because they are out of control and also have to eat, which leads to anxiety. After eating, all patients have to sit still together - this is very challenging.*

**SAD:** Patients with ED are prone for depression and/or anxiety, but it is not a symptom of ED to be seasonally affected.

**Nigh-shift:** Evidence is growing, that circadian lighting can play a significant role in hospitals, for both patients and the 24-hour staff.

**Bright Light Therapy (BLT):** Tendency towards bright light in the morning as a tool for phase shifting, depression, SAD and dementia. It resets the biological clock and prepares the mind and body for a new 24h cycle.

**Circadian Light (CL):** Positive effects on sleep, resetting CR, body temperature rhythms and treatment of illnesses such as dementia and SAD. Associations between light in treatment and convergence in ED symptoms is still lacking evidence.

**Chrono-nutrition:** the mammalian circadian system is reportedly entrained by food signals (Tahara and Shibata, 2013) and this should be taken into consideration when working with ED patients, as they have a very strict food intake schedule.

**Vitamin D:** In ED, many long-term patients lack bone development and organs because of low nutrition levels. D3 benefits from sun and food, including binding calcium to the bones, energy and sleep.

*All material in nature, the mountains and the streams and the air and we, are made of Light which has been spent, and this crumpled mass called material casts a shadow, and the shadow belongs to Light.*

Louis Kahn

## 4.1 Sanatorium tradition

The tradition of providing beautiful spaces, interesting views and providing healing environments for inner healing is not new in Denmark. Focus on the patient rather than functionality used to be a common strategy. The new human-centred approach in healing architecture takes notes from historical sanatorium facilities. To highlight two facilities focusing on great architecture, beautiful landscaping and daylight, the psychiatric hospital in Risskov and the Tuberculosis sanatorium in Vejle is depicted below. The state of the art section in this thesis is delimited to current Danish health care architecture and will thus focus on the latest findings and the implementation of different cases of dynamic lighting.



Super architecture is a term used about new architecture that combines aesthetics and sustainability and additionally has a positive effect on the environment as well as the human wellbeing. Dr Terri Peters draws attention to old treatment forms known from care cottages and sanatoriums that was popular in the years 1885-1950. Sanatorium stays included fresh air, nature and therapeutic architectural features.

A human-centred approach to psychiatric treatment, and putting people first, was the objective in the end of the 19th century. Many famous buildings, such as the Alvar Alto sanatorium in Paimio from 1933, were erected during that period. The Paimio sanatorium differentiates from the current state of the art, being tall and functionalistic ( Photo J). Peters emphasises the importance of the human-centred approach, providing patients with architectural quality, daylight and experience, combining landscape and beautiful architecture in the healing process. (Peters, 2017)

*“Hormones are formed when humans feel good – this is why they call it healing architecture. (...) Actually, these are all parameters that architects should always take into consideration”*

*(Quote translated from Danish, Nord arkitekter, Johannes M. Pedersen, 30.08.2017)*

«  
PHOTO 8  
RISSKOV PSYKIATRI,  
1852 BINDESBØLL)

»  
PHOTO 9  
VEJLE FJORD,  
TUBERCULOSIS SANATORIUM,  
1900 DAHLERUP OG MEYER



## **4.2 Modern** *healing architecture*

PHOTO 10  
THE PAIMIO SANATORIUM  
ALVAR ALTO, 1933

Entering a hospital is not the most comfortable situation, for most people, depending on the occasion. Arriving as a patient or a loved one, it can be the anticipation of good or bad news, or simply an employee arriving at work. All with a purpose, and all in need of wayfinding and safety. (Ulrich et al., 2004) Design, landscape and materials meet you, when you arrive at a hospital, no matter what state you are in. Inside the hospital, different functional needs will appear, e.g. a professional environment for the staff and a healing and soothing atmosphere for patients. (Nickl-Weller and Nickl, 2013)

Everyone who spend time in the hospital will benefit from daylight, thermal comfort and access to nature during the stay.

Healing is about promoting wellbeing or adding a therapeutic effect. When it comes to healing architecture, it is all about how the physical space affects the healing in patients and staff. Providing spaces for treatment and recovery while adding windows for view and daylight. This is supported by the masters of daylight, as Louis Kahn "A room is not a room without natural light" and Le Corbusier "Architecture is the masterly, correct and magnificent play of masses brought together in light".

According to Nickl-Weller & Nickl, 2013, the spaces people encounter affects them in some way. A big responsibility for the designer of the space, is to use knowledge, empathy and creativity to enhance balance and form. Further, they suggest that the architectural space will become an embodiment of the self, for a person who is hospitalised. This means that the health care design must be driven by the users, since *"this will pay off in the long term"*(p. 243). In the chapter, "The healing power of space" the importance of personalised space in fostering healing powers is enhanced.

The chapter suggests that space is first about *"being"*, then about *"being in a certain way"*, followed by the added dimension of *"exploration"*. In health care, personal space should *"demonstrate a protective function, while at the same time providing the opportunity for an open encounter without restriction or limitations."* (p.243)(Nickl-Weller and Nickl, 2013, pp. 238–251) ("The healing power of space" p. 238-251)

Findings suggest positive correlation between on one side reduced anxiety levels in patients and on the other side staff being visible, available and present. (Frandsen et al., 2009, pp. 152–179) Related to this, a nurse (Rigshospitalet ED) experienced that patients would only use the "living room" if the staff were present. When all members of the staff were otherwise engaged, patients did not use the living room, even though this space was considered cosier. (Interview C2, 00:07:34) Research suggests that openness in spaces can have a positive effect on moving patterns in patients and enhance visibility. This causes new time-consuming problems related to is bigger distances for staff, in the new one-plan hospital buildings

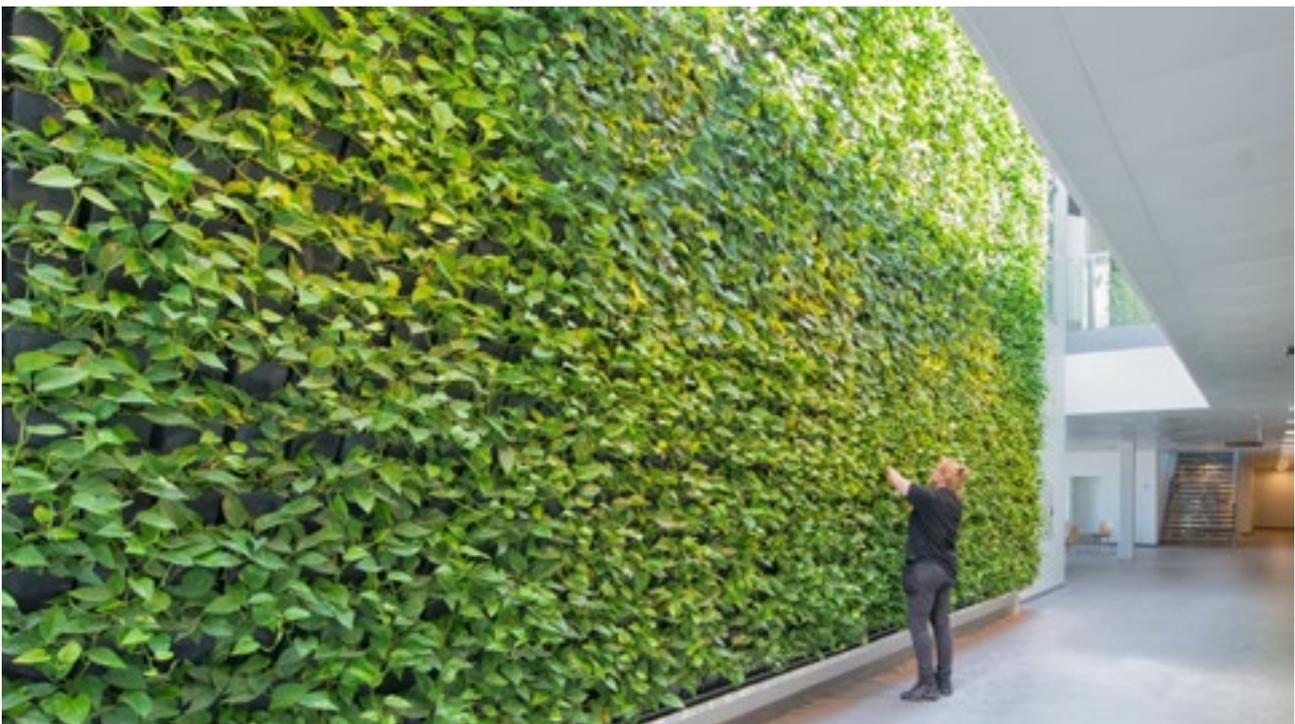
### 4.2.1 Nature

With criteria as equity, beauty, materials, site, water, energy and health, access to nature is a common feature in all aspects of healing architecture. Findings from 1984 brought evidence to the healing effects of a window, and how it affects surgical recovery, fear, anxiety and stress related to the hospitalisation. Natural landscapes were of preference and especially views of water (Ulrich, 1984) Evidence for the experienced healing effects of access to nature was explored, based on clinical and non-clinical research. While there is a solid ground of evidence of improved health as an effect of fresh air, as well as sufficient evidence of health benefits from quiet environments and the stress and pain relief from views to nature, there is only weak evidence of health benefits provided by natural light and indoor plants. (van den Berg, 2005) This presents evidence for future design of health care buildings and environments.

Related results of positive effects on stress levels, concentration, hospitalisation time, general satisfaction and work joy has been found with connection to nature and access to the outdoors. (Frandsen et al., 2009, pp. 182–212) Supported by famous words from Thoreau, *"nature is but another name for health..." "If the prospect of an early morning walk does not banish sleep, if the warble of the first bluebird does not thrill you—know that the morning and spring of your life are past. Thus may you feel your pulse."* (Henry David Thoreau, 1859, p. Feb 25)

The indirect health benefits of daylight can be related to sleep quality, CR and physical aggression. Compared to patients with rooms in shade, the patients in rooms with more natural light had 3.67 days shorter stay in the hospital. This suggests that rooms with windows facing east offers the fastest recovery. Window related issues are connected to privacy, and patients in a vulnerable state being visible to the outside. (Ulrich et al., 2004; From and Lundin, 2010, pp. 149–169)

Green hospitals are currently in the scope, but all nature access is not necessarily good. The natural environment must offer room for activity, meet the preferences and needs of the visitor and enhance curiosity to add value. (Arkitekterne, 2013, pp. 134–146) In the words of Nickl-Weller & Nickl, 2013, the healing hospital should not only treat patients, but also work as a life-enhancing work environment for employees as well. (Nickl-Weller and Nickl, 2013, pp. 230–238)



#### 4.2.2 Cultural impact

Cultural impact affects the use of indoor light, (Seghi, Noskaitis and Spanos, 2017) and plays a huge role in the perception of a space. Because of this, foreign facilities have been excluded from this state of the art review, as the objective of the thesis concerns treatment and facilities in Denmark. Therefore, delimiting new facilities in Scandinavia, Europe, Canada and the United States to focus on the current Danish situation. (See appendix #B with a short list of foreign facilities)

PHOTO 12  
GREEN WALL  
AABENRAA PSYCHIATRIC HOSPITAL  
//NATURAL GREENWALLS

## **4.3 Danish** *psychiatric hospitals and specialised facilities*

New national objectives in psychiatric treatment include better quality, coherence and geographical equality alongside more patient involvement, more effective health care systems and shorter stays. ('HEALTHCARE IN DENMARK AN OVERVIEW', 2017) As evidence based design became connected to shorter hospitalisation, less prescription medicine and stress, more current hospital buildings are based on this line of thinking. This approach demands for high levels of openness and knowledge sharing, as evidence based design demands for knowledge from finished buildings. (Arkitekterne, 2013, pp. 28–35) Recent psychiatric buildings in Denmark, have recently been designed with the concept of healing architecture in mind. With the architectural focus on daylight, materiality and human scale in mind, engineers work with indoor climate and air for thermal comfort, landscape architects are in charge of surrounding landscapes and lighting professionals to design and implement state of the art lighting design for healing and meet the standards of modern health care architecture. (Arkitekterne, 2013, pp. 54–57) Experts and knowledge drives the design, and puts everything but the atmosphere into high priority in new hospitals, buildings for elderly and psychiatric facilities.

Modern psychiatric hospitals are no longer permanent places of residence, as somatic and psychical treatment of patients have been integrated in the same buildings. Patients are the centre of treatment, taking personality and resources. Current psychiatric treatment focusses on healing and getting the patient home. Compared to the common belief in the days of the psychiatric asylums, where a psychiatric stay was considered permanent, the current average stay at a psychiatric hospital is 17 days. (Arkitekterne, 2013, pp. 47–49)

## **4.4 Light** *in new Danish psychiatric buildings*

The health sector in Denmark started in the forming of an interest in daylight and how daylight intake can affect long term-committed patients within the health sector, and about five years ago the scene was set for implementation of dynamic lighting systems. First movers in Denmark included the new regions and especially Region Nordjylland and Region Syd.

Access to daylight equals satisfaction, daily rhythm and sleep, and shows significant effects on levels of depression, hospitalisation time, recovery and stress connected to hospitalisation. (Frandsen et al., 2009, pp. 23–59) At night time, artificial light from surrounding gardens and parking lots can be troubling for patients. (From and Lundin, 2010, p. 157)

Denmark has been highly productive in new health care architecture within the latest five years, closing down small hospitals and making five big super hospitals instead. During this process, the topic of healing architecture has been included and daylight and dynamic lighting for enhanced sleep has been buzzwords. (Interview G, 00:00:50) As a product of the new knowledge of the internal clock and the programming possibilities of LEDs, dynamic lighting to support the daily internal clock has been hypothesised. (The Nobel Prize in Physiology or Medicine 2017, no date) This is popularly referred to as human-centred lighting (HCL) or CL and has been installed in hospitals and care facilities all over Denmark. (Figure 15) Due to a lack in evaluation, it has yet to be determined how it affects the patients and how it should be programmed accordingly. Future evidence could provide standards and support new knowledge based lighting design.

