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The influence of light on our spatial experience

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Aalborg University Copenhagen
Frederikskaj 12,
DK-2450 Copenhagen SV
Semester Coordinator:
Secretary:

Supervisor(s): Nanet Mathiasen

Project group no.: N/A

Members:
Anna Lykke Thorup

Kasper Fromberg Støttrup

Abstract:
This thesis discusses the importance of designing and evaluating lighting, based on the spatial experience the lighting provides. However, the design and the evaluation of lighting tends to be based upon quantitative measures such as standards, regulations, economy etc. rather than qualitative.

The thesis investigates the discrepancy between what we measured and what we see through a literature study. The phenomena, aesthetics and atmosphere, and their relation to lighting parameters, are investigated. Through the investigation different means to produce an atmosphere has been exposed. The findings from the literature study is accumulated in a Light Experience Model.

The developed Light Experience Model is used in a specific space, to study the space and propose a new lighting design. The space in question is the respite space located at Rigshospitalet in Copenhagen. For this space, the existing lighting should produce a restful and calm atmosphere, however this was not found to be the case. Using the Light Experience Model, challenges of the space, in terms of lighting, were exposed. Based on this, a new proposal for the lighting design was developed. The proposal takes the purpose of the space into consideration, and strives to create a calming atmosphere, thereby changing the spatial experience of the respite space.

Through these investigations, the thesis illustrates how working with aesthetics and atmosphere, through the Light Experience Model, can ensure that a lighting design, contributes to a better environment in terms of spatial experience.

Lighting with a purpose

The influence of light on our spatial experience

Anna Lykke Thorup
Kasper Fromberg Støttrup

Master thesis
M.Sc. Lighting Design
Aalborg University Copenhagen

This report is a documentation of the master thesis executed by
Anna Lykke Thorup & Kasper Fromberg Støttrup in the spring of 2019.

In addition an appendix, a video and a 3D-model has been handed in:
Video: https://vimeo.com/338212556
Model (.exe): https://drive.google.com/file/d/1YIV0sgovPrI3NGhzOUribepXO5R1yA0Z/view?usp=sharing
Model (online): https://api2.enscape3d.com/v1/view/13a8c177-66ea-4b22-9d80-e2f15f9164b9

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AALBORG UNIVERSITY
COPENHAGEN

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Initiation

Background

We are sensuous beings. Our senses have always been centre of interaction between the world and us. It is through the senses we explore and understand our surroundings. The traditional means of exploration are illustrated in figure 1.1. The French philosopher Maurice Merleau-Ponty regarded the body as *"[…] our first means of access to the world: in other words, […] we first have to come to terms with the embodied reality of our 'concrete situation'."* (Hale 2017, 1). Thus, our bodily experience and perception serve as basis for *"our"* world. It can therefore be considered truthful in regard to which feelings and emotions a given space evoke and how the space is perceived.

However, we evaluate a lighting design based on norms, regulations, standards etc., which do not consider our sensory experiences. Thus, a lighting design is evaluated based on quantitative lighting measures, that does not consider our bodily experience, with regard to sensuous understanding, the creation of atmosphere and evoking of emotions. Other aspects of evaluation are lower energy consumption or economy. When evaluating a lighting design based on this, the actual purpose of designing a space is easily forgotten or neglected.

It is obvious that parameters such as luminance, illuminance, light distribution, uniformity, glare, flicker, spectral power distribution and so on, are important dimensions of the luminous environment. But these parameters do not reveal anything about the perceived lighting in terms of sensuous understanding or created atmosphere (SYN-TES 2011).

Our vision and perception can be deceptive, meaning it is not equal to facts or measured parameters. Goethe stated that *"Optical illusions exemplify the functions of vision."* (Liljefors 1999, 4). This is illustrated in figure 1.2.

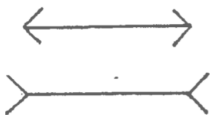


Fig. 1.2 Optical illusion

The eye finds the upper line shorter than the lower one, even though they are equally sized. Anders Liljefors states that *"What we learn from this figure is not that vision is defective, but that what we see is different from what we measure."* (Liljefors 1999, 4).

This raises the questions: should the quality of a lighting design primarily be defined through quantitative measures, and, how can a lighting design influence our spatial experience. These are the questions the thesis strives to answer.

Means of exploration
Photo by: Allan-Hermann Pool
Fig. 1.1 The five traditional senses

Introduction

This thesis is regarding light's influence on our spatial experience. The background is, as mentioned, the discrepancy between what we measure and what we see. The discrepancy is very interesting to be concerned with, since a (lighting) design often is described by its measures, and not by how we see or perceive it. This is in spite of the fact that our perception serves as basis for our world view. When designing lighting we must therefore consider, not only the standards and regulations, but also our perception and experience, in order to ensure a successful lighting design. In addition to this, the lighting design should always support the purpose of a space.

Lighting holds a great opportunity to influence a space and our spatial experience. The purpose of the thesis is to investigate this influence. In doing so, the investigation has been divided into two main categories. The context-independent knowledge, based on a literature study, results in a Light Experience Model. This is then implemented on a context-dependent case, to make use of the Light Experience Model in praxis.

In conducting the literature study, it is important to research the science of phenomenology, specifically aesthetics and atmospheres, as well as luminous environment as natural science. Phenomenology is a philosophy which was founded by Edmund Husserl in the early 20th century. As the name implies, it is the study of a phenomenon. As a science, phenomenology acknowledges personal engagement and experiences, as a valid source for observations, when studying a phenomenon.

By researching aesthetics, atmosphere and luminous environment, an understanding of the factors influencing the lighting design and the perception of the lighting design, is achieved. Especially the phenomenological approach is important to expose, since the concept of atmosphere in an aesthetic discourse often is used and articulated in a very vague and ambiguous manner. The German philosopher Gernot Böhme writes:

> *"The frequent, rather embarrassed use of the term atmosphere in aesthetic discourse suggests that it refers to something that is aesthetically relevant but whose elaboration and articulation is still pending." (Böhme 2017, 14)*

Many designers, architects or artists claim to produce a specific atmosphere through their works. However, this claim is rarely elaborated in a scientific manner, but often described in vague terms or visions. To work with the concept of atmosphere in a practical, specific and tangible manner, it is important to investigate the science of phenomenology.

In order to relate the theoretical knowledge to the practical knowledge, an analysis of a specific space is conducted. Thereby the theoretical, and sometimes abstract knowledge, is utilised in a practical and specific manner. The chosen space revolves around a room of rest and calmness in a healthcare context. This is an interesting space to examine because patients and relatives exposed to this space, often are in a difficult state of mind. The atmosphere of the space could therefore contribute to a better spatial experience.

Based on the literature study and an analysis of the space, the gained knowledge is transformed into design criteria. The purpose of the criteria is to ensure a design is developed that supports the purpose and desired atmosphere of the space. These criteria are then exploited through a design proposal for the lighting. This design proposal serves to investigate the hypothesis of the thesis.

Hypothesis

The hypothesis of the thesis relates the aforementioned concept of aesthetics and atmosphere to spatial experience and perception of a space. The hypothesis of this thesis is:

> *By understanding the purpose of a space and by working with the concept of aesthetics and atmosphere, we can ensure a lighting design contributes to a better environment in terms of spatial experience.*

Scope of thesis

The thesis is only concerned with the spatial experience of a luminous environment, and how this can be manipulated and utilised in practical manner. Although the space analysis takes place in a healthcare context, the thesis does not consider how lighting affects humans in a biological manner, or how it has a therapeutic effect. The investigation of this lies outside the scope of the thesis. Furthermore, the design proposal will not be governed by standards, norms or regulations, although they may apply in the specific space. In addition to this, the design will also not be governed by costs or budgets. The thesis will not explain or elaborate basic concepts and terms related to lighting. It is assumed the reader has an understanding of these in advance.

Method

The approach of the thesis, to investigate how lighting influences our spatial experience, is based upon the procedural model developed by Hansen and Mullins (Hansen and Mullins 2014). This model describes how to approach a design process in a transdisciplinary manner, where different fields of knowledge inform the design. Based on these different fields of knowledge, design criteria are generated. This is to ensure the design is developed in line with the knowledge, and to ensure the design fulfils the vision for the space. The thesis process is illustrated in figure 1.3.

The transdisciplinary knowledge of the thesis is methodically approached in two parts, which are:

The context-independent literature study
The context-dependent space analysis

The thesis is concerned with how lighting supports the function and purpose of a given space or architecture. The thesis uses a space of rest and calmness in a healthcare context to unfold this topic.

The context-independent literature study takes its origins from a literature study, where theories on luminous environment and phenomenology, specifically aesthetics and atmosphere, and multisensory experiences, have been reviewed. Based on this a Light Experience Model is developed.

A context-dependent space is observed and studied in order to identify positive and negative characteristics of the space, in regard to luminous environment, aesthetics and atmosphere, and multisensory experiences. Through the context-dependent space, the Light Experience Model is applied.

Based on the space, a lighting design is developed. The purpose of this design is to explore how to utilise the design criteria derived from findings from the literature study and the space analysis. Thereby, these criteria and findings are employed in a realistic and practical manner. The discussion will then reflect upon the design proposal and the design criteria based on the transdisciplinary knowledge. It will also be discussed how well the bridging of theory into design has been executed.

Through this combination of literature study and a space analysis, the creation of a design proposal shows how the theories can be applied in a practical manner, developing design competences and discovering new scientific knowledge.

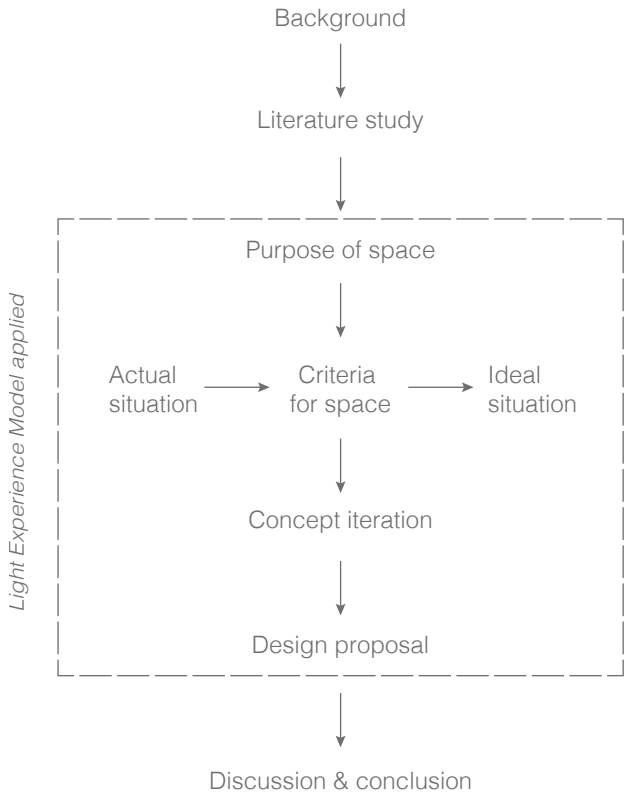


Illustration of the different phases of the thesis

Fig. 1.3 Thesis process

Chapter 1

A literature study

The context-independent knowledge is unfolded through a literature study. In this literature study light is approached from the side of natural science, as well as from the side of phenomenology. These two approaches are described in a quote by Böhme regarding architecture:

> *[…], traditional architecture has conceived of space from the perspective of geometry and considered the people in it as bodies. In contrast, what matters today is to strengthen the position of the experiencing subject and to foreground what it means to be bodily present in spaces. This aspect will take architecture to a new level of design potential. Neither side, however, should be made into an absolute. Rather, the truth resides in the interplay between the two, between felt and objective body, between disposition and activity, and between actuality and reality. (Böhme 2017, 95)*

In this quote Böhme differentiates between architecture as geometries and materials, and architecture as an exchange between people and space. In the traditional way of considering architecture, he argues that a person is merely considered a body in the space, meaning the person can be determined through dimensions, measurements, materials, just as the architecture can. Contrary to this, he argues that present design focusses on representing architecture through the personal experience. This description of architecture can certainly be translated into light and related to the design of lighting. Through the quote Böhme also stated, that the two different approaches should work together in lifting the design to a higher level. One should not be the dominating approach; rather should they supplement one another. He differentiates between the two approaches using the terms:

actuality and reality.