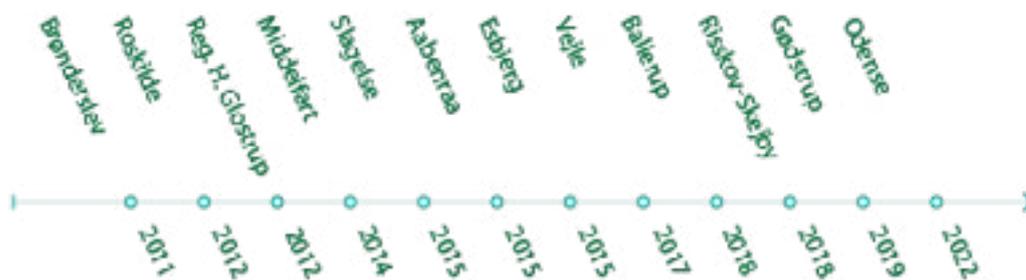


Figure 15, timeline with new Danish health care buildings

As hospitals need to support professional staff as well as patients 24 hours a day, CL is currently hypothesised to help inpatients and staff with resetting the internal clock and aligning their respective sleep patterns. Some psychiatric facilities report of less drugs and physical restraints, (HELENDE ARKITEKTUR - PSYKIATRISYGEHUSET I SLAGELSE, no date) while patients with dementia and SAD can benefit from cues of a stabilised daily rhythm and BLT. [section 2.6.1] (Halper, 2017)

When seasonality, orientation and healing were investigated and later the discovery of the biological clock and hormone markers within the brain, it gave new clinical evidence for investigating the influence of daylight exposure. Iben, from Lightscares explains that initially the question of lighting was about sleep, especially in forensic psychiatry where patients can be admitted for up to eight years. (Interview G, 00:03:30-00:05:24)

LED technology is getting better with time and an important sustainability factor as energy consumption is now a given in new Danish health care. Better LED fixtures does not only allow for better light quality, but also for lighting quality allowing for implementing of dynamic daylight sensors, circadian lighting schemes and seasonal changes in the lighting, thus offering a more

tailored lighting design. Specifications take account for the implemented light quality but not lighting quality. (Interview G, 00:12:27-00:13:36) Dynamic lighting varies from different companies within Denmark and lighting designers have different opinions and ideas for suitable solutions for health care, offices and schools. Despite this, there is a lack of evaluation on the outcomes and more research is needed in the field of dynamic lighting, for the industry to approach a best practise and design e.g. circadian lighting with research based knowledge.

#### ***4.4.1 Different light in Danish psychiatric treatment***

An investigating of currently build psychiatric facilities in Denmark shows a tendency towards an acceptance of the effect and healing qualities of light, but presents no common denominator. Twelve psychiatric facilities either have or have planned to install dynamic lighting, HCL or CL from 2011-2022, but to this day, no formal evaluations of comparisons has been published, stating outcome and effect from different designs. This could suggest that the effects of light on mind and body are well accepted in Denmark.

Not only patients will benefit from the dynamic light installations, but also the employees. The new light installations post and emphasis on supporting the biological clock for the patients and at the same time not disrupting the sleep pattern for the people working night shifts, like in Bispebjerg and Sydjylland. (Rusbjerg, 2017) Research in night shift workers show that the red/amber light schemes used at night is the best light combination, to support the work tasks without disrupting the circadian rhythm [section 2.6.5]. (Figueiro et al., 2009; Figueiro and Rea, 2010; Münch et al., 2014) In an evaluation of the installed dynamic lighting in Region Syd, staff reported predominantly positive experiences, but a lack of knowledge of the system, prevented optimal usage. In most cases, the night light was evaluated as mostly positive, but in some cases the red or amber light had negative effects on patients with anxiety and the ability to perform work tasks during night shifts. (Syddansk Sundhedsinnovation, 2012; Dalkjær, Mikkelsen and Clemmensen, 2016)

A number of psychiatric facilities report of reduced restraining episodes and reduced drug use, and this can be a direct effect of the new architecture, happier staff or better access to nature and daylight, just as well as a direct effect of the dynamic lighting.

### 4.4.2 Slagelse psychiatric hospital, 2015

The psychiatric hospital has an optimised daylight intake, healing LED lighting, and enhanced connection to the outside. Art and poetry has been involved as well as extensive user collaboration. The public access to surrounding landscape and main building, redefines the identity of this psychiatric facility. (Arkitekterne, 2013, p. 48; Lys skal helbrede psykisk syge - Region Sjælland, 2014, HELENDE ARKITEKTUR - PSYKIATRISYGEHUSET I SLAGELSE, no date)

**Architect: Karlsson arkitekter & VLA (architect and advisor)**

**Size: 44.000 m<sup>2</sup>**

**Client: Region Sjælland**

**Lighting design: Bartenbach**

The dynamic lighting is implemented to reduce stress, anxiety and physical restraint. Bartenbach will be involved in future research projects testing the effects of the lighting.

- » Focus on daylight
- » Dynamic circadian lighting
- » Multi stimuli rooms
- » Small courtyards, with vertical light on walls at night to minimise darkness.
- » Hallways with varying light zones, from dark to light
- » 10lx warm night light in rooms, at floor level



PHOTOS  
SLAGELSE PSYCHIATRIC HOSPITAL  
KARLSSON ARKITEKTER

### 4.4.3 Aabenraa psychiatric hospital, 2015

The facility supports social interaction and landscape integration. An enhancing of the view of greens both inside and outside emphasises peace, atmosphere and openness. It is sustainable in terms of energy-consumption and daylight use. (Chromaviso, no date; Arkitekterne, 2013, p. 59; Dalkjær, Mikkelsen and Clemmensen, 2016; Happich, 2017)

**Architect: White arkitekter**

**Size: 20.000 m<sup>2</sup>**

**Client: Region Syddanmark**

**Lighting design: Chromaviso**

The healing architecture by White Architects has focus on light, colours and natural materials to reduce the drugs prescriptions in the facility.

- » Full automatic ergonomic CL
- » 6 light sources in each fixture to collect  $\rightarrow$ CL, general light and activity settings in one
- » Options: work, relax, calm, energy and watch light (night)
- » Movement sensors turns of light in patient rooms when not activated
- » 25lx night light
- » Emergency light option + attach option with 100% white light (4000K)
- » Gently adjusted fades between the scenarios



PHOTOS  
AABENRAA PSYCHIATRIC HOSPITAL  
WHITE ARKITEKTS

#### 4.4.4 Middelfart psychiatric hospital, 2014

##### Forensic psychiatry

In the forensic psychiatry, there is special demands for space, activity and safety. Patients stay in the facilities for an average of 8years. The facility offers common areas as well as smaller niches. It has a high level of security for staff and counteracts escape attempts. (Psykiatrien har set lyset - Dagens Medicin, no date; Dalkjær, Mikkelsen and Clemmensen, 2016)

**Architect: CREO arkitekter**

**Size: 7.900 m<sup>2</sup> extension + 6.500 m<sup>2</sup> conversion**

**Client: Region Syddanmark**

**Lighting design: Luminex LightCare (Originally: MotoMutu)**

- » CL with artificial sunrise (RGBW)
- » High quality wide-spectrum light as in lamps developed for SAD
- » CL for stimulation if Serotonin and Cortisol for wellbeing and energy
- » Red night light for minimum disruption of Melatonin levels in staff and patients in hallways and open areas (RW)
- » Intensity ranges from 1%-100%
- » Emergency option



PHOTO  
MIDDELFART FORENSIC PSYCHIATRY  
CREO ARKITEKTS

#### 4.4.5 Esbjerg Psychiatry, 2015

Esbjerg psychiatry is based on earlier buildings and an orthogonal disposition, which creates a compact structure but also a clear division between the different specialisations on the same location. A new integrating approach has led to redefined boundaries and a transition between the private and the public space. (Lightcare, no date; Dalkjær, Mikkelsen and Clemmensen, 2016)

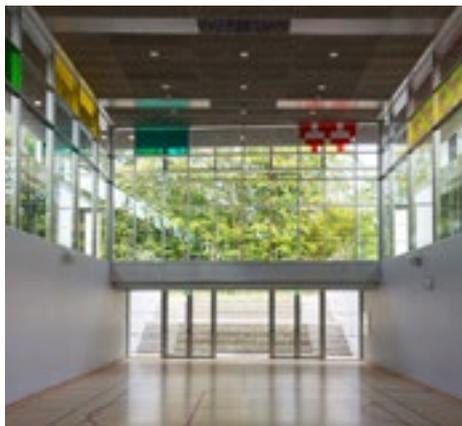
**Architect:** Arkitema arkitekter

**Size:** 6.600 m<sup>2</sup>

**Client:** Region Syddanmark

**Lighting design:** Luminex LightCare

- » Full dynamic RGBWW LED
- » White CL option
- » Circadian rhythms control (6000K in the end of the afternoon)
- » Min. 400lx at eye level (double of current standard)
- » Emergency option + cleaning
- » Intensity can be regulated (25% - 50% - 75% - 100%)
- » Hallways and open areas can be adjusted manually by staff to CL or other



PHOTOS  
ESBJERG PSYCHIATRIC HOSPITAL  
ARKITEMA ARKITEKTS

#### 4.4.6 Vejle psychiatric hospital, 2017

This facility consists of eight houses with access to courtyards and common areas. All is set in a simple and functional architectural approach, emphasising circular flow for employees, green access and a clear transition between public and private areas. This facility is the most recent health care facility with installed dynamic CL. (Orton, no date; Lys skal hjælpe psykiatriske patienter - [www.regionyddanmark.dk](http://www.regionyddanmark.dk), 2013; Sigh, 2013)

**Architect:** Arkitema arkitekter

**Size:** 17.000 m<sup>2</sup>

**Client:** DEAS A/S

**Lighting design:** Lightscapes

- » Daylight in every room – as this helps the circadian rhythm
- » Darkness – to induce melatonin
- » Good sleep - prevent blue and strong light in the evening
- » Dynamic light – follows both daylight and seasons
- » Predefined settings – can be changed manually



PHOTOS  
VEJLE PSYCHIATRIC HOSPITAL  
ARKITEMA ARKITEKTS

Before “Light in psychiatry” (Lys i psykiatrien) was initiated, a review and a framework for the implementation of dynamic light in the region was compiled. (Syddansk Sundhedsinnovation, 2012; Sigh, 2013)

CoLab and Region Syd have made a public evaluation of the three psychiatric facilities with circadian lighting in Southern Denmark (Middelfart, Esbjerg, Aabenraa). This evaluation is based on experiences of patients and staff, and compares the three different companies delivering the light.

Staff and patients consider the CL to have a positive effect, favouring the warm tones at night because of the quiet and cosy atmosphere it creates. The red night-light is evaluated as good on biological parameters, but some members of staff experience difficulty performing everyday tasks. Some patients find the night-light uncomfortable and in a few cases, it has enhanced symptoms as night-time anxiety and psychoses.

Overall the evaluation is positive towards the installed CL, but further education on the technical possibilities and function is needed for staff. (Dalkjær, Mikkelsen and Clemmensen, 2016)

#### **4.4.7**

#### ***Psychiatric hospital Ballerup, 2018***

##### **Eating disorder unit**

The psychiatric centre is designed to integrate the patients in the surrounding landscape, in a building that is connected to nature for healing and sustainability. It offers intimate spaces and a home like atmosphere to patients and visitors.

As the building is still under construction this is a short brush up of what is expected. The current PCBA ED facility is functional with installed dynamical CL designed by Vanpee for health care, but a new lighting design will be implemented in the new building. (Vanpee A/S, no date; Rusbjerg, 2017)

**Architect: RUBOW arkitekter**

**Size: 5.600 m<sup>2</sup>**

**Client: Region Hovedstadens Psykiatri, Psykiatrisk Center Ballerup**

**Lighting design: Sweco**

- » Dynamic circadian lighting supporting the biological clock
- » Artificial dynamic daylight sensors
- » Emphasis on access to green court yards and view to green

[Renderings from PCBA ED 55 in section 6.6]

## ***4.5 State of the art summary***

To sum up the findings from this brief investigation, the focus from new Danish architecture for the health care sector is focusing on the following:

- » Dynamic CL lighting
- » Access to daylight and nature
- » Atmosphere and visual stimuli
- » Work environment and effectiveness
- » State of the art healing architecture
- » Focus on materials, landscape and colours



PHOTO  
BALLERUP PSYCHIATRIC HOSPITAL  
RUBOW ARKITEKTS

## 5.1 Lighting design research

Initially, the objective of this thesis was to answer the following research question: *“Can lighting design be used as part of the treatment of severe eating disorders, calm the patients and still support a professional work environment?”*

In order to solve the initial research question, the three criteria (healing, atmosphere and function) was investigated. The expectations to the lighting design, in connection to each criteria has been clarified below:

- **Healing:** *When it is a tool for a faster healing process by enhancing rest, sleep, motivation and minimise comorbidity by intentionally stimulating the human biological clock.*
- **Atmosphere:** *When it is calming and comforting for the patients both emotionally and aesthetically, by stimulating the anxiety and have positively effects on the mood and overall wellbeing.*
- **Function:** *When it supports the professional functions of the staff throughout day and night with minimal disruption of their sleep, thus giving the staff a better work environment.*

To answer the initial research question, the literature review elaborated on current findings and knowledge of light in psychiatric treatment. Investigating the somatic, cognitive and emotional effects of natural and artificial light on the mammalian body clock. (2.0)

Findings from the literature review was subsequently linked to ED. Where internal symptoms (e.g. body clock, sleep patterns and hormone segregation, wellbeing, mood and energy level etc.) was linked to light therapy and discussed. (3.0) Through a thorough review of symptoms and behaviour of severe ED and a line of expert interviews, these effects were summarised in connection to the disease. (3.3)

Understanding the changing work hours, schedules and demands from the staff in the facility has been important. Supporting their job functions, by meeting current professional standards (DS/EN-12464-1:2011, 2012) should be of top priority in the lighting design.

Elaborating on this and the three criteria, the final research question was formed:

*“How can lighting design be used as part of the treatment (healing) of severe eating disorders in a 24h facility, calm the patients (atmosphere) and still support a professional work environment (function)?”*

Salient touch points from the discussion (3.0) were taken into account in the evaluating of how to work with the three criteria in the lighting design.

These statements will serve as a tool when addressing opportunities and weaknesses in the implementing of the final lighting design for ED treatment.

### **Healing**

**Nutrition:** Regulated food intake and strict schedules suggest that patients undergoing ED treatment are already nutritionally synchronised circadian, but nothing suggest that circadian lighting will disrupt anything.

**Glare and sensitivity:** Findings/information from this thesis would suggest that patients with eating disorders are more sensitive and thus maybe they experience CCT and intensity as exaggerated compared to other patients.

**Low energy levels:** Patients with energy during morning and evening might experience more energy in the middle of the day as a result of the afternoon boost. Presuming that this will add to a healing environment and not induce more exercise.