The terms actuality and reality originate from Ludwig Klages, who was a German philosopher from the 20th century. Klages distinguished with these terms between the science of appearances and the science of fact. In Klages philosophy, factual science investigates the cause of things, which is connected to *"the reality of images"*. Science of appearance investigates our experiences, which is connected to *"the actuality of images".* Böhme comments on this distinction by saying:

> *Already in his early work, Vom kosmogonischen Eros (On the Cosmogonic Eros), Klages attempted*

> *to elaborate that appearances (images) possess a relatively autonomous reality and efficacy in relation to their carriers. (Böhme 2017, 19)*

From this it can be derived that, an experience holds an independent power and actuality in relation to who experiences it. This can be independent from the reality, which contributes to produce the experience.

Relating the two terms to architecture and lighting, one can argue, that reality expresses the real state of a space. In terms of architecture, this expresses the geometry, the materials and other physical dimensions of a building. Actuality, on the contrary, describes the character or appearance of a space. With regard to lighting, reality describes the elements of a luminous environment in a scientific manner, such as through light distribution, illuminance, luminance and so on, and actuality describes it in a phenomenological manner, such as through atmosphere.

Anders Liljefors, a former professor at the School of Architecture in Stockholm (KTH), also comments on this distinction between reality and actuality, by saying that the world of science states that *"what is factual is what we can measure."* (Liljefors 1999, 5). He then argues that if we are willing to leave the understanding that, *"what we see is less reliable than physical measurement"*, we will expose ourselves to new fascinating fields of knowledge (Liljefors 1999, 5). Again, it is stressed, that by letting the two approaches supplement each other, we gain more knowledge and a better understanding. This is the core of transdisciplinary knowledge, as described by Hansen and Mullins (Hansen and Mullins 2014).

Using the terms of actuality and reality, this first chapter takes it's departure from the literature study. Through the literature study, materials describing the elements of a luminous environment have been revised and investigated. The parameters of a lighting design have been researched within natural science. Besides the natural scientific approach, literature regarding our sensuous experiences have also been revised. Through this, the phenomena of aesthetics and atmosphere are introduced. This describes the experience and appearance of a luminous environment in a phenomenological manner.

Actuality

Actuality as a concept refers to the science of appearance, and through this concept the experience of a space is investigated. How we experience a space is depended upon many different things, both internal and external. Whether considering daylight or electrical light, lighting holds the opportunity to completely change the character, and thereby the experience, of a space.

> *"Light is of decisive importance in experiencing architecture. The same room can be made to give very different spatial impressions by the simple expedient of changing the size and location of its openings." (Rasmussen 1964, 187)*

It thereby follows, that lighting has a great potential to influence a space in terms of experience. In exploring this potential, the concepts of (new) aesthetics and atmosphere have been examined.

Aesthetics

The American architect Louis Kahn pointed out the difference between nature's laws and society's rules. Nature's laws are determined and cannot be changed, whereas rules of society can easily be changed. Nature's laws are unconscious, while society's rules are conscious. A rule is always on trial and constantly awaiting validation or rejection. Louis Kahn wrote: *"To discover a new rule is to discover a new avenue of expression."* (Lobell 2008, 26). He described aesthetics as *"rules of art"*. Derived from this, Kahn regarded aesthetics as constantly changing, due to the new expressions of art. Because of this continuum of rules, he recommended not to deal with or employ any aesthetics to a design (Lobell 2008).

This way of considering aesthetics as rules of art, follows the manner in which the concept of aesthetics is used nowadays. However, this has little to do with the original meaning of the word aesthetics. The word origins from the Greek language and relates to nature and to sensuous experiences. The use of the word aesthetics today, in for instance speeches, openings of exhibitions, critique of art pieces, social functions and so on, relates little to the original meaning. Rather, it relates to the aesthetics of judgement, which refers to taste. Aesthetics of judgement describes the right to accept or reject something as an aesthetics piece of art. The theory of aesthetics has developed into a vocabulary for art history and art criticism, and the themes of sensuousness and nature has disappeared from it's meaning (Böhme 2017).

A language of art. An interpretation of art

Aesthetics has become a language, through which we can communicate and judge art. The influence and dominance of linguistics has resulted in communication being the primary way in which we interpret art. The theme of aesthetics is thereby used to, not only judge, but also interpret a work of art.

Nietzche stated: *"There are no facts, only interpretations."* (Sontag 1966, 3). By this Nietzche was referring to interpretations in a broad sense, that everything we experience is interpretations. However, this broader sense of interpretations seems to have been forgotten. Instead, the task of interpretation has become the task of translation or the task of resolving discrepancies. Interpretation is either concerned with erecting another meaning on top of the literal one or digging behind the content to find the true meaning of the content. Either way, interpretation refuses to leave a piece of art alone, and reduces the piece to only content, by which it becomes manageable (Sontag 1966). The American writer Susan Sontag argues in her essay *Against Interpretation,* that we should abandon the considerations of content and start regarding those of form. This stresses that we should not overanalyse and try to extract a meaning, but rather be concerned with the way in which a work of art expresses itself. She also argues that due to our excess culture, we receive a *"steady loss of sharpness in our sensory experience"* (Sontag 1966, 9). To accommodate this loss of sharpness and recover our senses, we must learn to use our senses again, learn to see again, to hear again, to feel again and so forth. In doing so, both art and our own experiences, will be made more real to us.

New Aesthetics

New aesthetics, as a concept, is introduced by Böhme. The concept challenges the tasks of aesthetics. It is no longer to determine what art or a work of art is. New aesthetics considers the correlation and exchange between environmental qualities and human states. This *"and"* is very important since that is what relates the qualities of the environment to the state of a human, which is represented through atmosphere (Böhme 2017).

An aesthetic work is a wide phenomenon. However, aestheticians have regarded all production of aesthetics from the perspective of art and measured against arts standards. Because of this, they have not acknowledged other productions as art or aesthetic works. Those, they have recognised as mere beautifications, arts and crafts, applied arts and so on (Böhme 2017). As a result of new aesthetics, not only art is considered an aesthetic work. The concept of aesthetic labour is introduced, which breaks with this normative orientation that *"aesthetics was not simply concerned with art but with genuine, true and*

great art, with the authentic work of art, the work of art of distinction." (Böhme 2017, 16). Thus, aesthetic works, by the means of new aesthetics, is defined as anything that produces an atmosphere. This covers, amongst others, commercial productions, architecture, stage design, art and lighting design.

The concept of atmosphere

Atmosphere is a familiar, yet very vague and ambiguous concept. It describes the aesthetic qualities of a view or space, but is also an intermedia phenomenon, meaning it is dependent on an exchange between subject and object. Therefore, an atmosphere cannot be singled out as something autonomous. The term atmosphere originates from the fields of meteorology. The literal meaning of the term relates the envelope of air surrounding the earth. In the 18th century atmosphere began being used as a metaphor, describing a specific mood, or describing something *"in the air"*. An emotional tinge of space (Böhme 2017). This normative use of atmosphere as a metaphor for something in the air, has led to the concept being very vague and difficult to elaborate on.

Atmosphere as mindful physical presence

Böhme describes an atmosphere as a space of mindful physical presence into which one finds oneself, owing to the type of experience involved. The experience Böhme mentions is described as mindful physical sensation (Böhme 2013a). The phrase *"mindful physical"* relates to the body. Through the development of modern technology, the body has been de-emphasised. This tendency is now being changed, and the body is rediscovered through different types of expression. In architecture corporeality has again become a theme of consideration when designing. This renaissance of corporeality draws references back to the late 1800s, where art historians stressed the importance of corporeality. The art historian Heinrich Wölfflin etsblished that *"[…] the spatial shape of architecture was not merely a matter of what you see, but is rather experienced in and by the body, as if it were realised internally."* (Böhme 2013a, 21). This recognises the importance of the body. Corporeality has initiated a change of focus in architecture, which was first taken on by Art Nouveau architects. In his book *Die Schönheit der großen Stadt* the German architect August Endell wrote:

> *"Whosoever thinks of architecture initially always thinks of the elements of a building, the façades, the columns, the ornaments, and yet all of that is of second rank. What is to most effect is not the shape, but its inversion, the space, the emptiness that spreads out rhythmically between the walls, is delimited by*

them, and that vibrancy is more important than the walls." (Böhme 2013a, 23)

The change in focus from designing architectural objects to designing spaces considers the negative space and what is framed rather than what frames. The change is apparent from building to body and from object to subject. What is important from this, is the focus on mindful physical sensation which one should experience when presented to a space. This experience is due to the atmosphere, which was described as a space of mindful physical presence. The phenomenon of mindful physical presence is characterised through the concept of sensitivity, which relates to the sense one has of the space where one is. Atmospheric effects on spaces should be taken seriously, because the sensitivity associated with feeling where one is in a specific space, sets an underlying tone, that influences one's mood (Böhme 2013a). Thus, atmosphere directly influence a persons mood.

Although atmosphere should be taken very seriously when designing, it is still a vague concept. An atmosphere is something intangible and airy, something that is simply over us, and something that changes over time. And yet, we can produce and manipulate an atmosphere, as it is done in the profession of stage design. The word *"producing"* refers to something tangible, but as just described an atmosphere is intangible. Although it is paradoxical, we still ask the question: how is an atmosphere produced? In producing an atmosphere, Böhme talks about generators of atmosphere. These generators set the condition under which an atmosphere appears. The generators can be of physical or none-physical character, such as specific objects, lights or sounds. Böhme categorises generators of atmosphere in three: the physical, the sensorial and the social. The physical generators mainly focus on the geometrical structures and physical constellations of a given space. The sensorial generators relate to synesthetic properties, which can be defined as *"qualities of the senses that belong to more than one sensory field at once"* (Böhme 2013a, 29). This interaction between sensory experiences is *"actually experiences of mindful senses and can therefore only ambivalently be spread across different sensory fields."* (Böhme 2013a, 29). The social generators refer to social and cultural differences, and the fact that atmospheres might be interpreted differently across cultures. The different generators of atmosphere contribute to the character of the atmosphere, which is the way an atmosphere communicates a feeling to the participating subject. The participating subject is important, since an atmosphere is an intermedia phenomenon. The atmosphere only emerges with an active contribution of the subject (Böhme 2013c). The Finnish architect Juhani Pallasmaa elaborates on this in his statement regarding the great function of all meaningful art:

> *"In the experience of art, a peculiar exchange takes place; I lend my emotions and associations to the space and the space lends me its aura, which entices and emancipates my perceptions and thoughts." (Pallasmaa 2007, 12)*

One must expose oneself to the atmosphere and experience it in terms of one's own emotional state. This means that without an participating subject, the atmosphere does not exist (Böhme 2013c).