### **Atmospheric**

**Therapy boosts during the day:** The relatively high light levels needed for therapy boosts will negatively affect the experience of a warm and homey atmosphere at the facility.

**Not being able to control the light level and CCT:** Cold and bright light can in Denmark be experienced as institutional, professional and be linked institution and health care treatment.

**Ceiling mounted fixtures:** Culturally speaking, Danish people tend to lower the source of light to create a cosy mood in a space.

**High uniformity demand:** Evenly lit spaces prevent for patients to choose whether to sit in the dark or bright spots.

**Glare:** can be hard to avoid with the high illuminance levels required for the CL to have an effect.

### **Functional**

**Minimum standards:** By following the current minimum standards for healthcare environments and treatment, the staff should have sufficient work light.

**Eating situation:** Allowing a cosy dim light can be limiting on the level of observation for the staff in an eating situation.

**High CRI:** when observing the patients eat, high CRI will enhance colours and contrast, helping the staff to focus and see clear.

**Curtains:** in the hall ways will prevent the staff from observing the patients when they are in the court yards, allowing for exercise.

**Vertical light:** Cove lighting in hallways, opposite from windows can lower reflections in combination with vertical light in courtyards.

**Night light:** Lower light levels at night will support the circadian Melatonin rhythm in night time staff.

## 5.2 Design hypotheses

Based on the three criteria that solves the initial research question, the final problem statement and the following design hypotheses has been formed:

*“Lighting design can contribute to the treatment (healing) of severe eating disorders, calm the patients (atmosphere) and still support a professional work environment (function)”*

- A)** Atmosphere and visual stimuli can affect mood and well-being
- B)** Light temperature can affect the thermal comfort
- C)** Use of natural materials can create a better healing environment
- D)** Circadian lighting can help balance the sleep/wake rhythm and seasonality
- E)** ED patients are more sensitive to light thus direct light and glare should be minimised
- F)** Adverse effects of light therapy will be the same as some symptoms of severe ED
- G)** Adjustable lighting can personalise patient rooms and enhance a sense of control
- H)** A dynamically lit environment could support the daily and seasonal changes in the northern hemisphere
- I)** Lighting could be more suitable for the staff working at night
- J)** Low CCT at night will enhance sleeping patterns for night time staff
- K)** Reflections in glass hallways can be minimised, to reduced body-checking

## 5.3 Design criteria

Working with the final problem statement and design hypotheses, three design related research questions has been formed, as a tool establish the final design criteria for the lighting design:

### ***How can lighting design improve the work environment?***

- ***Safe/Professional:*** maintaining current standards, as it is also important for the staff to be able to fulfil the daily tasks, be safe and keep an eye out for the patients.
- ***Supporting:*** when the light levels are adjusted for the task and time of day, it will minimise the unwanted sleep delay in night shift workers.

### ***How can lighting design add spatial identity and healing atmosphere?***

- ***Calming:*** Avoiding glare, creating visual stimuli by adding contrast and layers of lighting, to avoid the institutional hospital feeling, thus enhancing relaxation and reducing anxiety levels.
- ***Personalised:*** The private space, where patients go to seek peace and quiet should have adjustable lighting, allowing for personal preference. Providing patients with options and choices of what they feel in the need for – whether it is comforting or focused.

### ***“How can circadian lighting be designed, to contribute to the treatment of severe ED?”***

- ***Dynamic:*** Specialised, designed and programmed to make a valid contribution to the healing and overall well-being according to the daily schedule and seasons.
- ***Resetting:*** Focusing on normalising sleep patterns, anxiety and mood as tools to accelerate the healing and reducing the hospitalisation time.

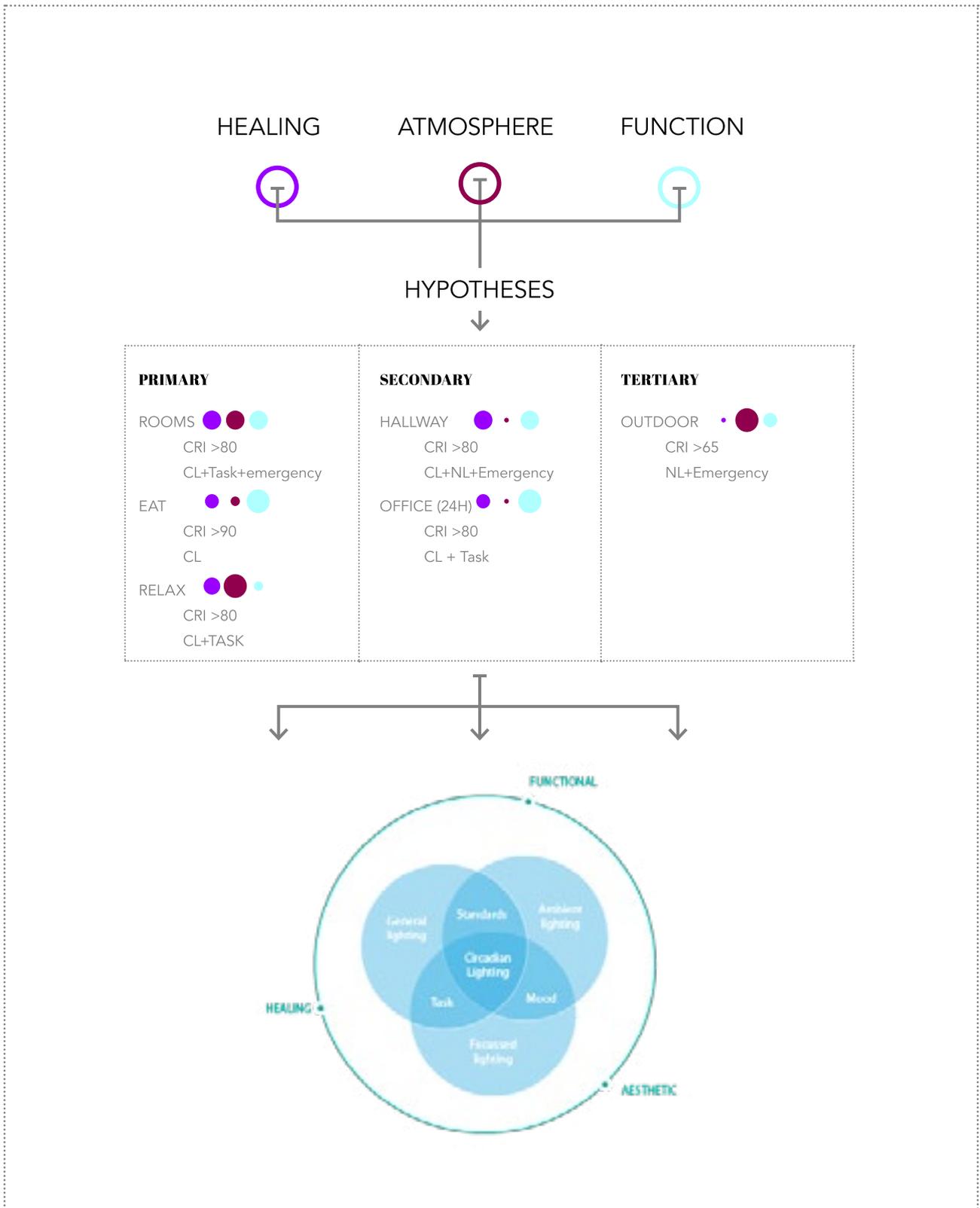
## 5.4 Final scope

The final solution for the PCBA ED facility will consist of a lighting design concept including circadian lighting for primary areas. Focusing on a research-based design, including current knowledge of bright light therapy, daylight, sensors and atmospheric lighting. The lighting design should consist of three layers of light (general, accent and focussed), each adapting to season and time of day, adjusted according to the activities and use of the space

Health care facilities contain many spaces of various use, size and function. Going through different lighting concepts for the different spaces, PCBA ED 55 will be divided into categories of importance, according to the time spend in the rooms.

- » The main focus will be on primary spaces including dining area, common area and personal rooms, Patients will be spending the majority of the daily hours in these spaces, suggesting that the strongest influence from atmosphere and CL can be connected to these spaces.
- » Secondary areas are connected to the night-shift (23-7), as they are functional areas with short term stays, including the open 24-h office for employees and the connecting hallways. Secondary spaces are openly connected to the primary areas within the building.
- » Context analysis and state of the art shows that there should be an emphasis on windows and view to green surroundings. Based on findings connecting nature and daylight to healing, court yards and landscape form the tertiary areas, with a strong emphasis on light for the dark hours (morning, late afternoon, evening and night) depending on the season.
- » In the quaternary group, treatment rooms and offices with regular occupation have been collected, including therapy rooms, meeting rooms, treatment rooms and daytime offices.
- » The rest of the spaces in the building have been excluded from the scope, e.g. toilets, storage, maintenance, staff dressing room.

# Design process model



## ***6.1 Design principles***

Graphic overview shows the priority of criteria in each type of space. On top of criteria and considerations based on the hypotheses, the three layers of lighting has been applied.

Further design considerations, based on findings from the literature review, resulted in the following design criteria:

### **Healing**

*Emphasise CL according to daily schedule and seasons  
Work with BLT or blue peaks for boosting and resetting*

### **Atmosphere**

*Focus on warm and soft atmospheric light, outside peak periods  
Introduce daylight as an important source for energy and wellbeing  
Create special settings for each area and function*

### **Function**

*Meet current standards  
Apply functional lighting to enhance the work environment  
and motivation for patients and professionals*

### **Day - including daylight**

*Visually stimulating  
Seasonal and daily changes  
Support circadian rhythm  
Task oriented and professionally functional*

### **Night - including all dark hours**

*Calming  
Reduce glare and mirror effects  
Avoid sleep disruption*

## 6.2 *Three layers of light*

Prior research within eating disorders suggests the possibility of a positive response to lighting design and atmosphere. The following three layers of lighting will be introduced in the lighting design concept to enhance atmosphere and the different functionalities. The three layers of lighting are, ambient lighting, accent lighting and focussed lighting. On top of these layers, the general lighting with circadian lighting will coexist.

### **General light**

- » To reach standards and introduce circadian lighting.
- » Type: Pendants, up-light, down-light

Creates the ambience in a room, usually wide coverage, creating soft shadows. The general lighting should be diffusing, using an opal lens to ensure high uniformity.

The general lighting is ceiling mounted and makes soft shadows. The purpose of the general lighting layer is to fulfil the standards and reach desired horizontal light levels. Additionally, the general lighting has an extra intent, as it also introduces the healing function to the space, with the programmed circadian lighting. In this case, the CL will be part of the general light fixtures.

### **Accent light**

- » To create atmosphere, visual interest and highlight architectural features, art etc.
- » Type: Spots, table lamps, recessed light, wall light

To introduce some atmosphere into the spaces, lower light sources will be part of the accent lighting. (Stidsen, 2013) In Denmark we rarely use ceiling mounted lighting in private homes, which makes hospitals, workplaces etc. feel very different than a home.

### **Focussed light**

- » To use for specific tasks and enhance functionality, productivity and focus for cooking, reading and working.
- » Type: Adjustable task light, spot

On top of the ambient lighting and the atmospheric lighting layer, the task lighting will be added, to enhance the functionality of the space. CRI, brightness and location are important to avoid unnecessary shadows and glare.

Dimmers and separate switches can be added for comfort and energy consumption.

## 6.3 Technical specifications

According to current minimum standards for indoor lighting, the human requirements include: visual comfort, visual performance and safety. Technical parameters for the luminous environment include: distribution, illuminance, directionality, variability, colour rendering and appearance, glare and flicker. (DS/EN-12464-1:2011, 2012)

The following table (#Table 2) states the current standards applicable to PCBA ED 55, in terms of illuminance (E), discomfort glare (GR), Uniformity (U) and Colour rendering (R).

EN 12464-1	Read		Room		Kitchen	Dining		Soft area		Hallways	
#	5.39.2	5.39.5	5.25	5.39.1	5.12.5	5.2.1	5.29.3	5.2.2	5.37.6	5.37.2	5.37.4
E (lx)50	300	5	500	100	500	200	?	100	200	100	50
UGR (max)	19	?	19	19	22	22	?	22	22	22	22
U (min)	0,7	?	0,6	0,4	0,6	0,4	?	0,4	0,6	0,4	0,4
R CRI)	80	80	80	80	80	80	80	80	80	80	80

Table 2:  
standards pr. EN 12464-1

### Natural light

- Daylight (length of day)
- Glare
- Shading

### Artificial light:

- Brightness (lumen)
- Intensity (Lux)
- CCT
- CRI

### 6.3.1 Variables

Variables that will be introduced in the following includes:

CCT, CRI and LUX:

#### CCT (K)

The colour of white light is measured in Kelvin, and is formally called CCT (correlated colour temperature). High Kelvin temperatures are cold and blueish, and have short wavelengths close to UV-light in the spectrum, whereas low Kelvin leads to warm and golden light and longer wavelengths, towards the infrared spectrum.

There are no standards for CCT, but it can be uncomfortable or disturbing if CCT is too low or too high, as this can distort the way we perceive colours. According to the Kruithof curve, illuminance and CCT can appear pleasing, when combined at desirable levels. According to Kruithof, 1941 people prefer low CCT at low at low illuminance and high CCT at high illuminance. Oi and Takahashi, 2007 compared the hypothesis to different spaces and found that preference of CCT and illuminance is depending on space and activity. (#Figure 18) (Kruithof, 1941; Oi and Takahashi, 2007)

1900K: Candlelight  
 2200K: high pressure sodium  
 2300-2500K: early sunrise  
 2700K: incandescent  
 2700-3200K: warm white (sunrise/sunset)  
 4000K: moonlight  
 4000-4500K: natural white (early morning)  
 5200K: midday sunlight  
 5000-6000K: day white (midday)  
 6500-7500K: cool white (overcast sky)  
 7500-8000K: shade  
 10.000K: blue sky

Figure 17:  
Kelvin temperatures explained  
in natural light

Artificial light is usually not tuneable, and emits light in a standard CCT as 2700K or 3000K. Findings suggest that cognitive performance and short-term memory is better under warmer light, than cool and white light. In terms of long-term memory, males performed best under warm and cool lighting conditions, whereas females had higher performance than males in the white condition. (KNEZ, 2001) Results suggest that there is no significance in positive mood, but negative mood decreased in females in warm light and increased in cool white light. The male's negative mood increased dramatically in warm light, compared to the cool white condition. (Knez, 1995; KNEZ, 2001) Positive mood was best preserved in warm white at 300lx and in the cool white at 1500lx. Problem-solving increased in the condition that served for best preserved mood. Mood and cognition differs in gender and age, and designing mainly for young females, this can be taken into consideration, in the final lighting design.