Reception aesthetics and production aesthetics

One can approach atmospheres from two different directions: reception aesthetics and production aesthetics. Reception aesthetics refers to the subject, while production aesthetics refers to the object and the space. Reception aesthetics affect the subject and tends to induce the subject in a particular mood. Production aesthetics refers to the object and space, and approaches atmospheres in a rational manner. Even though the phenomenon of atmospheres depends on the active participation of the subject, it would be pointless to approach atmospheres from a purely subjective angle. If atmospheres could not be experienced more or less in the same way by a group of people, the stage set designer would not be able to provide an atmospheric background to support a theatrical play. This demonstrates that atmospheres are quasi-objective (Böhme 2013c).

The word quasi is synonym for something which is almost, but not completely, the thing described (Cambridge University n.d.). Therefore, the concept of quasi-objectivity refers to the cross field between objectivity and subjectivity, meaning something is objective to a certain degree. Although atmospheres are perceived subjectively, we communicate about them intersubjectively, when we discuss what kind of atmosphere appears in a space. In social science intersubjectivity refers to an agreement between individuals. This means two individuals can communicate intersubjectively about an atmosphere, because they share a subjective state. Böhme states, that this demonstrates that some kinds of intersubjectivity is not grounded in objectivity, but rather in quasi-objectivity. This means, that we can discuss atmospheres almost objectively. Based on this it can be derived that *"the quasi-objectivity of atmospheres, […], reveals itself in its linguistic communicability."* (Böhme 2017, 160). This communication presupposes a certain homogeneity, which can be defined as a certain mode of perception installed through cultural socialisation. If this is true for two individuals, exposed to the same atmosphere, in the same space, at the same time, this atmosphere is quasi-objective (Böhme 2013c).

Multisensory experiences

Following the phenomenology of atmosphere by Böhme, the concept of multisensory experiences is introduced. This concept is highly advocated for by Juhani Pallasmaa. Pallasmaa introduced this concept through his book *The Eyes of the Skin*. The book stresses the importance of multisensory experiences, and how humans perceive through the senses. He argues that too much emphasis has been put on the sense of sight, at the expense of the other senses and at the expense of our experiences and perception. The book is based on a polemical essay he wrote in 1995, and the motivation for the essay was:

> *"The polemical essay was initially based on personal experiences, views and speculations. I had become increasingly concerned about the bias towards vision, and the suppression of other senses, in the way architecture was conceived, taught and critiqued, and about the consequent disappearance of sensory and sensual qualities from the arts and architecture." (Pallasmaa 2007, 10)*

This quote from Pallasmaa points to a problematic discourse, where the eye is separated from its natural interaction with the other senses, which reduces our experience of the surroundings to a sphere of vision. The separation of the senses, results in a fragmentation of our otherwise complex perceptual system, and leads to alienation of sight (Pallasmaa 2007). Pallasmaa hereby argues, that by favouriting sight in art, architecture, design, and so forth, we limit our experiences to the experience of one, isolated sense. In doing so, we deny letting our bodies experience as a whole. Merleau-Ponty also criticised the tendency to separate the senses. He saw the self and the world as interpenetrating and mutually defining one another. As a result of this, he described his perception as *"[…] not a sum of visual, tactile and audible givens: I perceive in a total way with my whole being, which speaks to all my senses at once, […]."* (Pallasmaa 2007, 21). The understanding that perception is an act of the whole body and not an isolated sense, serve as basis for the multisensory experience. Through his work, Merleau-Ponty also addresses *"[…] our often unconscious aesthetic preferences, by showing how our perception of the world around us necessarily begins with a process of bodily engagement, […]."* (Hale 2017, 5). This bodily engagement draws references to mindful physical presence and the concept of atmosphere.

Pallasmaa sees the sense of touch as the fundamental sense and argues, that all other senses are extended from the sense of touch. This is due to the fact, that the senses are specialisation of skin tissue, and because of this, all

Vision as a tactile sense
Photo by: Himalayan art resources
Fig. 2.1 Vision as touch

sensory perception is related to touching (Pallasmaa 2014). Louis Kahn described the correlation between sight and touch by saying: *"To see was only to touch more accurately."* (Lobell 2008, 8). This is illustrated in figure 2.1. As sight is the extension of touch, one touches more accurately, because another dimension of understanding is added to the experience. It should be stressed though, that when Pallasmaa talks about the importance of touch, he does not mean touch in the literal sense. He talks about touch as *"[…] tactility in an existential sense, as an experience of one's being and sense of self."* (Böhme 2013b, 99). The tactile experience therefore involves all our senses and our body, as it refers to the experience of being in the world. Pallasmaa relates the multisensory experience, described by tactility, to the concept of atmosphere by stating:

> *"It is this haptic sense of being in the world, and in a specific place and moment, the actuality of existence, that is the essence of atmosphere." (Böhme 2013b, 99)*

The Swiss architect Peter Zumthor also describes atmosphere as a product of tactile qualities. Contrary to Pallasmaa, Zumthor thinks of tactile qualities in more literal manner. He argues, that by taking materials seriously we create a space of multisensory experiences. When using and staging materials, the space becomes visually interesting and engages the sense of sight. It appeals to the sense of touch, when you urge to let your fingers touch the material, and it draws your attention to the volume and spatiality through the acoustics. Louis Kahn also argued that materials should be honoured and stated: *"The beauty of what you create comes if you honor the material for what it really is."* (Lobell 2008, 40). He said never to let a material become a servant or use it in a subsidiary way, but to respect the character of the material. In doing so, materials are experienced synesthetic.

Although the sense of sight is prioritised in many ways, it can also be unnecessary and destructive in relation to an experience. For instance, we often suppress sight when dealing with emotions or deep thoughts. The unnecessity of sight is beautifully described by the Japanese writer Junichiro Tanizaki in his essay on Japanese aesthetics *In Praise of Shadow*.

> *"With lacquerware there is a beauty in the moment between removing the lid and lifting the bowl to the mouth when one gazes at the still, silent liquid in the dark depths of the bowl, its color hardly differing from that of the bowl itself. What lies within the darkness one cannot distinguish, but the palm senses the*

> *gentle movements of liquid, vapor rising from within forming droplets on the rim, and the fragrance carried upon the vapor brings a delicate anticipation.“ (Tanizaki 2001, 25)*

This description of the serving soup in Japan proves to show why sight is not more important than other senses. The multisensory experience engages the body in the space, merges the present with the absent and the sensed with the imagined. It creates images in our brain and stimulates our imagination. In this case the body becomes more than a physically defined body, because it is consumed with memories. And so, the body is not merely present in the space, but it is mindfully present, as described by Böhme.

Light as a phenomenon

Light has through natural science been defined as electromagnetic radiation within a certain frequency spectrum. Based on this, light is defined independently from the eye. If we however consider light through the science of phenomenology, Goethe defines light, in his book *Theory of Colour*, as *“nature acting according to its laws upon the sense of the eye.”* (Böhme 2017b, 194). In the wake of this Böhme states, that if we consider light as a phenomenon *“it is absurd to assert that you don’t see light itself.”* (Böhme 2017c, 205). By this statement, Böhme challenges the independence of light, as defined by natural science. Rather Böhme defines light as a phenomenon dependent on sight. He argues that the claim that we cannot see light is due to an ordinary way of thinking of seeing something. Light, however, is not something (Böhme 2017b). As a phenomenon, light is characterised as brightness, which is a precondition for seeing. This is due to the fact that we only see anything as long as light (brightness) is present. This was stated by Plato, in his metaphor for the sun:

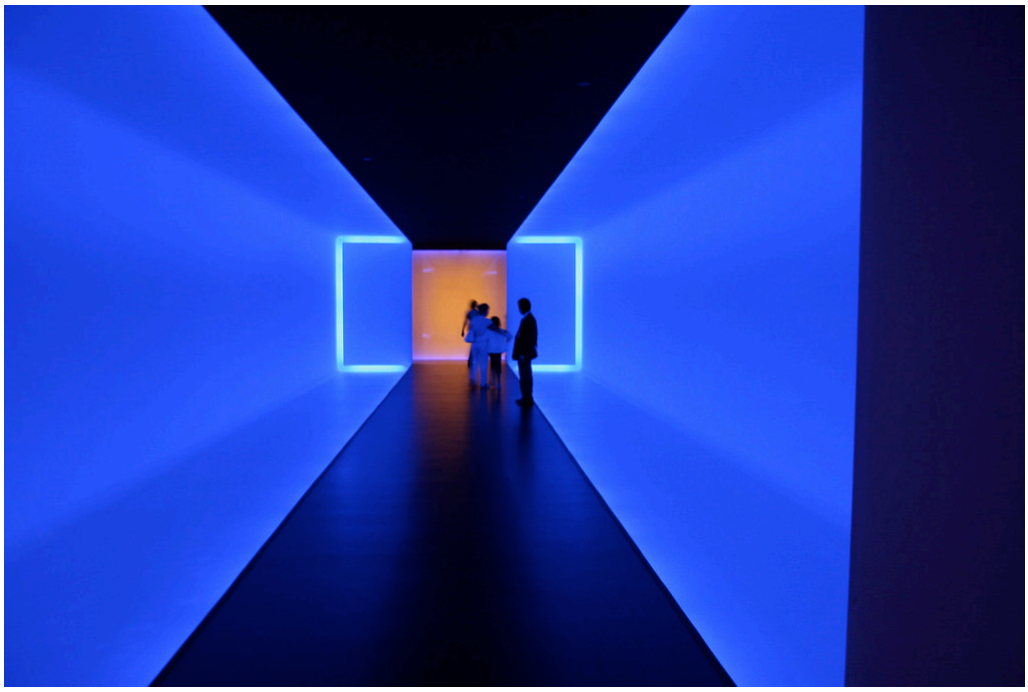
> *“If in the eyes the faculty of seeing exists and one wants to make use of it, and if also there are colors (in the things) – if then there is a third entity missing which in particular is fit for it, then – you know it well – the sight will not see anything and the color will be unseen.*
> *What is it you are talking about?*
> *That, what you call light, was my answer” (Böhme 2017c, 206)*

However, darkness is also a precondition for visibility. It is important in terms of differentiating what brightness reveals. If brightness is a precondition for

seeing at all, then darkness (here interacting with light) is a precondition for seeing something (Böhme 2017c). The relationship between brightness and darkness is therefore important, if we are to distinguish what we see. This point is also stressed by Steen Eiler Rasmussen when he argues, in his book *Experiencing Architecture*, that all mimic of an actor's face dissolves and we see no form, when the actor is bathed in light from both left and right. He argues that, "*if the lighted parts are too light the form on that side is killed, and if the parts in shadow are too dark no form will be seen there."* (Rasmussen 1964, 190). If we do not have darkness to balance the light, then we are overpowered by the exposure to (too much) light, which can lead to blinding us. This can be described as a pure light phenomenon, where we find ourselves in a hemisphere of colour. When closing our eyes and turning towards the sun, this pure light phenomenon can be experiences, and we find ourself in a hemisphere of red/orange colour. The artist James Turrell has created art pieces where the pure light phenomenon is manifested in totalities. In these art pieces the uniformity of the light embraces the entire field of vision, which underlines the phenomenon as a totality. The spectator experiences no surfaces, no boundaries, no defined space, and is thereby exposed to a total loss of depth perception. By detecting no contours in the space, the spectator is cut off from reality and exposed to a spatial phenomenon created by light (Böhme 2017b). This is demonstrated in figure 2.2, which shows one of James Turrell's works.