During a day, daylight will change dynamically, both in terms of illuminance and colour. (#figure 17) The human eye is designed to adjust to the experienced light level and intensity, so the changes are usually not disturbing the eye, unless the change in contrast is higher than 1/3.

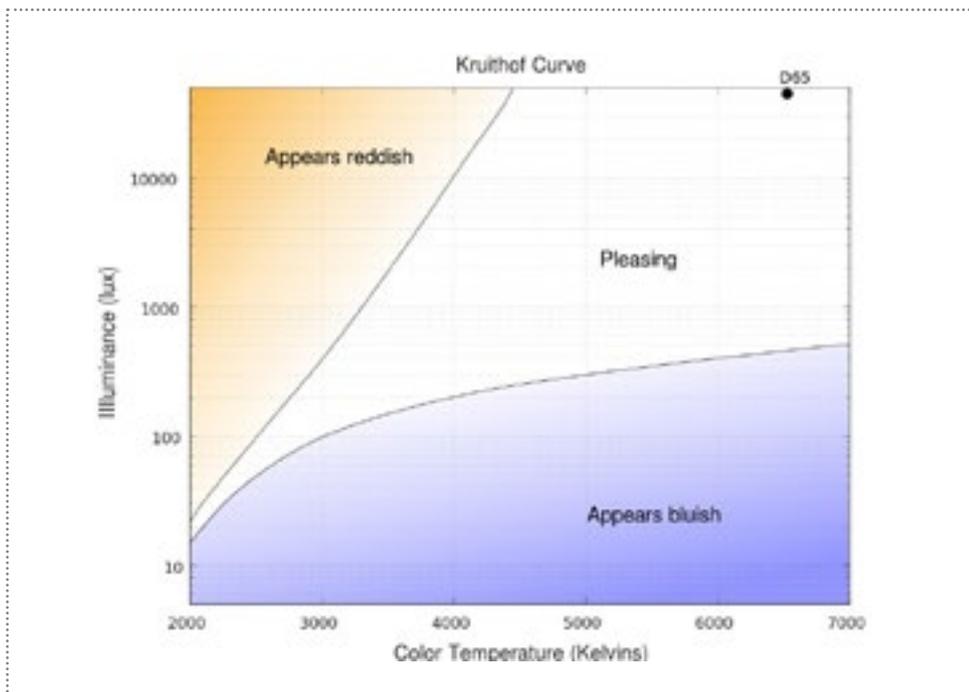


Figure18:  
Kruithof comfort curve  
(Kruithof, 1941; Oi and Takahashi, 2007)

### CRI/Ra

The colour rendering qualities, popularly referred to as Ra or CRI, are measured from 1-100. This number describes the spectral distribution based on eight sample colours. Daylight is full-spectrum, which compared to RGB LEDs and Halogen makes colours look better. A CRI above 80 is considered standard, but 90+ is preferable in PCBA ED 55, 100 equals full-spectrum daylight and is hard to reach with artificial light.

High CRI is used mainly in situations with colour-critical tasks. In PCBA ED 55, CIE +90 is desirable for eating situations, making the food look better and more interesting. Healthcare standard for rooms, hallways, offices and common areas are CRI+80.

Hypothetically, results from Küller et al, 1995 implies that low CRI (<55) can have a negative effect on long-term recall, as low CRI does not enhance recall and recognition, as it does not produce appropriate context cues. (Knez, 1995) This implies that both CCT and CRI can affect mood and cognition.

### LUX

Light emitted from a light source is called flux (cd) and measured in candela, referring to the light emitted from one candle. The intensity of the emitted light in a certain direction is measured in lumen (lm) and when the light hits a surface, the light is measured in lux (1 lumen/m<sup>2</sup>) also referred to as the illuminance. When light reflects of a surface and finally reaches the eye, this reflected light is measured in cd/m<sup>2</sup> and called the Luminance. One cd/m<sup>2</sup> is the amount of light that one lit candle would produce. (Lysviden. dk, no date)

The energy use and by this the performance of a luminaire is evaluated in Lux, as this is the easiest value to measure and control.

In a cross-cultural study with four countries, Küller et al, 2006 suggest that people in colourful workplaces have better mood than people in neutral or colourless environments.

The illuminance levels also differed over the year, from 30lx-2000lx in the four different countries, but showed no significant impact on mood at any time. (Küller et al., 2006) During February, the distance to the window did have a significant impact on mood.

### **6.3.2 Quality**

The quality of a light is evaluated in connection to the specific space and function. Light quality is mainly about how the light is perceived and how it supports the daily tasks, varying from work tasks to driving at night. To ensure a common denominator, the European standards were adopted and are continuously updated. As humans react to light both physically and psychically, the quality of light is evaluated, based on a combination of architectural factors, human needs, economy and environmental impact. (Lysviden.dk, no date)

Evaluation of the quality can be divided into two groups, lighting quality and light quality. In trying to differentiate between the two, it is important to underline the importance of the lighting quality, when you work with people. This refers to atmosphere, glare and flicker etc. - factors that plays a great role in the experienced quality of the light in a space. (Interview G, 00:17:20) The lighting quality is hard to predict or measure before it has been installed.

Light quality refers to the qualities of luminaires in terms of things you can specify in a tender e.g. CRI, size of the cone and lumen output etc.

### **6.3.3 Visual experience**

The visual experience is an important part of the specifications. This will depend on factors as contrast, light distribution, spatial awareness and colour.

#### **Uniformity**

The variety in light distribution is measured in uniformity, and is about shadows and contrast in a space. In a VR-experiment, findings suggest that people find light in spaces more interesting when a certain level of contrast is added to an architectural space (e.g bright direct sunlight entering the room, creating sharp shadows or added shapes and patterns in the shading). (Chamilothori, 2015) As PCBA ED 55 is a professional workplace, comfort and safety is of very high importance which could imply that it should be designed with high uniformity. However, when the light distribution is less uniform and includes vertical illumination, this can add to the spatial awareness and the space will be perceived as more interesting. As CR focuses on the natural cycle, the indoor environment should vary as well, in both time and space. (Velux, 2013)

***“For me, light is the main thing. Light is a natural physical phenomenon the complexity of which reveals the structure of human consciousness.***

*Objects, including buildings, in their absorption and reflection of light, stimulate a human brain’s neural networks, in effect activating the brain. The more complex and nuanced the stimulation, the more fully the brain comes to life.”*

Lebbeus Woods,  
2012

### Glare

The eye can adjust to very high luminance levels, which means that glare is all about contrast. If the contrast in a space is suddenly too high, it can be very disturbing and glary. This can happen, in an open fixture with a naked light bulb or if there is a very bright surface on the fixture. Natural glare will happen when direct sunlight hits a vertical surface and reflects on the eye. Disturbance glare should be avoided in the lighting design, especially because the patients might be extra sensitive to glare. (Pauley, 2004; Brawley, 2009)

### Flicker

Flicker can be visible and invisible and is generally connected to the driver in cheap LEDs. Dimming can be another factor that can cause flicker. The visible happens, when a light source changes light intensity very rapidly. The problem is known from fluorescent (120Hz) lamps. The human eye can detect a flicker frequency  $< 100$  flashes/sec. In high quality fixtures, the visible flicker should be minimised, as this can be very disturbing, and in some people, it can cause epileptic seizures. Invisible flicker is an even bigger problem, as it is present but cannot be noticed by the human eye. This can cause disturbances such as eyestrain, headaches, dizziness and general symptoms of feeling sick. (Boyce and M.Rea, 2001; van den Berg, 2005)

## 6.4 Circadian rhythm

When working with patients who are hospitalised for longer periods of time, it is of high importance, that the CL has a positive impact on the CR of patients. From the literature review [section 2.3] and the discussion [section 3.3.3] we know how to reset and disrupt with light pulses as the main Zeitgeber.

*” Light is the most powerful environmental entraining stimulus and daily ocular exposure to a 24-hour light-dark cycle is required to reset the internal pacemaker to 24 hours. ”*

*(Pechacek, Andersen and Lockley, 2008)*

A recent study found, that a thoughtful introduction and control of light, both natural and artificial, not only aid and speed up the healing process for patients, but also significantly improve the performance of hospital staff, undertaking a variety of visual tasks. (Joseph, 2006)

In this lighting design concept, the CR will be supported according to seasons, daily schedule and biological clock in the target group.

### **6.4.1 Target group**

Primary, the average subject is a young adult female with AN stage 1-3, only one out of ten is male. It is a changing group of patients, including 12 girls at a time. The length of stay can range from a few months to a year or more. Personalised lighting would be the best solution, but it is very difficult, as the patients have different needs according to mental stability, level of depression, seasonality score, diurnal type and mean melatonin rhythm etc. (Putilov, Donskaya and Verevkin, 2015) The scope of the following CL concept will thus be determined by the common denominator and metrics will be evaluated against the ones proposed by Barroso et al, 2014. (Barroso, Simons and De Jager, 2014)

Secondary, the CR of the 24-hour staff should be supported. In PCBA ED 55, the staff works in three shifts: 7-15, 15-23 and 23-7, and an emphasis should be on the ones working in rotating night-shifts. ALAN can cause side effects, when experiencing shift work and circadian disruption over longer periods of time, can lead to cancer. (Schernhammer et al., 2001; Pauley, 2004; Figueiro, Rea and Bullough, 2006; Kamali and Abbas, 2012)

### **6.4.2 Biological clock**

The rising and setting of the sun will reset the human circadian clock, unless the timer is influenced by other factors, such as artificial light, food, muscle activity or social contact. As a combination of the daily schedule and the location in the Northern hemisphere, the light stimuli from the natural light will not be enough to reset the biological clock in the patients.

They spend most time inside and the artificial light and light-emitting-screens will continuously disrupt their circadian rhythm at night. If the artificial lighting has to serve as the main Zeitgeber, the illuminance has to be significantly higher than current standards suggest. [section 3.3.6] BLT is commonly used as light box with up to 10.000 lux for 30-60min in the early morning. [section 2.6.1] This therapy can be part of a morning routine, reading or answering email, but findings suggest that similar results can be obtained with lower light levels at longer duration. A minimum of 400lx at eyelevel, should be emitted for ~2h in the morning, ~8.5h after Melatonin onset, for resetting, as findings suggest that exposure to light peaks, like BLT for resetting of the biological clock is preferable in the morning. A blue light peak at 460nm will induce higher chance of a successful phase shift, as well as intermitted light pulses. (Rimmer et al., 2000; Zeitzer et al., 2000; Terman et al., 2001; Lockley, Brainard and Czeisler, 2003) This could be explained by an overweight in people with peak activity in the afternoon and a society build for people with a morning peak. Four different chrono-types has been determined (Putilov, Donskaya and Verevkin, 2015) and there is a small tendency towards disrupted Melatonin rhythms in AN, but no significant chrono-type was found. [section 3.3.2]

*“The human body when kept in an indoor environment of low lux light will not realize that it is daytime, as it cannot sense the increasing levels of daylight that the genetics are accustomed to. As such, by late morning your body may start sending a signal for you to sleep!”*

*Steven Magee, Electrical Forensics*

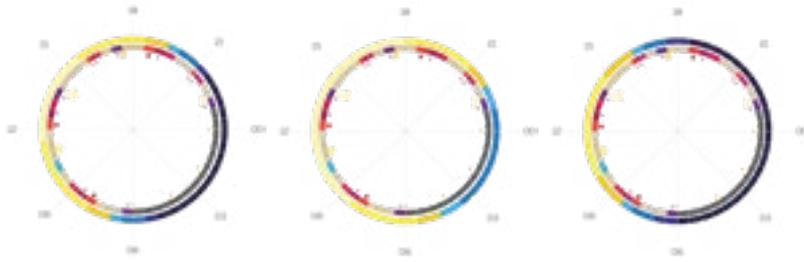
### 6.4.3 Schedule

All patients have almost the same daily schedule of sleep/wake, eat/digest, and exercise/therapy. (#Table3, daily schedule) But all patients are in the psychiatric facility out of free will and they can move around freely inside the facility. Estimated time schedules with “tasks and purpose” have been formed, based on information from the head nurse to establish needs, and regular occupation across the different areas. (Interview H)

#### Daily schedule

Table #3: The daily schedule at PCBA ED for stage 1-3 patients:

7.00-15.00:	day staff enters
7.45-8.15:	First big meal, breakfast
8.15-8.45:	sitting still together 30min (sudden shift in light condition with very bright light)
8.15-9.15:	sitting still 60min for severe cases like BN patients
≈ 11.00:	maybe 30min slow walk
12.00-12.30:	Second big meal, Lunch
12.30-13.00:	sitting still together 30min
12.30-13.30:	sitting still 60min for severe cases and BN patients
≈ 14.00:	maybe 30min slow walk (if not at 11) or suggestion of 30min rest in private rooms
15.00-23.00:	evening staff enters
15.45-16.00:	small meal
16.00-16.15:	sitting still together 15min
16.00-16.30:	sitting still 30min for severe cases and BN patients
≈ 17.00:	maybe 30min slow walk or gentle exercise for releasing tension
18.30-19.00:	Third big meal, dinner
19.00-19.30:	sitting still together 30min
19.00-20.00:	sitting still 60min for severe cases and BN patients
21.00-21.15:	small meal
21.15-21.30:	sitting still together 15min
21.15-21.45:	sitting still 30min for severe cases and BN patients
≈ 22.30:	patients should be alone in their rooms, in bed. No compulsory exercise allowed.
23.00-6.00:	Night staff enters, checking up on rooms every third hour.
23.00-6.00:	all patients get 3 check-ups from night staff, to check breathing and compulsory exercise.
6.00:	last check-up and patients are allowed to get out of bed



Graphic #3  
Overview of PCBA ED 55 daily  
schedule and the seasonal daylight  
changes

#### 6.4.4 Seasons (incl. daylight)

In Denmark, the path of the sun is very low compared to the equator, which influences DF in multi-storage buildings. PCBA ED 55 is only one level and no surrounding buildings or trees will cause massive shade during the majority of the year. (see sun paths Appendix #C)

Seasonality in the Danish weather conditions changes not only over the course of the year, but also during the day. In #Graphic 4, the length of the day is compared to the daily schedule in PCBA ED 55. During the summer solstice, the night will never become darker than nautical twilight. The spring and fall equinox distribute light and darkness in a balanced way that supports the daily rhythms very well. The light/dark conditions during the winter solstice offer twilight and night conditions from early afternoon till late morning, resulting in symptoms of winter depression or SAD in many people living in the northern hemisphere. During late fall, winter and early spring, there is a great need for high quality artificial light to enhance the sense of day and add energy.