Light as brightness

Light qua brightness opens up and creates a space. Not in a mathematical or physical sense, where one can measure the dimensions of a space even in darkness. Brightness creates the space as we experience it and through brightness things become visible and appear to us. A space is not defined by the distance between these things, but rather expressed by the things and by the composition of light and dark. Böhme describes a space, as characterised by the opportunity to move around, not just physically, but with one's eyes (Böhme 2017c). This opportunity to move around in the depth of a space through our eyes, is important for our spatial experience, the feeling of finding ourselves in the space, and thereby being mindful physical present. The opportunity of the eye's spatial movement is created by the relationship between brightness and darkness. This relationship may be asymmetrical and dynamic, in the sense that the degrees of light and dark may vary over time. The composition of light and dark is important for activating our retinal (peripheral) sight. Our retinal sight, dependent on the ambient lighting, integrates us in the space while the foveal (central) sight distances us from the space, and in doing so, reduces us to spectators. This difference in sight articulates the difference in being included in a space and experiencing a space, or being a third party, an outsider, observing the space. The retinal vision also relates to our intuition, which has a great influence on our experienced moods. The intuition triggers



Pure light phenomenon
Photo by: Miguel Da Silva
Fig. 2.2 James Turrell, The Light Inside

our perceptual and cognitive processes, forming our overall impression of a space, after which we start to notice the details of a space, going from retinal vision to foveal vision (Pallasmaa 2014). Louis Kahn also pointed out that, *"Your intuition is your most exacting sense, it is your most reliable sense."* (Lobell 2008, 12). Kahn distinguished intuition from knowledge, and thought that knowledge and knowing are skills, which can be taught. Intuition however, he considered more demanding but also the greatest gift, since it provides immediate responses based on our former experiences and knowledge. Thus, the balance of brightness and darkness has a big influence on our presence in a space and the moods we experience.

Light as a generator of atmosphere

As described before, Böhme has defined three generators of atmosphere: physical, sensorial and social. Light contributes to all three. It opens up a space and sculpt it, it stimulates our senses and creates synesthetic experiences, and it frames social events and relates to our culture and cultural history. In doing so, it generates an atmosphere (Bille and Sørensen 2007). Through lighting, tuned spaces are created, where hues and shapes, and light and dark, contribute to the production of a particular atmosphere. This being said, atmospheres are fleeting, which means they may persist for a while, but they are always subject to be transformed (Edensor 2015). Based on the works of the philosopher Alphonso Lingis, it is established that light is *"endlessly characterized by everchanging levels across space and time that incessantly produce different patterns and conditions and accordingly responsive attunements to those who see and are enveloped by them."* (Edensor 2015, 334). This illustrates how light is always capable of changing, which may result in changing moods and changing atmospheres. The effect of lighting on an atmosphere is very closely linked to our cultural socialisation. Exposure to different types and qualities of light, for instance the light in northern countries compared to the light in southern countries, influences the way in which lighting is sensorial and affectively experienced. This is described by: *"Cultural attitudes towards particular designs, colours and levels of illumination influence responses that may feed into the production of atmospheres […]."* (Edensor 2015, 333). Light is a generator of atmosphere and a lighting design must therefore take into account how it generates and influences a given atmosphere.

The importance of shadows

The shadow is an important aspect of the composition of brightness and darkness. Shadows can undertake many different qualities, which underlines the mystery of the shadow, as described by the Japanese writer Junichiro Tanizaki. The dynamic properties held by shadow and darkness stimulates our senses and our imagination. In his essay *In Praise of Shadow* Tanizaki describes the importance of the shadow in Japanese aesthetics. He writes:

> *"The light from the garden steals in but dimly through paper-paneled doors, and it is precisely this indirect light that make for us the charm of a room. We do our walls in neutral colors so that the sad, fragile, dying rays can sink into absolute repose." (Tanizaki 2001, 30)*

The delicate manner in which Japanese architecture unfolds the potential of the shadow, illustrates how variations of light and dark can serve as decorative. This is demonstrated in figure 2.3. *"We never tire of the sight, for to us this pale glow and these dim shadows far surpass any ornament."* (Tanizaki 2001, 30). Not just in Japanese culture, has the absence of light come to prove its potential. The qualities of darkness have lately been reassessed and is increasingly being utilised in new ways to produce atmospheres (Edensor 2015).

A shadow is the result of the interaction between light and an object to which the shadow belongs. It is determined by the physicality of the relationship between light source and object (Bille and Sørensen 2007). This means, that the qualities of the shadow, such as the colour, the edge, the size and so on, is a product of this relationship. Many different shadows can be cast by the same object as a result of different light sources and different placement of these. Thus, the light holds the opportunity to create a shadow, and the object becomes an instrument of the light. The shadow can be fleeting and change over time. This variable provides a dynamic, mysterious and beautiful character to the shadow. *"[…] we find beauty not in the thing itself but in the patterns of shadow, the light and the darkness, that one thing against another creates."* (Tanizaki 2001, 46). Shadows reveal the space and the spatial relationship to us, activates our depth perception, and provides the opportunity for our eye's spatial movement.

From this study of actuality, through the science of phenomenology, it is evident that atmospheres can be created through generators, and that light acts as such a generator. However, how to work with light as a generator of atmosphere and which parameters of a luminous environment, one can work with, will be investigated in the next part regarding reality.

Light and shadow
Photo by: Christian Bauer
Fig. 2.3 Traditional Japanese interior

Reality

Anders Liljefors states that there lies an important challenge for today's research, in developing methods that more adequately describes physical conditions for visual quality. He states: *"There is no physical instrument functioning like vision."* (Liljefors 1999, 38). This being said, the experience of a space can be elaborated through the interplay between actuality and reality. Reality is concerned with the science of facts, which relates to natural science and to measurable parameters. However, this concept is approached with a focus on what one actually sees and experiences. Based on the concept of reality, the elements of a luminous environment are investigated.

A space and its surroundings are often analysed with a focus on the measurable parameters. Of course, this is a good way of understanding a given situation, but often these measurements end up as numbers that can be difficult to correlate to the real situation or one's sensorial experience. When analysing a space or luminous environment, the primary focus is often based on the room dimensions and geometry, the reflectances, illuminance levels, luminous flux, colour rendering index, correlated colour temperature, luminance distribution, etc.

Based on the way Liljefors describes the experience of lighting in his compendium *Lighting – Visually and physically*, this subchapter strives to unfold and elaborate focus points regarding reality inputs and reality outcome.

Reality inputs:
these relate to the spatial inputs, which determines a space in a physical manner

- Shape (dimensions, openings)
- Surfaces (reflections, texture, colour)
- Interior (entrance, objects/furniture, behaviour)

Reality outcome:
these relate to the luminous outcomes, which are dependent on the spatial inputs and the light's interaction with these

- Level of light
- Spatial distribution of brightness
- Shadows
- Reflections
- Glare
- Colour of light
- Colour of surfaces

Reality inputs

The properties of a space which exist without lighting (meaning, in a physical extent), have a great importance and impact on the lighting in the space and thereby, on the appearance of the space. These properties are described as reality inputs, and will be elaborated on in the following.

Shape

A space's shape and geometry are given in both two and three dimensions. How a space is formed, can be easily measured, but how a space is experienced can vary from situation to situation. Two different spaces with almost adequate dimensions, can easily provoke different perceptions of volume, density, visibility and overview. This stresses the importance of unfolding the experience of a space, together with the measured parameters.

When entering a space one glances around, and in a split-second information of the shape and appearance of the space is acquired. This happens due to our senses, which *"co-operate first to confirm the "I exist" and "where I am"."* (Liljefors 1999, 12). In doing so, the space is outlined *"so "I" can orientate myself."* (Liljefors 1999, 12). This perception and understanding of the environment is based on all our senses. It leads to an overall, subconscious impression of the space, where different feelings are awakened, such as safety vs. insecurity, enclosed vs. free, sheltered vs. exposed (Liljefors 1999).

When trying to explain the shape of a space, one would not refer to it as for instance three by three meters. Often one would say; it is a dense or airy space, short or long, big or small. All these words change according to the given situation. One situation might be dense and cosy in one case, but dense and claustrophobic in another. This all relies on the expectations of the space and its supposed use.

The first things that strikes the retina in a lit room, is reflected light. This instantly reveals the space's geometry. At the same time, it shows placement of openings, like windows and doors, and other objects, such as furniture. The reflected light thereby reveals the space to us.

Surface

The appearance of a space is also highly depending on the materiality of the surfaces in the space. Many parameters define the impression of the surface. These are parameters such as, the ability to reflect light, texture, colour, transparency, translucency, specularity (matte, glossy, specular) and emitting. Some of these parameters are difficult to measure because they are dependent on the light and it's direction.

Reflectance (ρ) can be described as a surface ability to reflect light. It is given as a value between zero and one, where ρ=0 is a perfect black surface, absorbing all light, and ρ=1 is a perfectly reflecting material that reflects all light. The reflectance does not take division of wavelengths into account, but only the amount of reflected radiant energy, which can be indicated in a black and white photo. The reflectance can be determined with a reflectance meter, with a lux meter or with a luminance meter. One can also use a lightness meter to estimate the reflectance of a surface. The reflectance is often used in norms and standards, supporting designers in choosing surfaces that suits a given purpose.

The reflectance is commonly used to explain if a rooms surfaces are either dark, bright or mixed. It therefore has a big impact on the overall level of light and sensorial experience of brightness and darkness, which will be elaborated in the next section. Thus, the reflectance can be an important parameter and tool in creating atmospheres as it can change the perception of the space drastically.

The texture of a surface is given by its materiality and pattern. Texture as a parameter can be smooth, rough, stripped, checked, glossy and matte, all depending on the properties or final treatment of a materials surface. Often textures are confronted with our expectations of what we know through our senses. Texture does not only activate the sense of sight, but also the sense of touch, and at times even the sense of hearing, taste and smell. For instance, it takes no more than a look at a tree trunk, to get an understanding of how the texture of it might be, how it might feel to touch it, and maybe even how it smells and sounds. Texture can be exposed through light, as it supports the understanding of texture through shadows and reflectance. Thus, texture is a very important tool to trigger the senses and create atmospheres. Texture is difficult to measure, and therefore it is often explained through how it is experienced. Hence, through our senses.

There are different occurrences of colour that are equally important in the way we see and interpret them. Colour is a phenomenon that appears when light, with a given wavelength, hits a surface, that reflects light back in a certain way. In this way the surface colour we see is determined by which wavelengths are being reflected back into our retina. The perceived colour depends both on the wavelengths that strikes the material, and on the properties of the surface material.

Liljefors divides the occurrence of colours into five fragments (Liljefors 1999):

1) First of all, there is colour occurring as a surface colour. An example could

be a matte painted red surface. The surface determines which wavelengths are being absorbed and which are being reflected. This means that a red surface is actually absorbing all green and blue wavelengths and reflecting only the red wavelengths. Thereby we experience the surface as red.

2) Field colour is characterized primarily by large fields of solid colour spreads that creates areas of unbroken surface. An example could be looking at the blue sky. This relates to the next section about light.

3) Volume colour, Liljefors describes as wine in a glass. This could also be other coloured particles like coloured smoke, dust or liquid.

4) Luminous colour is described as a surface that emits coloured light. This happens in materials that are translucent or transparent. The materials filter wavelengths as they penetrate through the material and distort lighting colour. This is not considered a light source, but a surface with a static or dynamic luminance. An example of this is a traffic light.

5) The last colour phenomenon is colour of light and will be introduced in the next section about lighting.

Colour can be perceived differently. This depends on many factors like health, eye diseases, colour blindness, age, cultural aspects, etc. As stated in the scope of the thesis, this thesis will not investigate the causes of different perceived colours.

Interior

The interior of a space influences the behavior and interaction of the users in the space. To understand how users are influenced, and analyse their needs, a space can be analysed with inspiration from urban planning. A space analysis can cover, among others, human flow, placement of entrances, placement and orientation of furniture, obstacles, landmarks etc. Great inspiration can be found in the Danish architect and urban planner, Jan Gehl, and in the American urban planner and author, Kevin Lynch. Despite the fact that they both concern themselves with architecture and urban planning, very important parallels are found in their work of implementing human environmental psychology. As Kevin Lynch puts it: *"Environmental images are the result of a two-way process between the observer and his environment. The environment suggests distinctions and relations, and the observer - with great adaptability and in the light of his own purposes - selects, organizes, and endows with meaning what he sees."* (Lynch 1990, 6). Both Jan Gehl and Kevin Lynch has created great tools that strives to describe, analyse and improve human environments from a human perspective. A major key in both their work, is the importance of designing

for the human, in a human scale.

Kevin Lynch approaches this by focusing primarily on flows and how they appear in an environment. By introducing five different elements in *"the city"*, he creates a mapping tool that marks out different appearances as a physical form. These are elements described as paths, edges, districts, nodes and landmarks. The elements support the understanding of human behavior in an environment, and support the detection of invisible borders or unexpected flows and rhythms. In addition to this, also Jan Gehl tries to identify human flows and behavior by introducing topics, such as *"to assemble or disperse"* and *"to invite or repel*", in his book *Cities for People*. He stresses the importance of understanding people in the header: *"The city at eye level - designing the ground floor"* (Gehl 2010, 240). Many useful tools are found in his toolbox (Gehl 2010, 232–45), especially his 12 defined quality criteria. These describe important aspects for the quality of the urban environment in relation to people, under the themes delight, comfort and protection. Thus, it is evident the design of a space greatly influence the experience and use of the space.

Reality outcome

The reality outcomes relate to the luminous outcomes, which are reactions to the spatial properties described above. The visual experience of the light in a space is described through seven basic terms introduced by Liljefors (Liljefors 1999).

Level of light

The level of light describes how light or dark a room is. It is probably the first and easiest lighting phenomenon that we detect through our sense of sight. It can be measured in different ways, for instance, as the illuminance [lx] of given surface measured with a lux meter, or through a surface's ability to reflect light, which is measured through the surface's reflectance (ρ). Other aspects influence the level of light, such as the correlated colour temperature (CCT) which is measured in kelvin [K]. Of course, all this relies on the shape and properties of a space, as well as the position and direction of the light and the light source itself.

When approaching the level of light from a natural science point of view, the range of light level is wide, from very dark to very bright. This is true in terms of the measuring equipment and the results it provides, but when comparing these numbers to the human experience of the light level, this is not necessarily the truth. When looking closer to the steps between very dark and very bright, relatively few noticeably steps are found (Liljefors 1999). This means, that even

big measured differences can be hard to see with the naked eye. It is easier to experience the differences when comparing different lighting situations, such as when entering a brighter space from a darker space. This leads to an important aspect: eye adaptation. When entering a dimmed space from a brighter space, the eye adapts to its surroundings. What first appeared dark, slowly becomes brighter and thereby, our vision adapts to the darkness so we can see. This adaptation is quicker from dark to bright, than from bright to dark.

The level of light can be considered as an overall experience or as a local experience in a given space. These two experiences must be separated as they are not directly related and depends upon the activities in the space (Liljefors 1999). This means, that the overall experience of the light level in a space might be perceived as bright enough, while the level of light near, for instance a reading corner is perceived as too low for reading, or vice versa. Another way the level of light is influenced, is by a difference in brightness. Often a monotonous lighting scheme across a space appears less bright, compared to an unevenly distributed lighting scheme. Also, by creating bigger contrasts locally in a space, differences in the general lighting level appear. An example is to increase the light level in a corner, which results in the rest of the space appearing darker, and the opposite when decreasing the light level. Finally, the level of light can be influenced by the CCT of the light source. If a room is lit with a moderate luminous flux, the room will generally tend appear brighter with a low colour temperature, compared to a higher colour temperature, due to the physiologic evolution of our vision (Liljefors 1999).

When referring to the previous section about reality inputs, the perceived amount light, when one enters a space, is generally more influenced by the surface reflectance, than by the amount of light put into the space. A space with high reflectance, like white walls, need very little light to feel bright, whereas a space with dark surfaces and low reflectance might feel dark, even though the illuminance of the space is high. This stresses the importance of reflectance choices in regard to level of light.

The level of light has a big influence on our spatial light experience. Liljefors stresses this, in stating:

> *“Entering a light room, coming from a darker is essentially different from the opposite, entering a dark space, coming from a brighter one. How the level of light is evaluated in a space will depend on what you do, on what you need to see, but certainly also of who you are, what you are used to, what you like and dislike.” (Liljefors 1999, 27)*

The level of light can indicate or change the pattern of human behaviour. For instance, low levels of light are often associated with calmness or a passivity, whereas high levels of light are associated with high activity and wakefulness. An interesting quote by Pallasmaa unfolds that *"The imagination and daydreaming are stimulated by dim light and shadow. [...] Homogenous bright light paralyses the imagination [...]."* (Pallasmaa 2007, 46).

The feeling of wellbeing and the ability to see and orientate is highly depending on the level of light. If a space feels too dark, this can make one feel uncomfortable in terms of safety, performance or tiredness. Contrary, too much light can be hurtful and make one feel blind and loose orientation. As Steen Eilers Rasmussen puts it: *"If we do not see a thing well enough we simply demand more light. And very often we find that it does not help because the quantity of light is nor nearly as important as its quality."* (Rasmussen 1964, 189). Furthermore, studies show that the level of light has an impact on the human sound level, as higher light levels lead to louder conversation and more communication (Veitch and Newsham 1996).

All this underlines the complexity of different factors that influence our overall experience of the level of light. It also underlines the importance of understanding the lighting purpose in a given space.

Spatial distribution of brightness

The spatial distribution of brightness regards the experience of brightness and darkness in a space, and how these relate to each other. It offers visual stimulation in terms of visual variation. It is of course highly depending on the light source, its position, its distribution and its orientation, as well as spatial properties, both when considering electrical light and daylight openings. From a natural scientific point of view, the spatial distribution of brightness is normally measured or observed through luminance measurements [cd/m^2] and false colour imaging.

As mentioned, many parameters influence the distribution of light. The shape of the space and its structural elements decides where light is present. Louis Kahn explains: *"Structure is the giver of light. When I choose an order of structure that calls for column alongside of column, it presents a rhythm, of no light, light, no light, light, no light, light."* (Lobell 2008, 34). Thus, the structure of a space is a choice of the character of the light, meaning that the chosen structure, the order, is the influencer of the rhythm of light. Structure can therefore be said to be the giver of light. This does not mean, that structure is more important than light. It only means, that the composition of light/dark is directly linked to the structure.

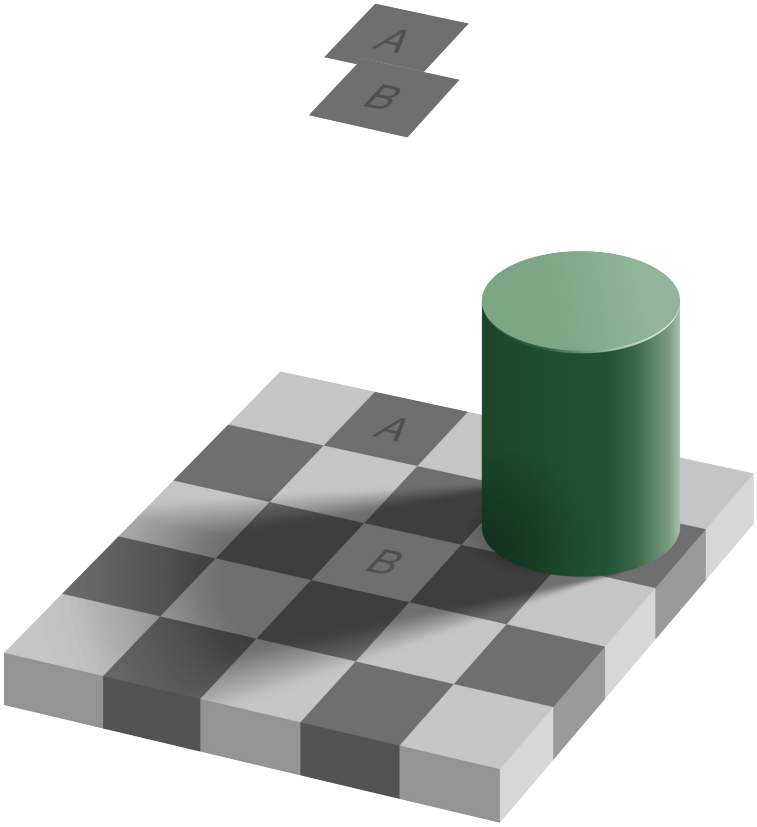
Another important parameter is the surface. The experience of the brightness distribution is not necessarily linked to the measured distribution of light reaching surfaces in a space. The context has a great impact on how the distribution of brightness is experienced. There are many optical illusions showing this phenomenon. Figure 2.4 illustrates such an optical illusion, as the squares A and B are exactly the same colour, but B is experiences brighter than A.

Another influencer is, of course, the distribution of light itself. "*Nonuniformity across a room appears to be preferable to uniformity because it creates interest and can highlight important information"* (Veitch and Newsham 1996, 23). Often little or no variation in lighting distribution is related to uncomfortable, gloomy or boring luminous environments. This is again stressed by Pallasmaa, when he talks about imagination and daydreaming. Therefore a visible hierarchy might support the understanding a given space in different ways.

Our vision is sensitive to differences of light, which makes the spatial distribution of brightness a useful parameter in creating different visual experiences. It offers abundant variations that result in different perceptions of a space. This is stressed by comparing a dark space with a single dramatic narrow spot placed in the centre of it, with the same space bathed homogenous lighting that casts no shadows.

There are some common principles of light distribution often related to different experiences, such as behavioural needs and expectations. This is stressed by Veitch and Newsham in stating: *"(...) relaxation is said to be cued by nonuniformity, particularly nonuniform wall lighting. Perceptual clarity is said to be reinforced by higher horizontal luminances in a central location. Spaciousness is cued by uniform lighting and bright walls."* (Veitch and Newsham 1996, 11). Even with these observations on how lighting and certain experiences are related, it is difficult to foresee how lighting may influence a space and an atmosphere. One must therefore *"[…] consciously train your ability to observe and characterise the factors in question, how they occur and how they can be described. […] This can never be reached only by reading, but must be studied and learned by seeing."* (Liljefors 1999, 11). Only through numerous and careful observations, can it be comprehended how the experience and quality of a space is influenced by lighting. This also emphasises the fact that a well-chosen lighting distribution is directly connected to the given space and the given situation. Therefore, a lighting solution for one situation might not be directly transferred to another situation.

"The lighting of the modern stage proves conclusively that it is not the amount of light which matters. The important thing is the way the light falls." (Rasmussen 1961, 192). However, one must be aware of other impacts related to the



Light and shadow
Fig. 2.4 Optical illusion

spatial distribution of brightness, such as contrast elaborated in the section about glare.

Shadows

"Where is light, you will find shadow." (Liljefors 1999, 14). Shadows are often understood as the resulting substance that happens behind the brightness. That being said, shadows are always directly connected to objects. Liljefors states: *"Independent of size, a shadow is characterised by brightness and often vague colour differences to the adjacent illuminated surface, and by the character of borders created by these differences, which can vary from sharp to diffuse, like the basic contrast types"*. (Liljefors 1999, 14). From a scientific point of view, shadows are normally measured or observed through luminance measurements [cd/m^2] and false colour imaging, just like the spatial light distribution. This results in the two aspects being closely linked, and often difficult to separate.