Natural light changes dynamically over the day, depending on location and weather conditions. However, subtle changes in brightness and colour temperature are hard to detect as the human eye adapts quickly. Changes will be visible when brightness is rising or falling in a range of 1:3. Contrasts like this can be detected in the appearance of shadows, change in temperature and saturation of colours (e.g. grass and brick walls). The biggest difference between an overcast day, a cloudy day and a sunny day can be measured in CCT, Lux and temperature.

*“It was one of those March days when the sun shines hot and the wind blows cold: when it is summer in the light, and winter in the shade.”*

*Charles Dickens, Great Expectations*

Inside a building, the same conditions will apply, but the surrounding buildings, level as well as direction and size of the window is of big importance when speaking of Daylight Factor (DF) and dynamical qualities of the light. (Andersen, Mardaljevic and Lockley, 2012; Francesco Anselmo and Mardaljevic, 2013)

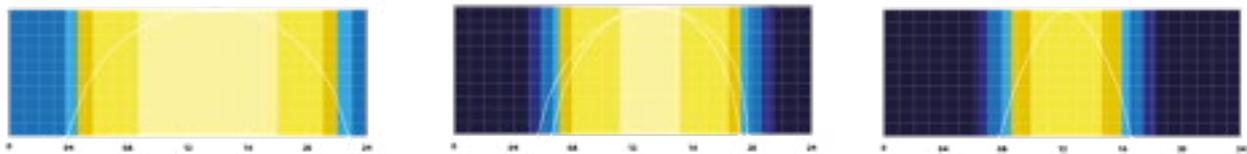
*“There was no sudden, striking, and emotional transition. Like the warming of a room or the coming of daylight.”*

*C.S. Lewis, A grief observed*

## 6.5 Circadian lighting

In order to answer the final research question, a customised schedule for the CL in PCBA ED 55 will be designed, focusing on enhancing the day and night activities while supporting the CR of patients and staff. [section 2.6.2 and 3.3.3] The most important thing is to ensure the right light at day and to provide darkness at night. The artificial light should support the natural light during the day and provide for sufficient light at night, without erasing the night. By implementing CL in the building, the CR will be the focus of the lighting design. Three CL designs will be suggested, sufficient for the winter, summer and equinox. Temporary locations within the facility have been excluded from the CL due to effect based on exposure time. (Pechacek, Andersen and Lockley, 2008; Wood et al., 2013)

	Civic twilight		Sunrise	Sunset	Sun high
Spring Equinox (Mar 21st)	5:34	19:03	6:11	18:26	12:18
Summer solstice (June 21st)	3:24	23:00	4:26	21:59	13:12
Fall Equinox (Sep 21st)	6:16	19:49	6:53	19:13	13:04
Winter solstice (Dec 21st)	7:51	16:26	8:38	15:39	12:09



### 6.5.1 Day

In the northern hemisphere, the daylight exposure during the winter, does not provide for sufficient amounts of light to stimulate the circadian rhythm, or for the daily production of vitamin D. Daylight has more qualities than artificial light, but habits of living and working indoors require for artificial lighting, even during daytime. [section 2.7 and 3.3.12]

Transition time, from dusk and dawn, into the blue hour and into sunrise or sunset, is part of the daily cycle. (#Table 3 + graphic 4 with daylight schedules) This period of time demands a high focus on light levels, as the transition will create a feeling of darkness inside a room, because of the contrast to the window, as the change in natural light adds high contrast to a space and make it feel dark, even though light levels are higher than at night.

The low sun, (see sun paths Appendix #C) also provide high risk of veiling glare, which induces people to turn down the blinds or block out the sun in

Table 3, seasonal dusk/dawn

Graphic 4, seasonal daylight schedules including sun paths (Almanak / Torben Herbansen, no date)

other ways. This creates a high demand for sunscreens that allows daylight to be transmitted without creating disturbance glare.

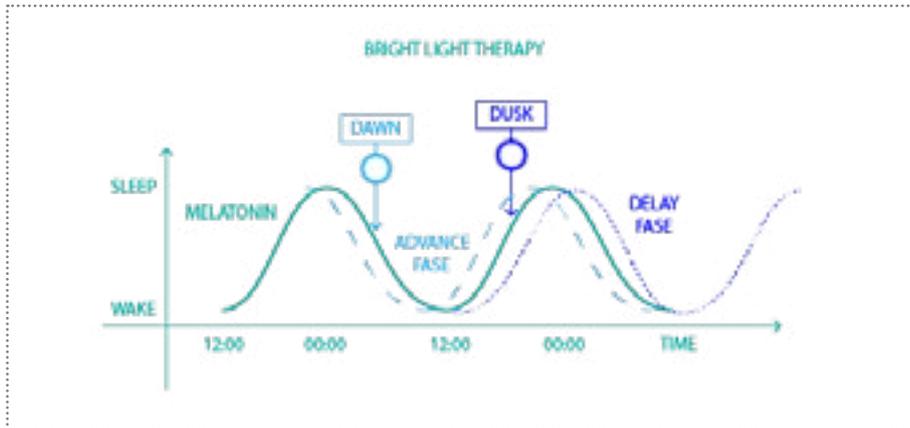


Figure 19: The effect of bright light therapy on Melatonin levels

The need for bright light in the morning is as important as darkness at night. To wake up in the morning, a small walk outside or exposure to bright light will help reset the circadian rhythm and start the new 24h cycle. When working with tuneable White fixtures, the CCT variation and spectral distribution is predefined by the manufacturer. When working with RGBW, CCT values can be composed in different ways, allowing for variations in the spectral distribution and by that, targeting specific circadian stimuli. This applies to high CCT used as cold light in short wavelengths and low CCT for the warm light and long wavelengths. Mood might be related to higher indoor light levels, as per P. Boyce on adequate light levels. (Boyce, 2014, p. 545)

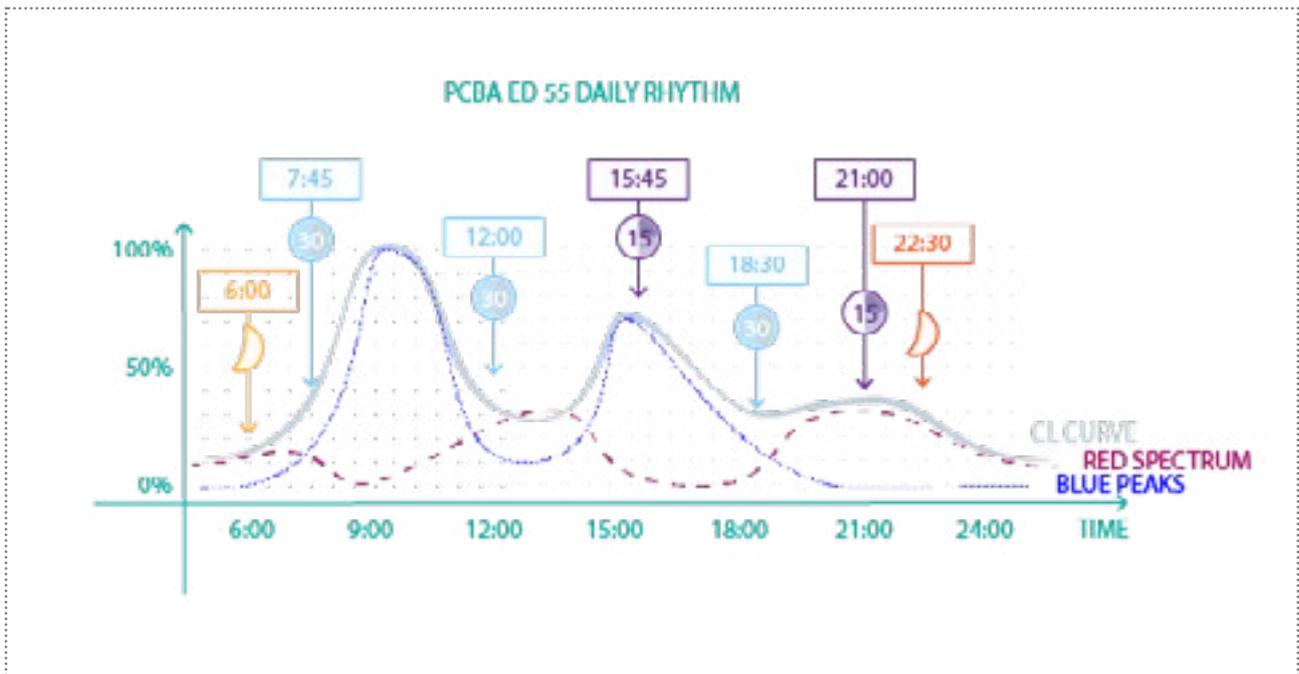


Figure 20: Proposed Circadian Rhythm for PCBA ED 55

## **Custom schedule for circadian lighting**

### **Morning**

In the morning, breakfast is followed by sitting in the common area for 30-60min. Patients tend to get up as early as they are allowed to, but should stay calm. Breakfast could be combined with a short walk, for natural light in the morning.

- » 6:00-7:00: Morning light 2500K and 100lx
- » 7:00-7:45: Transition from morning to breakfast 2700K and 200lx
- » 7:45-8:15: Warm white for breakfast 3000K and 200lx
- » 8:30-10:30: To reset CR, blue peaks ~460-470nm and  $\geq 500$ lx (eye level)

### **Lunch**

After lunch patients have a scheduled sitting in the common area for 30-60min. Afterwards different activity e.g. a walk, therapy, rest.

- » 10:30-11:00: transition from bright light to white dynamic daylight
- » 11:00-14:00: white light, 200lx

### **Afternoon**

Afternoon includes a short snack, afterwards patients have a scheduled sitting in the common area for 15-30min. Additional walk for 30min.

- » 14:00-17:30: afternoon peak of short wavelength light  $\geq 400$ lx
- » 17:30-18:00: transition from bright light to 2700K and 200lx

### **Dinner**

The last big meal followed by a scheduled sitting in the common area for 30-60min. Afterwards different activity e.g. movie, knitting, reading.

- » 18:00-19:30: White light for dining, 200lx
- » 19:30-21:30: Dim evening light 2700K 100lx with optional task light
- » 21:30-22:30: Transition before bedtime to warm night CCT

### **Evening**

- » 22:30-24:00: Bedtime light, patients in room 2500K and 100lx

### **Night**

- » 24:00-6:00: Night light 2000K and  $\leq 50$ lx

*NB! No specific fixtures have been preferred over others.*

The installed fixture is a slim, round, opal (non-glary) lamp with tuneable white (3000-6000K), McAdam 4, 59cm 3695 lm, 87cm 7890 lm, 115cm 13870 lm. Thus the opportunity is to dim from warm white to cool white in the future study.

### 6.5.2 Night

During the night shift from 23-7, the patients are advised to be in their room. Night staff will do random check-ups three times during the night, checking for compulsive exercise and if all patients are breathing.

In order to prevent the patients from knowing when the check-ups happen these are done randomly, an example could be every third hour 23, 3 and 6. They have to enter the room in order to check for breathing but try their best to avoid waking and disturbing the sleep of the patients.

Evaluations from patients and staff in Region Syddanmark (Dalkjær, Mikkelsen and Clemmensen, 2016) state predominantly positive reactions to low-level red light. The NL settings for all general light in PCBA ED 55 will dim down from 24.00, to the lowest possible CCT and <50lx. This applies to hallways, individual rooms and common areas.

### Sensors

**Daylight:** Dynamic daylight sensors can help balance the general lighting in the building, creating a more dynamical experience in the indoor environment.

**Movement:** PIR-sensors will track the movement of the patients without displaying their identity, taking account for ethics guidelines.

**Exercise:** The new architecture with floor to ceiling glass provides for a better view to patient rooms and courtyards, however, it would of great help for the staff if the sensors could start an alarm in case of rapid movement.

### Emergency setting

It is always possible to activate the emergency light setting. This can be used in case of an emergency or if there is a sudden need for bright light in a pressing situation, turning the light in the room up to 4000K + full brightness, distributing bright white light for better view and associability in emergency situations.

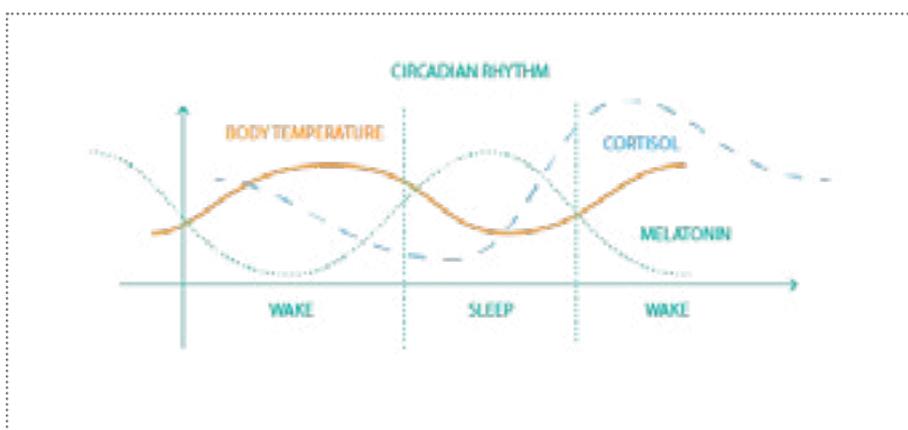
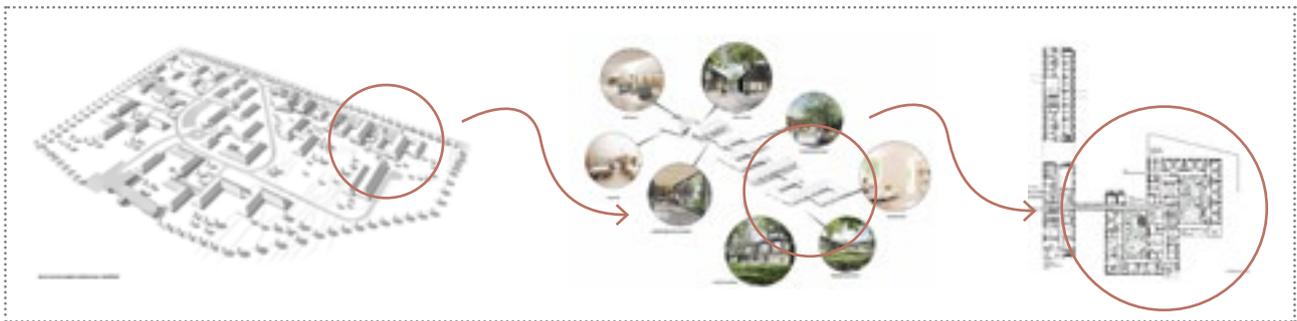


Figure 21:  
Circadianly regulated hormone levels, compared to wake/sleep.