Shadows are often easy to find and distinguish from each other. To get a better understanding of how shadows work and how it interferes with a space, Liljefors mentions four types of shadows (Liljefors 1999):

1) The big room shadow
Shadows seen on walls, floors, ceilings, describing the light coming from a window and/or lamps. This type can sometimes be difficult to distinguish as it is often mixed with the spatial distribution of brightness.

2) The big object shadow
Shadows cast by objects like chairs, couches, tables and other furniture etc.

3) The small object shadow
Shadows cast by objects like a book, a cup, a hand etc.

4) The detail shadow
Shadows e.g. cast by the texture of a surface or the tip of a pen.

A shadows position, form, intensity, edge and thereby appearance, is directly depending on the type, position, intensity and direction of the shadow-giver (the light source) and the shadow-creator (e.g. an object). Since a combination of factors affect the shadow outcome, one will find a numerous variation of shadow appearances. These factors are:

The shadow position, which is determined by the position of the shadow-giver related to the shadow-creator.

The shadow intensity, which is determined by the shadow-giver and by the light coming from other directions than directly from the shadow-giver. When looking closer at the shadow, it can have different nuances of darkness, where the centre-shadow is the darkest part.

The shadow edge, which is determined by the area of the shadow-giver in relation to the size of the shadow-creator. Furthermore, it depends on the distance between the shadow-giver and the shadow-creator.

The shadow colour, which is an illusion that appears when different kinds of shadow-givers are provided with different colours and placed so that shadows created fall differently.

The shadow holds a great power to influence a space. It is essential to understand both the shadow-creator and shadow-giver. The human evolution, with regard to shadows and light, has its origin in natural light. The natural light covers a broad scale, ranging from sunset to sunrise, from direct sunlight to diffuse skylight, and is dependent on the seasons and time of day. The variations between diffuse skylight, on an overcast day, to a sunny day, with intense sunlight, creates respectively less intense shadows with soft edges, and sharp and intense shadows. All types of shadows created by natural light, describes objects and spaces in a way we are *"accustomed to"*. Shadows can appear deteriorated, when they do not look like they are *"supposed to"* (Liljefors 1999). For instance, if a face is not lit in a natural way, which most likely is from above with an angle like the direction of the sun, it can make the face look distorted or wrong. This is demonstrated in figure 2.5. This of course depends on the given contextual situation. This distortion or emphasising of perceptual mimic is often used in theatre lighting. It thereby follows, that natural lighting not always is the ideal way of revealing an object or a space, but that natural lighting rarely results in skewed or deteriorated shadows. How a shadow should appear, all depends on the suited purpose of a space and object.

Shadows are not only a supporting characteristic, it can also be a disturbing or weakening phenomenon. This is strongly related to the section about spatial distribution of brightness. There are examples of bad positioned lighting, creating shadows that does not support the purpose of the space and object. For example, lighting on a workstation, where the light source is placed above and slightly behind you, results in shadows cast from your body and hands directly on to the working areas. Also, looking at a space, too vague shadows can make a space and object difficult to define and understand, whereas too complex shadow patterns might create irritation, tiring and confusion, instead of clarity (Liljefors 1999).

Illuminating a face from different angles
Fig. 2.5 Facial illumination

The shadow is an important parameter in forming our three-dimensional world, creating depth and perspective. As stated by Pallasmaa: *"The shadow gives shape and life to the object in light. It also provides the realm from which fantasies and dreams arise."* (Pallasmaa 2007, 47). Therefore, it is crucial that one understand the purpose of the space or object when designing lighting, as it supports our understanding, interaction and the appearance of an object and a space.

Reflections

Reflections regard reflections of light on surfaces, whether daylight or electrical light. Reflections can appear on any surface, which is not completely matte. Liljefors defines it as a *"mirror effect on surfaces, often called shines, lustre etc. from light sources or other bright surfaces."* (Liljefors 1999, 14). They can arise in all surfaces that are not perfectly matte. Reflections might in some cases be mixed or confused with glare, but these has two different definitions and must be carefully separated (Liljefors 1999). Scientifically, reflections are easy to calculate in theory, but in reality, they can be really complex and difficult to predict and measure. Also, they are highly depending on dynamic parameters, such as one's position in the space and daylight. Reflections can be observed through luminance distribution measurements [cd/m^2] and false colour imaging, just like the spatial light distribution and shadows.

Reflections are directly connected to the light source or bright surface, to the surface properties, and to the three-dimensional position and direction of sight, when looking at the reflection producing surface. The light source and the surface are in this section described accordingly to their function. The light source is described as the reflection-giver, and can both be direct light or reflected light. An example of direct light is the sun and an example of reflected light is a sunbeam hitting the surface of water, so that water becomes a bright surface. The surface is described as the reflection-creator, which contains all surface parameters as described in the section about surface. As reflection-giver electrical lighting is easier to control than daylight. Of course, how daylight is presented, can to some extent be controlled through daylight openings, their size, shape and characteristics. This being said, electrical lighting offers control over each parameter, such as intensity, colour and CCT, distribution, direction and position etc.

When unfolding the definition of reflection, one will find important factors that influence the reflections. These are:

Position of reflection: *"The position of the reflections is determined by the eye's position related to both the reflecting surface and to the light source/bright surface (causing reflections)."* (Liljefors 1999, 30). This means that reflections

changes depending on one's position in the space and angle to the surface.

Character of reflection: "*The character of the reflections is determined by the properties of the reflecting surface and by the extension of the light source/ bright surface that is reflected/mirrored."* (Liljefors 1999, 30). The properties of the reflection-creator thereby determine the reflections, for instance an all matte surface creates no reflections.

Brightness of reflection: *"The brightness of a reflection is also influenced by the luminance of the light source, measured from the position of the reflection."* (Liljefors 1999, 30). In addition, the reflective characteristic of a material also influence the brightness of the reflection.

Extension of reflection: *"The extension of the reflections is determined by the optical properties of the surface, the area of light source/bright surface and its distance from the surface."* (Liljefors 1999, 30).

A change in any of these factors, creates a different reflection appearance. This is why reflections very complex and difficult to predict. When moving around in a space, reflections can make surfaces come alive, both due to its position, its characteristics, its extension and its brightness.

"[…] reflections make what we see feel alive", Liljefors states (Liljefors 1999, 30). There are many words describing the liveliness reflections create, such as glitter, shimmer, lustre, or one of fundamentals in lighting, play of brilliant (Kelly 2006). A glittering or glimpsing effect is not necessarily achieved through the characteristics of the reflection-creator. This means that a glossy surface can appear matte because of the characteristics of the reflection-giver. If a glossy surface is lit with indirect light, there will be no play in the surface. Reflections are the interplay between unevenly distributed light, for instance created by small, intense light sources, and the surface it hits (Liljefors 1999). That is why the reflection-giver also has to be carefully selected to achieve wanted reflections.

The effects of reflections are not just positive and interesting interplays. Reflections can also lead to unwanted mix of patterns and contrasts, causing for example disability glare. An example of this is the unwanted reflections in laptop screens, which makes it difficult to see the content on the screen, as the reflections influences the visual contrast. This is a well-known problem at working stations. How the reflection-giver is placed and designed, has a big influence on how the reflections appear. As just mentioned, the position of the reflection-givers, especially at offices, can cause unwanted reflections at working areas. This is often controlled or eliminated by louvres on the fixtures,

directing the light.

As aforementioned, parameters that influences the perception of reflections lies within the properties of the reflection-creator and the reflection-giver. The many constellations of light and surface properties supply an almost unlimited amount of possibilities, when designing a space.

Glare

Glare is most often referred to as a negative lighting phenomenon. Liljefors defines it as *"[...] all situations where the brightness contrast in any part of the visual field is too big to be comfortably perceived within the prevailing adaptation level."* (Liljefors 1999, 14). If one experiences an undesirable big difference in brightness, one experiences glare. It can be caused by both daylight and electrical light, if it is not carefully considered. Glare can be both calculated, measured and observed. This can be done through luminance distribution measurements [cd/m^2] or false colour imaging. Glare is mostly experienced and explained in already existing situations. But it can also be quantified by a calculation referred to as unified glare rating [UGR], which by a scale predicts the level of comfort in a given situation.

"Glare is to light as noise is to sound. Just as noise is unwanted acoustic energy, glare is unwanted luminous energy." (Veitch and Newsham 1996, 15). It can vary from the just perceptible to the unbearable, and it can be caused by almost anything that reflects or emits brightness.

Glare can be divided into two segments: disability glare and discomfort glare. Disability glare is characterised by the vision adapting to a brightness that is bigger than the one of the visual object. This makes the visual object disappear into the background of brightness caused by glare from other objects. Discomfort glare is characterised by the light in the visible field starting to feel uncomfortable, almost hurting. Disability glare is not necessarily perceived as discomfort glare. However, this does not mean that disability glare does not cause irritation as it interferes with what one wants to see (Liljefors 1999).

Glare is a clear indicator that light is present in a given space. It can, in the right context, be a contributor of atmosphere and experience. Glare can be so intense it hurts, but for a moment it still creates a feeling of warmth or joy. An example could be the glimpsing effect of sunbeams being reflected in water, acting like *"play of brilliant"* (Kelly 2006). Another type of perceptible glare, is a mirror ball reflecting an intense light beam into moving small dots of playful light, turning even an uninteresting room into a magnificent place of lighting patterns and spectral colours.

Disturbing glare will commonly appear through daylight openings and electrical lighting. But it can also appear when there is too big of a contrast between surfaces, or through reflections. There are different ways to reduce glare. Liljefors describes three different parameters (Liljefors 1999):

1) Screening: screening of or reflecting the glary source is one practical way of reducing glare. Often this is done by blinds, louvres, curtains etc. But this might influence other important light aspects like the level of light, the spatial distribution of light etc. Thus, this has to be designed and selected with care.

2) Contrast reduction: by reducing contrast between the bright source and its immediate surrounding/background, the experience of glare can be reduced. The contrast is reduced by reducing the difference in luminance levels between the bright source and its surroundings.

3) Transition: the transition between the difference in brightness is the last parameter in reducing glare. If the transition is sharp, the differences in brightness will likely be perceived as more glary, than if the transition is more gradient.

How glare is perceived, again all depends on the purpose of given the space. For example, when approaching spaces where working efficiency is in focus, glare in any form will be distracting and reduce productivity.

Colour of light

The colour of light is defined as *"The tint which can be experienced by the light in a space. Thereby, it is not the question of the colour of the light source itself, which more or less can differ from the colours of light in the space. Neither can this entity be directly derived from the colours seen on surfaces and objects."* (Liljefors 1999, 15). When one tries to describe a space's colour tone it is often in relation to the perception of temperature conditions like warm, neutral or cold. Warm often relates to something *"feeling warm"*, embracing and welcoming, and cold often relates to something *"feeling cold"*, repulsive and abhorrent. Of course, tints of colours can also be explained by regular colour terms, if they appear more obvious. The colour of the light is, besides the spatial distribution of light and the level of light, very important in creating an atmosphere or setting a mood in a space.

The colour of the light can be measured by its spectral power distribution (SPD) [nm] and by its correlated colour temperature (CCT) in kelvin [K]. Both are physical measurements, but they still indicate or support the experienced colour tints in a space.

The experience of *"white"* is difficult to strictly define or set standard rules for in

spaces. This is due to the eye constantly adapting to its surroundings, not only as described in the previous sections regarding the level of light and glare, but also to the colour of light. For instance, when moving between rooms, differences in colour of light are enforced, in the same way as the differences between the levels of light (Liljefors 1999).

Since surfaces often have a colour, it may sound strange that spaces and its objects can have different general tints of colours, which are not directly related to their actual colour. To see these tints, a space or an object has to be in relation or in contrast to something tinted different. Often the spaces we are in are perceived as neutral and when looking out a window, everything appears cold or bluish. Contrary if you look through the window from the outside, suddenly what appeared neutral, may then appear warm.

Many light sources often look uncoloured or *"white"*, but this *"white"* refers to a broad range of tinted white, which is described by the CCT. It ranges between cold white, like general daylight, to warm white, like a candle or an incandescent light bulb. It is normally not something one see, but more something that one feel or experience. It is often referred to as cool and warm tinting, and it is strongly related to sources of natural light, like daylight and fire, which have imprinted the physiologic evolution of vision. This can best be exemplified through the appearance of daylight over time. During midday and sunrise/sunset, when the level of daylight is on its highest and lowest respectively, the colour of light appears *"white"* despite the fact that the change in colour temperature is vast, midday being cold and sunrise/sunset being warm.

Today's technology offers a great variation in colours of light. By using LED's, colour filters or coloured reflectors, every given colour in the visible spectrum can be replicated, which enhances the possibilities in creating atmospheres or triggering our senses. Coloured light is very much used in theatre lighting to enhance everything from the general characteristics of a space and its atmosphere, to moods, emotions and mimics. Theatre lighting or stage lighting is very different from architectural lighting, but the references can still be drawn between them, since especially the theatre is very good in producing atmospheres. The colour of light can be a great tool in creating different experiences of perceived atmosphere. As humans, we are very sensitive to colours and the feelings they awake, therefore colour has to be handled with care, as it can easily influence other lighting characteristics and the overall lighting experience.

Many of the parameters described in the previous sections influence the characteristics of perceived colour of light. The level of light, for instance, has an influence on the perceived colour. A high CCT will be perceived as being white

under high illuminances but starts to become blueish when lowering the illuminance. A low CCT, on the other hand, will be perceived as being yellow/redish under high illuminances, but starts to become white when lowering the illuminance. This is illustrated by the Kruithof curve. However, the colour of light, will still create a perception of either warm, neutral or cold, even though it might seem *"white"*. Only when changing the illuminance, the tinting will start to reveal itself towards more blue-ish and red-ish colour of light. But as Liljefors stresses *"[...], only addressing the colour temperature of the light source does not guarantee a certain atmosphere"* (Liljefors 1999, 32). A warm incandescent light bulb hanging in the centre of a room, does not necessarily create the feeling of a warm atmosphere, which leads to other influencing characteristics of the lighting. The spatial distribution of light may also influence the perceived colour of light, but in a slightly different way. The more uniform a space is illuminated, the more the colour of the light tends to appear greyish, which might create a flat or gloomy atmosphere (Liljefors 1999).

Also, surfaces painted in cold colours like green and blue do not ensure a cold feeling and atmosphere, just as colours like red and yellow do not ensure a warm feeling and atmosphere. Of course, the surface colours have a great impact on the general impression of a space. However, factors of lighting like the ones described above, have great importance in creating the resulting atmosphere. Furthermore, there are also cultural differences, which influence the experience of the perceived colour of light. *"Among lighting practitioners, beliefs such as "use cool colour temperatures in warm climates, and warmer ones in cooler climates" are long-standing."* (Veitch and Newsham 1996, 17). This is strongly confirmed by the lighting traditions in the northern European countries compared to the lighting traditions in the southern European countries.

Colour of surfaces

Perceiving colours is as natural as seeing. Liljefors defines colours as *"The appearance of coloured objects and surfaces"* (Liljefors 1999, 15). Light and colour are two inseparable phenomena in the way that they do not exist without both being present. The perceived colour of a surface is the total outcome of the spectral combination of wavelengths reaching a surface and how the surface reflects the light. Of course, a material's physical composition, results in a surface reflectance and thereby colour, but to humans, this is only presented through visible light. Colour is biologically and physically the result of the brain's interpretation of different wavelengths of light.

The colour appearance is influenced by the colour rendering index (CRI). The CRI is a characteristic of the light source and given as a value between zero and 100. If the CRI is 100, then the light source provides perfect colour rendering. This value is also known as Ra-value.

How colours appear in a space, is primarily depending on the surface characteristics and on the spectral composition and intensity of the light source, that light up the coloured surfaces. If the colour rendering properties of the light source and/or if the surface properties are changed, then the appearance of colours in a given space or on an object, also changes. Good quality of light has a high rendering of colour, which means that almost all colours are being rendered perfectly. Daylight can be considered the best quality lighting as it represents all colours in the visible spectrum and renders colours almost perfectly. A high colour rendering quality is achieved with Ra ≥ 90, whereas a good colour rendering quality is achieved with Ra ≥ 80. Ra lower than 80 results in poor colour rendering quality. It is the spectral distribution of the light source that affects the colour appearance of the light and how well it is rendering surface colours (Tregenza and Loe 2014).

Furthermore, the appearance of colour is also depending on the level of light in a space. As brightness decreases colours slowly starts to disappear. This happens as our vision passes from photopic vision to scotopic vision. The result of the level of light being very low is that everything we see, becomes colourless, and the colour-scale turns into a grayscale. Contrary to this, a high level of light is good in revealing colours, but at some point, the level of light becomes too high causing glare. Furthermore, material properties in the surface, like texture, reflections etc. can also impact the colour outcome, depending on how the surface is looked at in terms of direction.

Colours helps us determine what we actually see, and it is a very important part of understanding the visible world. For example a tomato and a plum can be difficult to differentiate if they are both presented as two white objects. A reason for this is that we as humans have a remarkable memory in colour and that we through our contextual experiences through life, gain knowledge of how objects and spaces generally appear. *"Our natural reference to the world of colour is what we see in the daylight."* (Liljefors 1999, 15). This is a really important clue when trying to replicate good coloured objects through electrical lighting.

Light can distort an environment, which can happen both in terms of a coloured lightings contextual adaptation in a space, but also in terms of colour rendering (CRI). If the characteristics of electrical lighting deviates from daylight, the colours in spaces and on objects will appear different and sometimes distorted. This often happens through low quality lighting. If a distortion is detected, it often leads to experiencing the space as cold, boring, dreary, ugly etc. (Liljefors 1999). Even windows with tinted glass or filters, often green or blue, can decrease the high rendering quality of daylight in a space, and make a space appear distorted.

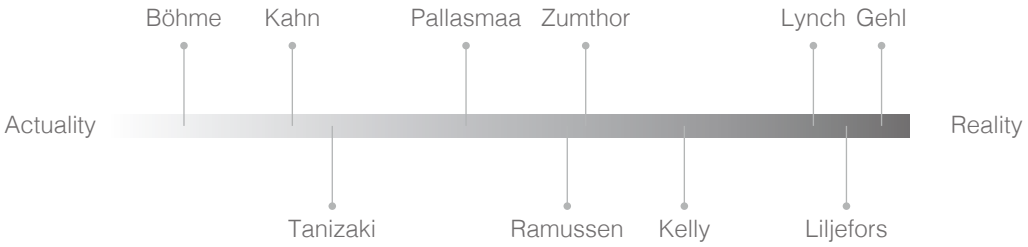
To achieve the most natural colour appearance and experience, a space must have as little colour distortion as possible. Therefore, light sources like pure daylight or electrical lighting with a high rendering index is preferred. A desired colour impression and experience can be reached both through modern LED technology, but also through coloured filters, reflectors etc. A distortion of the coloured environment in general, is often mentioned as a negative effect. This might be due to the expectations of colour constructed through our experiences. For example, a room with a distorted yellow tint might appear dirty, whereas if the light appears clear and shows the colours, we expect it to show, the space appears clean and healthy.

The study of reality has provided an understanding of practical elements of lighting, which influence the spatial experience. Although one cannot define a *"correct"* light setting to produce an atmosphere, an overview of the contributors and their influence is gained.

The Light Experience Model

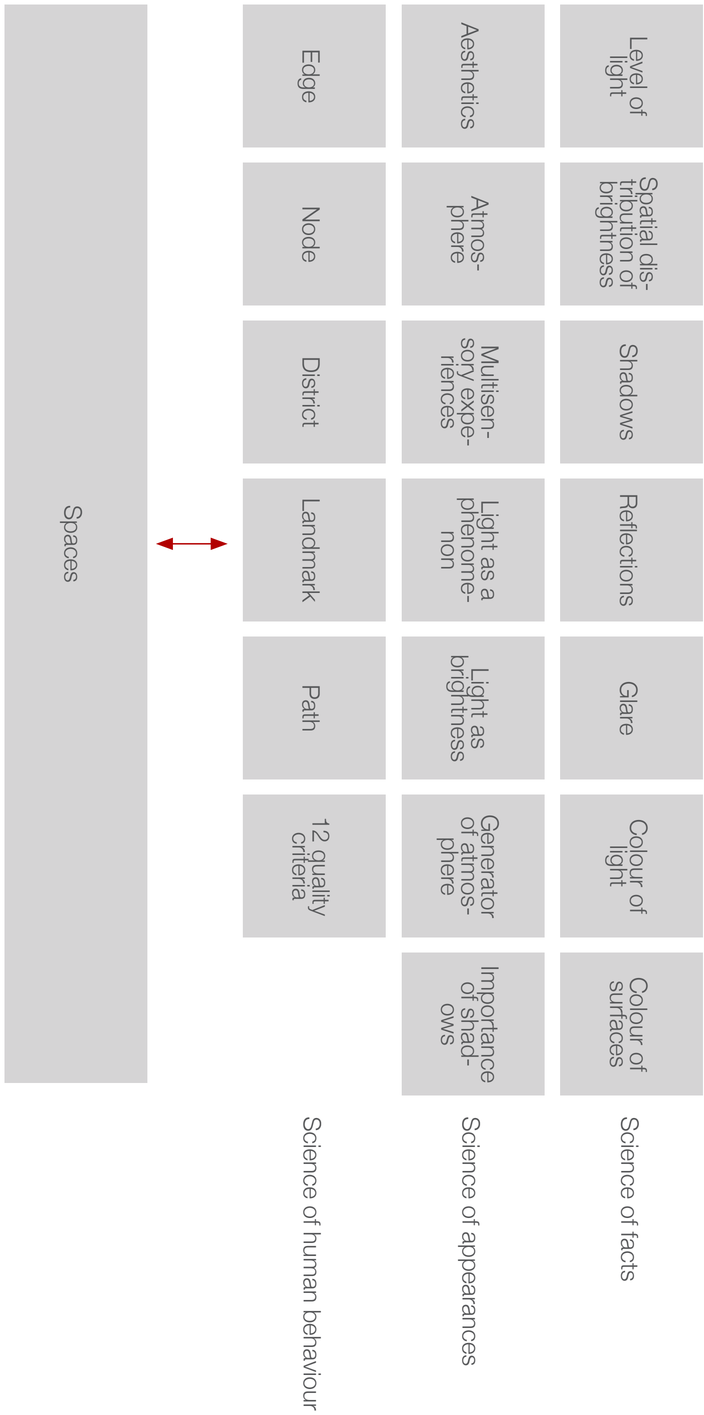
"Light and shadow describes the space while the space describes the light." (Liljefors 1999, 12). It is evident from the literature study, that the light reacts to the space and the space reacts to the light. It is also evident, that light holds a great opportunity to influence the atmosphere and sensorial experience of the space.