## 6.6 PCBA ED 55

The new ED facility in PCBA consist of five contiguous buildings designed by Danish Rubow Arkitekter. Situated at 55.7211563,12.3567921, Maglevænget 2, 2750 Ballerup in the North Eastern corner of PCBA.



The surrounding gardens and landscape have been designed to enhance different moods and feelings, for patients or staff passing by or looking out through the glass-corridors between the buildings. ED in treatment is divided into six stages inspiring the design. The Westernmost building is an open day centre and the more to the East you move, the more severe the ED. Building 55 is for patients at stage 1-3 who is there 24h a day, 7 days a week.

According to the shadow diagrams (Appendix #C) based on the sun path at 7.45, 10.00, 12.00, 15.00 and 18.00 at summer solstice, equinox and winter solstice at 55.7211563,12.3567921 (3D Sun-Path, no date), the daylight intake (and potentially the daylight factor (DF)) will be highest in the Southern end of the building, where temporary spaces are located, thus limiting the afternoon sun intake in common area and individual rooms. Six individual East located rooms will receive morning sun, two (West) might receive a little afternoon sun and the four North facing rooms will never receive any direct sunlight. (Ulrich et al., 2004; From and Lundin, 2010, pp. 149–169)

*Graphic 5,  
zooming in on PCBA ED 55  
Rubow architects  
(RUBOW, WESSBERG and  
BOGL, 2015)*

### 6.6.1 Architecture

Robow Arkitekter approaches the healing potentials in architecture for ED treatment with focus on: access to a therapy park (will engage patients and staff in getting fresh air), comfortable spaces with a special/ordinary balance with textures and light quality (will function as the main design elements), natural way finding, integrated art, equal access for all and dynamical lighting in the bed unit (PCBA ED 55).

The building design was inspired by Japanese houses providing for easy access to nature, including glass corridors and integration in the surrounding landscape. (RUBOW, WESSBERG and BOGL, 2015)



PHOTO 19  
RENDERIN, PATIENT ROOM PCBA ED 55  
RUBOW ARCHITECTS  
(RUBOW, WESSBERG AND BOGL, 2015)

*We can't solve  
problems by  
using the same  
kind of thinking  
we used when we  
created them.”*

Albert Einstein

# 7.1 Four categories

As per the design scope, the lighting design concept will focus on the areas within the building, where patients can move around 24h a day. [section 5.4] The four categories in the scope have been divided into categories of importance, according to the time spend in the rooms (#floorplan)

When forming the lighting design concept for the building, the four types of spaces has further been evaluated and categories based on the nature of the "activity" in the areas: slow, fast, expand and concentrate.



<b>Primary</b>	<b>Slow</b>	(Privates, kitchen/dining, common area)
<b>Secondary</b>	<b>Fast</b>	(Hallways, 24h office)
<b>Tertiary</b>	<b>Expand</b>	(Court yards, landscape)
<b>Quadrary</b>	<b>Concentrate</b>	(Therapy, offices, meeting, treatment)

### 7.1.1 Slow

Patients spend the majority of their time out of a 24hour schedule in the primary spaces. Most of the time is spend eating, resting or doing slow activities like knitting, puzzles, reading or watching movies.



MOODBOARD  
IMAGES: PINTEREST

## Individual rooms

**Atmosphere:** Private, cosy

- » Daylight factor – access to daylight in each room, but it might not reach the patient. According to Sandie (souschef at PCBA ED) the patients tend to close the blinds when the sun is shining because they want to avoid the heat from the sun.
- » Focussed light for reading, knitting and other creative interests.

**Challenge:** compulsive exercise + self harm

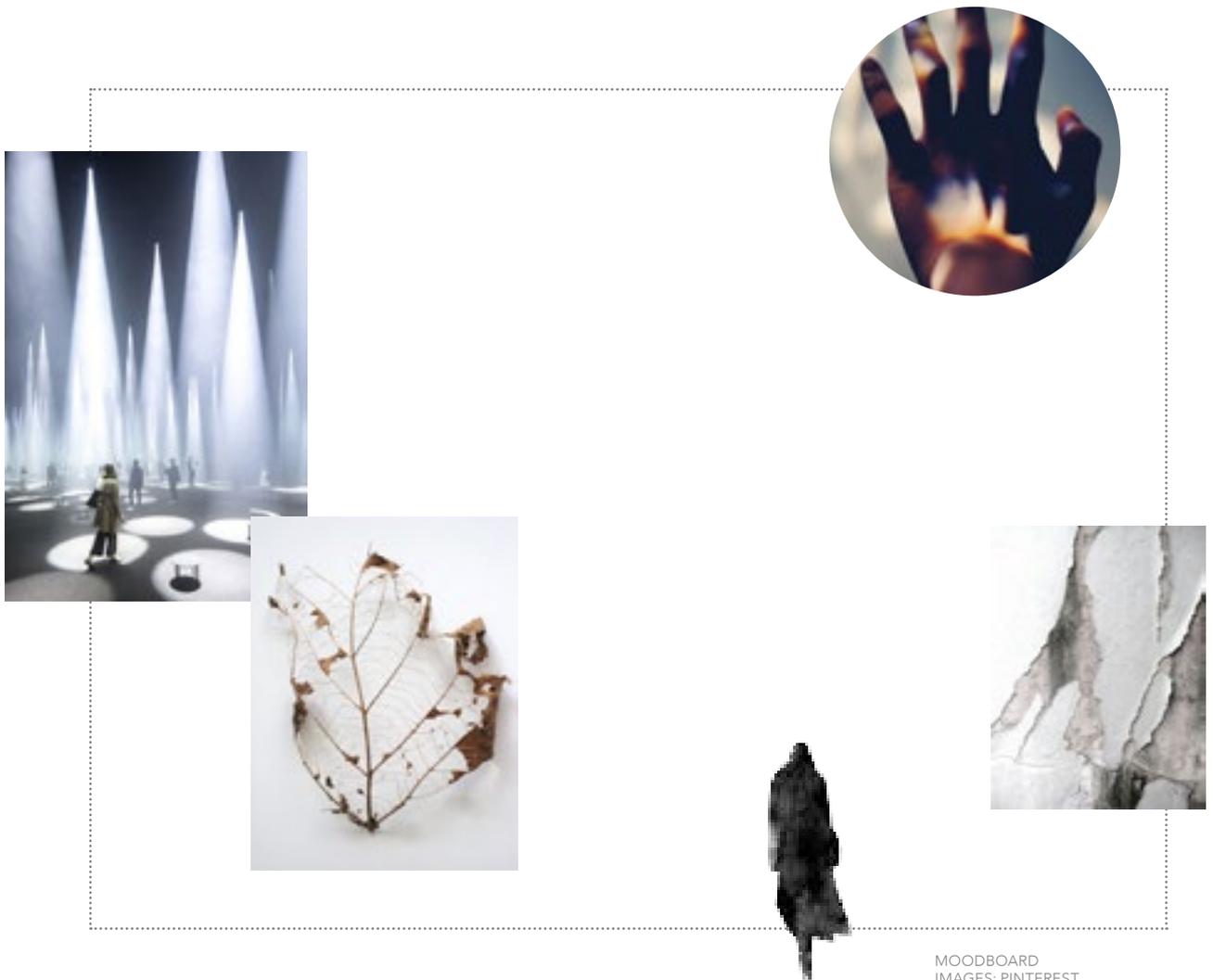
**Settings:** CL + Task + Emergency

Standard requirements for this type of space

**CCT-range:** Follows CL 2500-6500K

**Brightness:** 10-50lx

**CRI/Ra** >80



MOODBOARD  
IMAGES: PINTEREST

## Kitchen + eating

**Atmosphere:** professional + focus + dining

**Challenge:** eating and cheating staff

**Settings:** CL + task light in kitchen + Emergency

Standard requirements for this type of space

**CCT-range:** 3000-6500K

**Brightness:** 200-500lx

**CRI/Ra** >90



**Common area**

*Atmosphere:* Cosy + relaxed + conversation + DIY and reading

*Challenge:* Sitting still with no movement or purging

*Soft area* for socialising, visits and sitting together after meals.

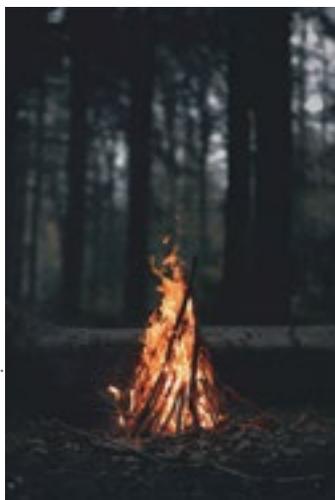
*Settings:* CL + task light + Emergency

Standard requirements for this type of space

*CCT-range:* 2500-6500K

*Brightness:* 50lx-500lx

*CRI/Ra* >80



MOODBOARD  
IMAGES: PINTEREST

### 7.1.2 Fast

In the secondary areas, patients and staff spend a significant amount of time during the day. They are for passage, slow thoughts and short stops. It is important to note that both these spaces are usually frequented for a shorter amount of time, as staff move around more or less consistently.



MOODBOARD  
IMAGES: PINTEREST

## Hallway

**Atmosphere:** transition space

**Challenge:** body checking, mirror effect and reflections

Cove lighting to minimise the mirroring effect

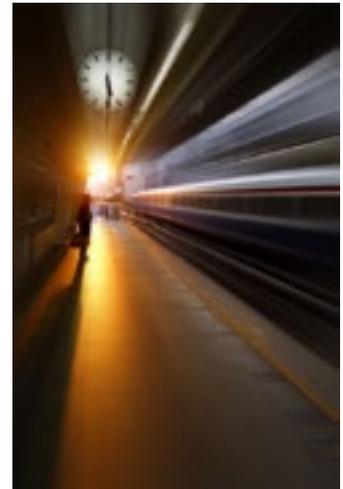
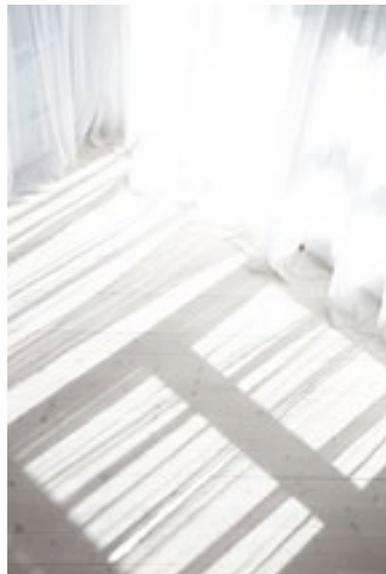
**Settings:** CL + Night light (NL) + Emergency

Standard requirements for this type of space

**CCT-range:** 2500-6500K

**Brightness:** 50-500lx

**CRI/Ra** >80



MOODBOARD  
IMAGES: PINTEREST



## 24h office

**Atmosphere:** professional + focus

**Challenge:** staff area with view to patient doors, gardens and common area for activity spotting

**Settings:** CL + Task

Standard requirements for this type of space

**CCT-range:** 2000-6500K

**Brightness:** 10%-100%

**CRI/Ra** >80



MOODBOARD  
IMAGES: PINTEREST



### 7.1.3 Expand

Natural light and seasonal change is considered an important part of everyday life in the facility. The tertiary areas are thus located outdoors in close proximity to the building. In ED treatment, patients are almost constantly watched and the interior court yards provide for better view for the staff, being able to observe without standing too close. Resent findings suggest that not only the patients, but also the staff can benefit from access to the gardens and view to nature during work hours.



MOODBOARD  
IMAGES: PINTEREST

## Gardens

**Challenge:** hiding for compulsive exercise on the ground, show night sky, vertical illuminance

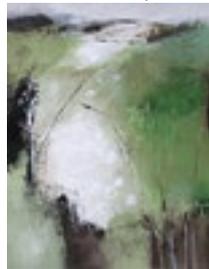
**Settings:** Night light (NL) + Emergency

Standard requirements for this type of space

**CCT-range:** ( $\leq 2700\text{K}$ )

**Brightness:** Limit uplight for light pollution

**CRI/Ra:** 65



MOODBOARD  
IMAGES: PINTEREST

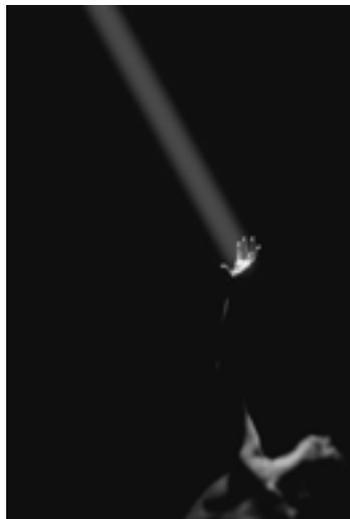


### 7.1.4 Concentrate

These areas are excluded from CL due to the effect based on exposure time, as they are regularly occupied, but are relatively temporary locations and only frequented for shorter periods during daytime



MOODBOARD  
IMAGES: PINTEREST



## Daytime offices

**Atmosphere:** professional + focus

**Challenge:** daylight factor

**Settings:** GL + task light

Standard requirements for this type of space

**CCT-range** 2700K

**Brightness:** 200lx

**CRI/Ra** >80



MOODBOARD  
IMAGES: PINTEREST

## Therapy rooms

**Atmosphere:** relaxed but focussed

**Challenge:** mood change and anxiety

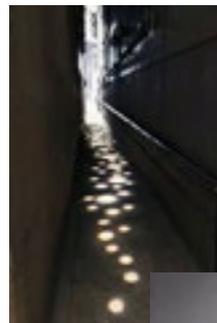
**Settings:** GL + Emergency

Standard requirements for this type of space

**CCT-range** 2700K, adjustable light for different treatment

**Brightness:** 200lx

**CRI/Ra** >80



MOODBOARD  
IMAGES: PINTEREST



### **Temporary treatment rooms**

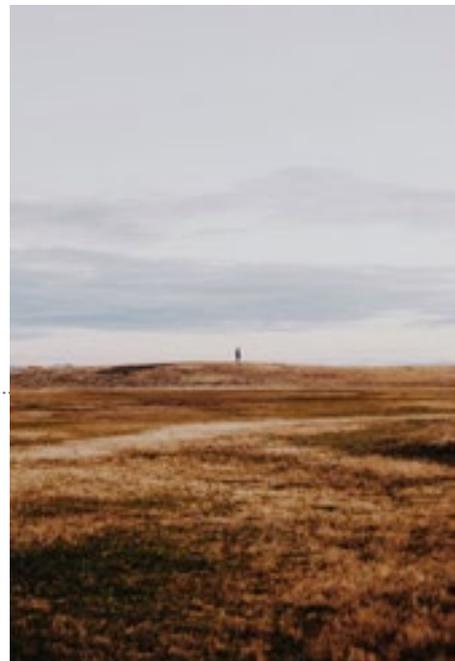
**Settings:** GL + Emergency

Standard requirements for this type of space

**CCT-range** 3000K

**Brightness:** 200lx

**CRI/Ra** >80



MOODBOARD  
IMAGES: PINTEREST

### Meeting rooms

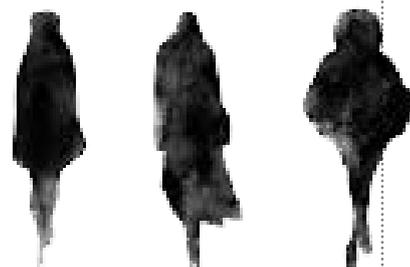
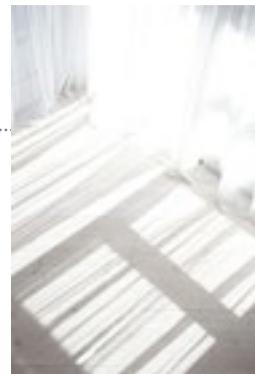
*Settings:* GL + Emergency

Standard requirements for this type of space

**CCT-range** 2700K

**Brightness:** 200lx

**CRI/Ra** >80



MOODBOARD  
IMAGES: PINTEREST

# 8.1 Evaluation

## 8.1.1 Research question

The aim of the thesis was to answer the following question:

*“How can lighting design be used as part of the treatment of severe eating disorders in a 24h facility, calm the patients and still support a professional work environment?”*

To answer the research question, a research-based lighting design concept has been proposed for PCBA ED 55. The concept is based on a lighting design with three layers of lighting and a categorisation of space, based on function and activity level. Depending on the category, the three layers will be applied within the different spaces in the facility; the approach is thus applicable to other ED facilities in Denmark. The concept, including a custom circadian lighting schedule based on the current daily schedule fulfils the three success criteria in terms of healing, function and atmosphere

### Criteria A) Contribute to the treatment

According to the design criteria, the lighting design is considered healing, when it changes dynamically over the day, to support the circadian rhythm and resets it according to natural cycles of day and night. Based on this, a customised lighting scheme for circadian rhythm stimulation, including blue peaks, has been designed. The dynamic changes in light are based on the daily schedule in PCBA ED 55, together with current knowledge on light therapy and eating disorders, which have been thoroughly researched and presented in this thesis.

The concept of circadian lighting is part of the treatment, as it has been designed to add circadian stimuli, reset the biological clock, regulate disrupted Melatonin segregation for better sleep and body temperature rhythms. In addition, it can have a positive effect on comorbidity e.g. seasonality, depression, bipolar disease and anxiety.

Blue light peaks will be used to boost patients and staff in the morning and early afternoon, adding energy and focus after two of the big meals.

### Criteria B) Improve the work environment

The lighting design for the staff working environment is primarily task oriented with minimised disturbance glare in the entire facility. To meet the design principles for function, all light follows current lighting standards, with an option to apply additional light for specialised functions. Work environment and motivation will benefit from the architecture, natural surroundings and daylight intake during the day.

During the evening and night shift, the lighting design is focused on warm white light, at minimum light levels, to avoid Melatonin suppression. The light is warm, but not red, as per evaluations, nurses complaining of task re-

lated disturbances because of red light as well as anxiety in some patients. The warm light is thus meeting the criteria of professional lighting that supports the sleep cycles in night-shift workers.

Nighttime safety will benefit from the option of turning on the emergency lighting, during evening and night.

### **Criteria C) Add spatial identity and healing atmosphere**

The criteria for enhancing atmosphere and spatial identity states that the lighting design should be calming and personalised. A calming atmosphere is enhanced, according to the design principles, as it focuses on low light sources and low illuminance levels outside peak periods. Introducing, calming and warm lighting environments for morning and evening. Different lighting schemes and adjustable light sources will create a changing atmosphere, based on function and preference. This can support the sense of home and add something personal to the space.

Through the completion of the lighting design concept, the concept of the three layers of light has been applied to the four space categories within the facility, (slow, fast, expand, concentrate) to enhance atmosphere, spatial qualities and functions.

The last design principle is about introducing daylight and view to nature in the indoor environment. During daytime, the emphasis is on dynamic shadows in the space and supporting the seasonal changes. Both can add to the visual and emotional perception of the space. The night lighting in the connecting courtyards and surrounding landscape will be subtle and poetic, stressing the importance of providing darkness at night, to stimulate daily rhythm. This is enhanced especially in courtyards, where the mirroring effects are minimised with low light levels and applied vertical light.

### **8.1.2 Lighting design concept**

A large number of factors can stimulate the patients when they move into the new facility. The outcome of the lighting design will be hard to evaluate, distinguishing light therapy from the effects of the healing architecture. It will thus be difficult to separate the benefits from the circadian lighting from other confounding factors, such as:

- » Positive effects of changing the scene, moving into a brand-new building
- » Healing architecture, including materials, new rooms, better facilities for therapy, relaxation etc.
- » Access to nature and daylight, including the possibility to look out into court yards and enter at any time
- » Staff may be positively affected by the above mentioned as well, creating a better healing environment and mood in the building.

The customised scheme for circadian lighting will be implemented in PCBA ED 55 as the normal setting after the finishing of the three scenarios in the trial, and can thus be evaluated and compared to the three test scenarios.

Future evaluation of the circadian stimuli (CS) potential of all installed fixtures in PCBA ED should be initiated during the project, using the circadian stimulus metric for evaluating the circadian potential. (Rea and Figueiro, 2016) In addition, the perceived “pleasing” level of the combination of lux and CCT could also be tested among patients, according to the Kruithof scale. (Oi and Takahashi, 2007)

The population, chosen for the future study will consist of twelve hospitalised patients with severe ED (stage 1-3), living in a 24-hour treatment facility. It is not an intensive care facility, meaning that the subjects are all allowed to move around freely inside the facility, stage 2 and 3 can also go outside without staff attendance.

### **8.1.3 Hypotheses**

The proposed lighting design concept will not be implemented in PCBA ED 55, but the design hypotheses can be evaluated during the Spring trial, according to the installed lighting design. After the trial is finished in Fall 2018, according to the current plan, the stated hypotheses can be considered for future research and evaluation.

The research protocol (Sjögren, Mullins and Triantafyllidis, 2017) suggest that the outcome of the future study will help identify effect and use of circadian lighting in psychiatric treatment, as specified in colour temperatures, spectral distribution and light intensity.

All facilities included in the state of the art review are Danish, and cover Jutland, and the Islands Fyn and Seeland. The same applies to the experience of the interviewed experts, in order to make sure that the scope is expanded to the rest of Denmark and not limited to Ballerup Psykiatri.

Due to the severity of the disease, patients in Ballerup could not be interviewed or observed for this thesis. Instead, information about ED was obtained through a lecture (Landsforeningen mod spiseforstyrrelser og selvskade, no date) with three former AN and BN patients, a meeting with an AN blogger (Grønnebæk, no date) as well as a line of interviews with nurses and psychologists that have been involved in current treatment of severe ED in Denmark.

The group was combined of experts working in different facilities, making sure that they had previous knowledge from different groups of patients. This ensured that the answers could be applied to a larger group of ED patients. The relevance of seven experts can be justified by the difference in background, work experience and knowledge from different facilities. All experts volunteered for the interviews and had no previous experience with light therapy. (A list of interviews can be found in Appendix #A)

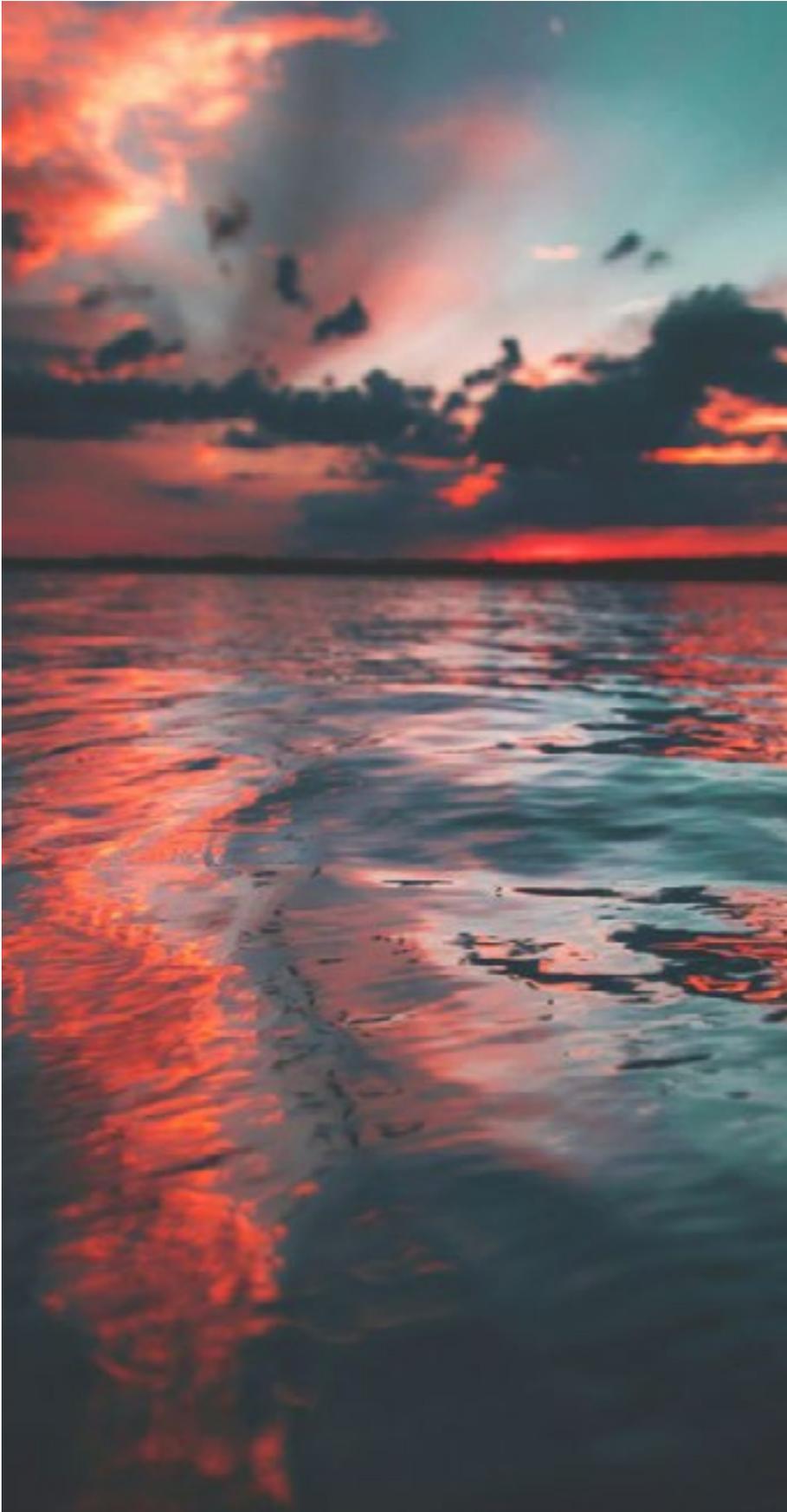


PHOTO  
LIQUID LAST LIGHT  
BY DENNY BITTE

## 8.2 Discussion

### 8.2.1 Circadian lighting

The CL hypotheses remain untested, but findings from the thesis suggest that it is correct to assume that patients with ED will benefit from the CL to some degree. Patients with seasonality and/or binge symptoms are to a high degree likely to experience some effect of the CL.

One of the limitations in the upcoming study is the quality of the installed fixtures. Future measurements will determine if the proposed CL scheme can be applied 1:1 in the installed fixtures in PCBA ED 55. All installed fixtures are tuneable white and can thus provide scenarios from warm white to cool white, of different span and illuminance levels. In the dining room, the installed fixture has the most limited span (3000-6000K), but Ra >90 and 3-MacAdams. This deprives the research project from tests with more exaggerated CCTs in the dining section. In other areas of the building, the light levels can differ from 2000-2500K warm white to 6000-7000K cool white.

One thing is to specify the exact CCT, CRI, intensity, brightness and reflection, but the SCN reacts to wavelengths, which means that CL should not solely be based on CCT and illuminance levels. The spectral distribution within the variation of desired wavelengths should be taken equally into account. Professional fixtures show high diversity of spectral distribution and CRI, when attempting to meet 2000K, 3000K or 6500K.

One of the delimitations in the design process has been the delay on the finishing of the PCBA ED 55 building. This prevented the option for planned tests and measurements on location, including calculations of daylight intake and daylight factor, material reflections, tests with hallway mirroring and evaluation of installed fixtures for flicker, glare, circadian stimulus and illuminance levels.

### 8.2.2 Healing

According to [vioss.dk](http://vioss.dk) (Ingen målbar forbedring i behandling af anoreksi og bulimi - ViOSS - Videnscenter om spiseforstyrrelser og selvskade, no date) more than 80.000 Danish teenagers (16-19y) are at risk of developing an eating disorder. AN is currently the most dangerous disease for young girls to develop, with mortality being 5.35% higher than average, because of severity, treatment obstacles and mortality statistics. (Interview E, 00:21:42)

Current treatment of anorexia is personalised and very experimental hence the need for research in new treatment methods. Circadian lighting will not cure AN, but could quite possibly have a positive effect on mood, energy levels and symptoms of seasonality and depression.

As seasonality and disrupted circadian rhythm are dominant factors in binge behaviour, the circadian lighting, including bright light peaks, will presumably have a higher effect on BN symptoms. The mortality in bulimia patients is much lower than anorexia, hence most bulimia patients will be

treated in daycentres and not in 24-hour facilities. This fact makes the connection between circadian lighting and BN hard to evaluate in this trial.



PHOTO  
OLD MATEIRAL, PINTEREST

## ***8.3 Conclusion***

The three criteria have been accomplished in the proposed lighting design concept and thus the final research question has been answered, with a research-based lighting design concept proposed for eating disorder treatment in Denmark, but the effect of the lighting design concept cannot be conclusively tested without further research.

There is a need for new research in ED treatment and the upcoming trial will provide some knowledge on the topic of circadian lighting in ED treatment. The concept is applicable in other treatment facilities, according to the four categories and three layers of light. The concept is based on the needs, activities and space categories in a Danish 24-hour facility, using PCBA ED 55 as a frame for the concept. The concept is not designed specifically for the style of architecture in PCBA ED 55, but as a common denominator for treatment facilities. The final lighting design concept can thus be applied to ED facilities all over Denmark, even though the trial and evaluation is limited to the patients and professionals in PCBA ED 55.

## ***9.1 Future thoughts***

The investigations in this thesis are all prior to a clinical trial with a variation of dynamic light scenarios, proposed as light therapy in PCBA ED 55. Findings and hypotheses will be evaluated based on the outcome from the three consecutive light scenarios that will be implemented in the dynamic lighting during the spring trial, according to the research protocol.

The purpose of the thesis is already based on future research, determining whether CL has any effect on ED patient. The following touch points can be in the scope for future investigations. Based on the outcome of the following study, a new project could examine the effects in a RCT, including some of the following hypotheses.

- » ED patients are extra sensitive to light
- » Warm light will stimulate the experienced thermal comfort in ED
- » Sensory lighting can stimulate anxiety in ED
- » Spectral distributions have a connection to different effect in ED mood and CR
- » Light can be experienced emotionally, somatically and cognitively
- » Kelvin temperature is not a sufficient measure for Circadian Lighting stimuli
- » UVB can be part of the lighting design to enhance Vitamin D in ED
- » Motion sensors in court yards and rooms can detect activities of high frequency, to avoid obsessive exercise



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P1: Tadao Ando, frontpage, Sanaa, RYUE NISHIZAWA & REI NAITO, TESHIMA ART MUSEUM, Vincent Leroux	frontpage	to CS value of natural and incandescent light	30	Q: Quote
Q1: Charles Dickens	intro	F12: spectral power and wavelength compared to weather condition	30	P: Photo
P2: Tadao Ando, house in utsubo park tadao ando	intro	P4: sunset, Image: Pinterest	31	A: Appendix
Q2: Pablo Picasso	10	Q3: Oxford advanced	32	G: Graphic
G1: timeline	14	Q4: Wiki	32	F: Figure
F1: DSM-IV-TR Criteria	17	Q5: Böhme	33	T: Table
F2: biological clock in mammals	18	P5: atmosphere, San Telmo Museum Extension, Nieto Sobejano Arquitectos, San Sebastián, Spain	34	
F3: hormone levels	19	P6: Echo Morgan. Image: Jamie Baker	36	
F4: illustrate how bright light effects Melatonin levels	20	F13: AN eating	40	
F5: illustrate how bright light effects Melatonin levels	20	P7: Signe	43	
F6: SCN Mela – Orex	21	P8: daylight curtain, Nina Holst	47	
P3: aabenraa, chromaviso night	26	P9: Risskov, 1852 Bindsbøll	53	
F7: body temp related to BL according to subjective day)	27	P10: Vejle fjord, Tuberculosis sanatorium, 1900 Dahlerup og Meyer	53	
F8: Melatonin concentration and brightness exposure	27	Q6: Nord arkitekter	53	
F9: spectral distribution of artificail light sources compared to natural daylight,	28	P11: Alto sanatorium	54	
F10: SPD	29	P12: Aabenraa plant wall	56	
F11: melatonin response compared				

# X

APPENDIX

## **A) Interviews**

*Audio-files attached*

## **B) State of the art**

*Foreign hospitals with circadian lighting*

## **C) Sun path**

*Ballerup Psychiatric Hospital*

# A

## EXPERT INTERVIEWS

#	DATE/MIN	NAME	POSITION	FACILITY
A	02.10.17/ (no record)	LMS talks	AN stories	3 x personal stories
B	09.10.17/18:48	Lindis	Psychologist	ED facility, Aarhus
C	09.10.17/04:03/17:18	Henriette	Nurse	Rigshospitalet ED
D	25.10.17/22:39	Signe	AN-blogger	AnorekSigne.dk
E	26.10.17/27:30	Tina	Psychologist	Private practice + research
F	27.10.17/41:56	Julie	Nurse (student)	Intensive ED, Risskov
G	02.11.17/36:52	Iben	Lighting Designer	Building owner consultant
H	18.12.17/34:35	Sandie	Nurse	Sous-chef PC Ballerup ED

(Audio files attached)

# B

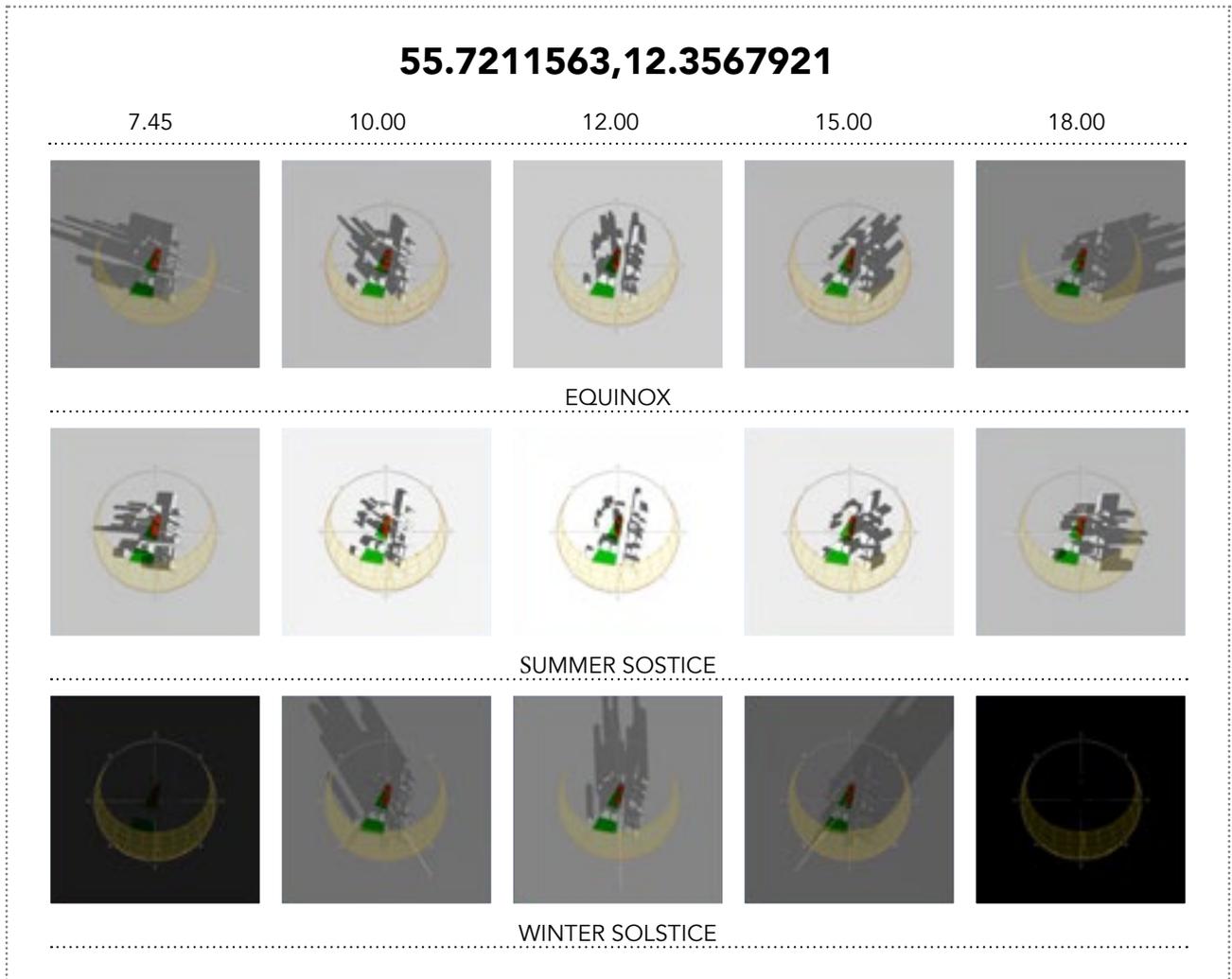
## CIRCADIAN LIGHTING IN FOREIGN HOSPITALS

- *London St. Mary's hospital – dementia*  
<http://www.ledsmagazine.com/articles/2016/04/circadian-lighting-is-developed-to-help-dementia-patients-at-uk-hospital.html>
- *Karlstad, Sweden*  
<https://chromaviso.com/en/circadian-lighting/cases/circadian-lighting-at-karlstad/>
- *Seattle Childrens hospital, Seattle*  
<http://www.metropolismag.com/interiors/healthcare-interiors/why-light-matters-designing-with-circadian-health-in-mind/>
- *Bradford Royal infirmary, UK*  
<http://www.lighting.philips.com/main/cases/cases/healthcare/bradford-royal-infirmary>
- *German Heart Institute, Berlin*  
<http://www.lighting.philips.com/main/cases/cases/healthcare/german-heart-institute>
- *Asklepios Clinic St. Georg, Hamburg*  
*HealWell, Philips* [http://www.lighting.philips.com/main/search#q=healwell&site=en\\_aa](http://www.lighting.philips.com/main/search#q=healwell&site=en_aa)
- *Kaiser Permanente, Orange County-Anaheim Medical Center & San Diego Central hospital*  
<https://www.ecmag.com/section/systems/illuminating-path-recovery-healthcare>

This study is limited to Danish health care buildings but other countries are also using lighting as a tool to achieve better healing for inpatients and a better working environment for the professional staff.

# C

## SUN PATH



Graphic distribution of 9 sunpaths:  
summer solstice, equinox and winter solstice

3D Sun-Path (no date).  
Available at: <http://andrewmarsh.com/apps/releases/sunpath3d.html> (Accessed: 18 January 2018).

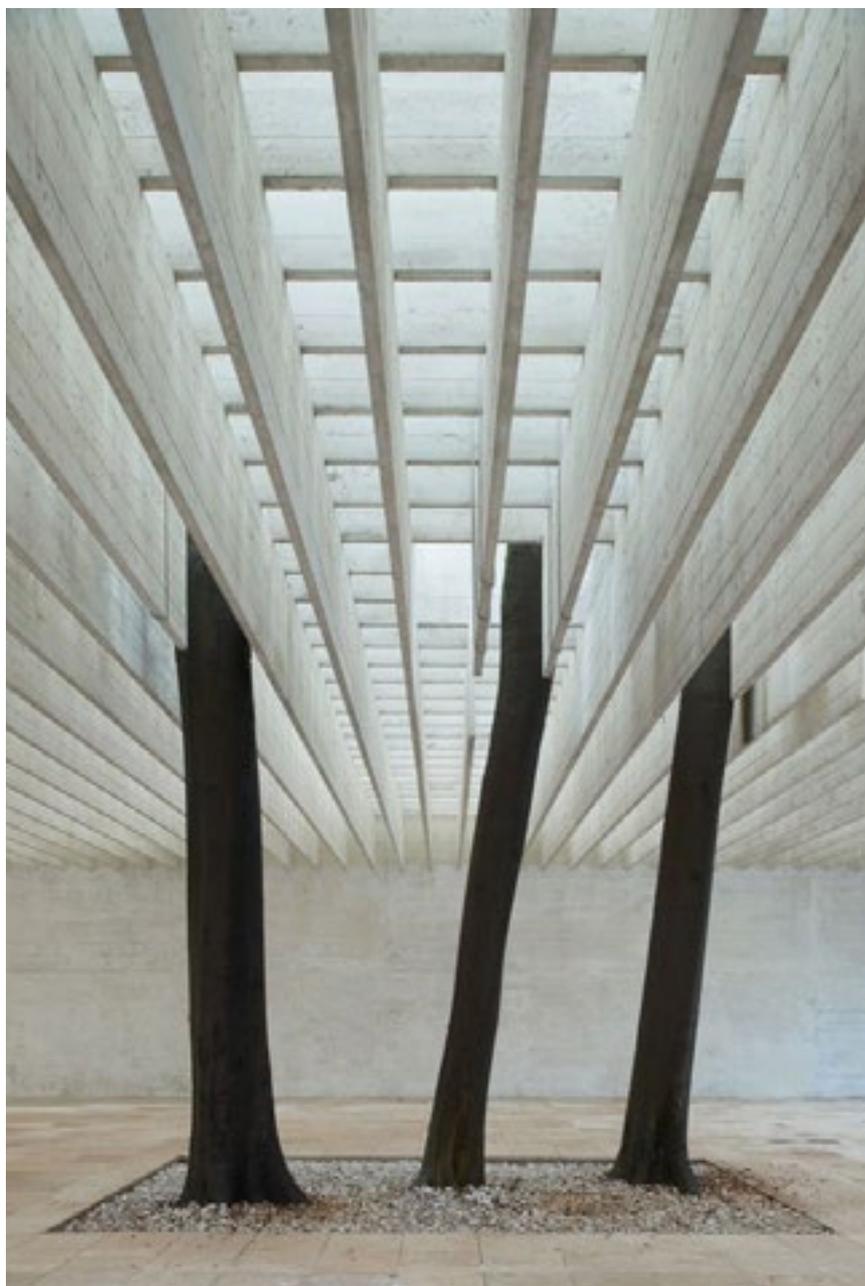


PHOTO  
THE DAYLIGHT HOUSE  
TAKESHI HOSAKA ARCHITECTS

HEALING WITH LIGHT  
IN A PSYCHIATRIC CONTEXT

A RESEARCH-BASED LIGHTING DESIGN CONCEPT PROPOSED FOR  
TREATMENT OF EATING DISORDER PATIENTS IN DENMARK

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[MASTER THESIS · MSC LIGHTING DESIGN · PERNILLE BECH-LARSEN · FALL 2017]