Based on the conducted literature study, the two aspects, science of appearance and science of facts, has been revised. The literature study has touched upon a broad spectrum of concepts and themes, to ensure a thorough understanding and investigation of the influence of light on our spatial experience. Amongst the themes are the concept of aesthetics and atmosphere, as well as the elements of a luminous environment. As mentioned, the literature study covers a wide range of literature, spanning from abstract essays to very specific and concrete measures. The span is illustrated in figure 2.6. The figure illustrates that the literature describing aesthetics, atmosphere and luminous qualities, is both very abstract and intangible, and concrete and specific. Science of human behaviour is briefly touched upon. Therefore, the figure also include Jan Gehl and Kevin Lynch, who work within the context of urban planning. The different parameters all contribute to spatial quality, which proves to show, that *"One cannot measure quality in the same sense as one measures length, mass, or lumen output."* (Veitch and Newsham 1998, 97).



Actuality/reality literature scale
Fig. 2.6 Summary of literature

The gained knowledge is summed up in a Light Experience Model. This model can then be applied in later investigations of spatial compositions, to uncover the influence of light on our spatial experience, and thereby, on the experienced atmosphere. The Light Experience Model is also utilised in the design phase as a mean to help generate a desired atmosphere. This will be demonstrated in chapter 2 and 3. Figure 2.7 illustrates the terms found through the literature study. These terms all contribute to the production of atmosphere and high spatial quality.



Mapping of terms that influence the spatial experience
Fig. 2.7 Mapping of terms

The Light Experience Model approaches the two aspects of the literature study differently. The model approaches science of appearance, as a table illustrating and summing up the different philosophers and architects, their focus area and their parameters or means to generate an atmosphere. This is illustrated in figure 2.8.

The Light Experience Model approaches science of facts from another angle. This focuses on illustrating the parameters of the luminous environment, as described by Liljefors. These parameters are demonstrated in figure 2.9. Not necessarily all parameters are equally important for a design proposal. Although the parameters are connected to one another, the emphasis and importance can be on some of the parameters rather than on all. They are illustrated as scales within which, the parameters are defined and can be experienced. This way of illustrating the scale of the parameters resembles the PERCIFAL tool, also developed upon Liljefors compendium regarding lighting visually and physically (SYN-TES 2011). The questions listed in the PERCIFAL tool can be applied to help observe and elaborate the lighting, when one wants to analyse a space, based on the Light Experience Model in figure 2.9. In analysing the lighting using the Light Experience Model, one indicates where on the scales the lighting situation is experienced to be. By indicating this, an overview of the different parameters and their contribution to the space is gained.

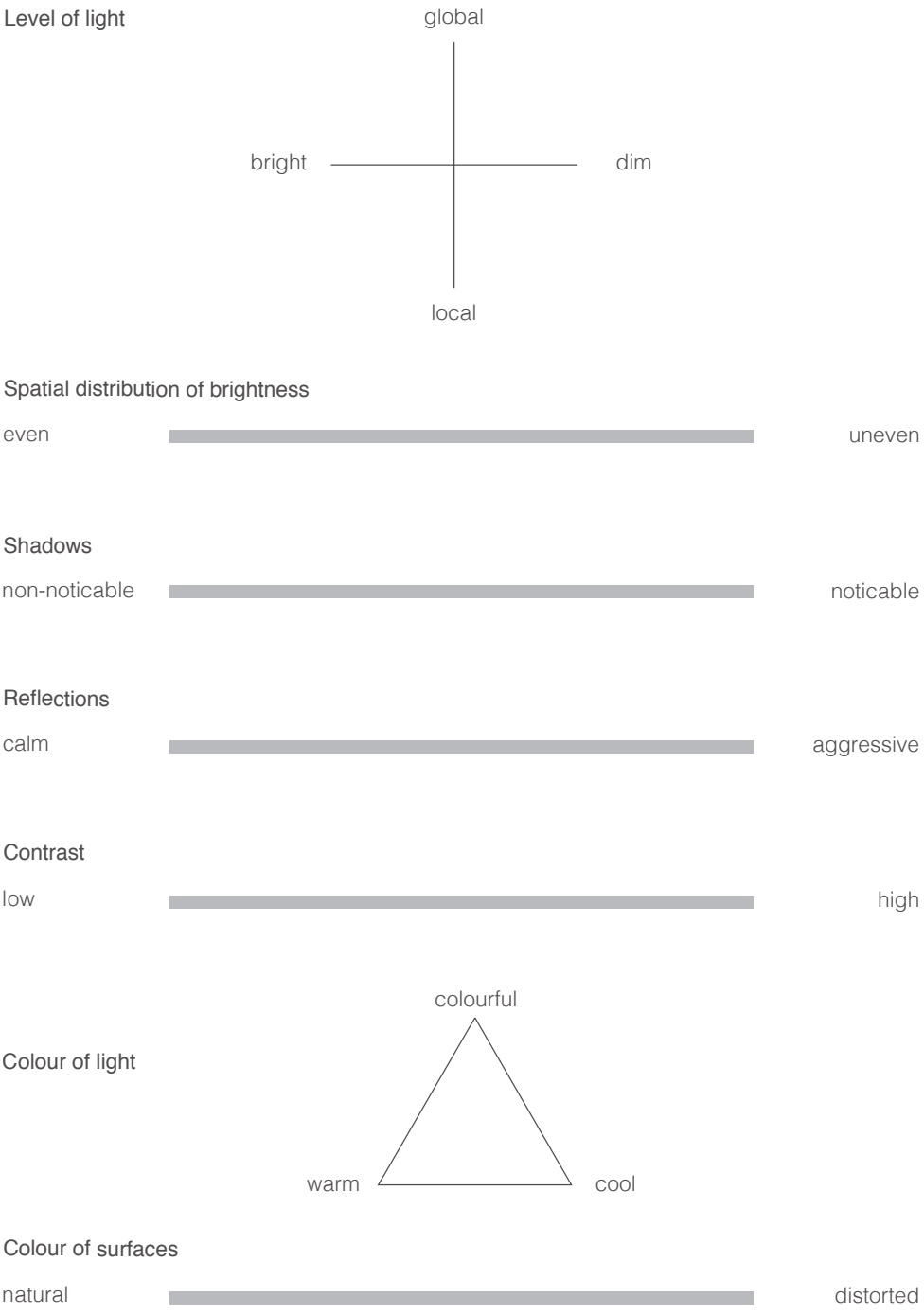
The Light Experience Model of actuality

	Focus	Parameters/means	Quotes
Böhme	Philosophy and phenomenology	— Reception aesthetics and production aesthetics — Atmospheres as spaces of mindful physical presence — Generators of atmosphere — Light as brightness: the eye's spatial movement	*"Atmospheres [...] arise between people and things; they are neither objective nor subjective but 'the shared reality of the perceiver and the perceived' [...]. How this reality is conceived will impact on perception and spatial practices, in turn."* (Böhme 2017, 3)
Pallasmaa	Architecture and phenomenology	— Atmosphere: an overall emotional impression — Multisensory experiences — Importance of tactility: not as physical sense of feeling — Tactile experiences: involving the senses and the body	*"[...] I had become increasingly concerned with the bias towards vision [...]."* (Pallasmaa 2007, 10) *"[...] tactility in an existential sense, as an experience of one's being and sense of self."* (Böhme 2013b, 99)
Zumthor	Architecture	— Multisensory experiences: engage the senses — Corporeality — Tactile qualities: the seriousness of materials	*"Quality in architecture is for me when a building manages to move me."* (Böhme 2013b, 99)
Kahn	Architecture and philosophy	— Prioritise intuition — Honouring materials — Treasury of the Shadow: bring something from potentiel (Silence) into manifestation (Light)	*"Silence, the unmeasurable, [...], meets Light, the measurable, [...], at a threshold which is inspiration, the sanctuary of art, the Treasury of Shadow."* (Lobell 2018, 20)
Rasmussen	Architecture	— Quality rather than quantity of light — Concentrated light (falling in same direction): best to see form and texture — Concentrated light: emphasise enclosed spaces	*"The lighting of the modern stage proves conclusively that it is not the amount of light which matters. The important thing is the way the light falls."* (Rasmussen 1964, 192)

Summary of science of appearance

Fig. 2.8 Light Experience Model of actuality

The Light Experience Model of reality



Lighting parameters related to science of facts
Fig. 2.9 Light Experience Model of reality

Much literature is regarding lighting quality. The definition of this is broad and changes, dependent on the literature. Lighting quality is a fluctuating concept because, like the concept of atmosphere, it is highly dependent on the purpose of a space and the individuals exposed to it. Lighting quality is said to be *"[…] a state created by the interplay of the lighted environment and the person in that environment."* (Veitch and Newsham 1998, 97). It cannot be defined as or limited to specific photometrical values.

> *"[…] we propose that lighting quality be defined as the degree to which the luminous environment supports the following requirements of the people who will use the space:*
> *• visual performance;*
> *• post-visual performance (task performance and behavioral effects other than vision);*
> *• social interaction and communication;*
> *• mood state (happiness, alertness, satisfaction, preference);*
> *• health and safety;*
> *• aesthetic judgments (assessments of the appearance of the space or the lighting).*
> *This definition focuses on the relationships between the luminous environment, the uses to which the space will be put (tasks), and the people who will use the space." (Veitch and Newsham 1998, 97)*

This definition of lighting quality can be correlated to the description of an atmosphere as an intermedia phenomenon between subject and the object. Lighting quality is by this definition given as a degree, to which, the luminous environment fulfils the purpose of a spatial constellation.

The Light Experience Model seeks to demonstrate the knowledge gained, and to illustrate the many parameters influencing our spatial experience. The correlation between the photometric measurements of lighting and subjective responses, is a very interesting, yet difficult, field to investigate. The Light Experience Model does not claim to have uncovered or investigated this, but it attempts to illuminate the basic factors involved.

Chapter 2

Presentation of a space

During the previous chapter the Light Experience Model, both regarding atmosphere, spatial experience and luminous environment, was developed. The purpose of the model is to assist the design process in ensuring conditions are created for an atmosphere to arise.

To make use of the Light Experience Model, a space needing a redesign of the lighting, was found. Firstly, it was important to examine and determine the use and the purpose of the given space. Based on this, criteria for the design proposal were created, to ensure the lighting design supports the purpose of the space. By understanding the purpose of the space, an analysis of the space is carried out to locate and analyse potential problems and challenges in the space. Based on this, a well-informed design process can begin. The design process is described in chapter 3.

The choice of space

As mentioned, a specific space had to be found. To choose the space we wanted to study and propose a design for, we narrowed the search down to hospital settings. The reason for the choice of the hospital setting was manifold. Firstly, the hospital can be experienced as a time capsule where many emotions are at the extremes. The state of emotions can be vast, and span from anxiety to happiness. Being in the hospital often requires patience and involves waiting time, both for patients and relatives. This time spent in a waiting position can be described as *"[…] a paradoxical human experience of turbulence/stillness all at once."* (Bournes and Mitchell 2002, 66). This turbulence can both be experienced when being diagnosed and when diagnosed. The hospital as an institution is also paradoxical. It is both a public space and a very private space, where the users are dealing with difficult state of minds. This cross field between public and private, and turbulence and stillness makes the medical context interesting as a space for redesign.

Fieldwork

Six different spaces were approached in different hospitals. These were five waiting rooms and a respite space (in Danish named *"hvilerum"*). All spaces lacked empathy for their patients and could all be subject to a redesign. In the respite space, an effort had been made to lift the quality of the space. However, the design did not seem to follow through and create the desired atmosphere. The different spaces were measured in terms of dimensions, illuminance levels, luminance levels, spectral power distribution etc. Three of the spaces were quickly discarded, due to them being either too small or having a too big daylight intake, which of course is a positive aspect. These spaces were not suited for our task of investigating lights influence on our spatial experience through the creation of atmosphere. Thus, three space with no or little daylight intake were considered appropriate spaces to examine our Light Experience Model

through. The three space can be seen in figure 3.1.

The respite space

Three potential spaces, two waiting rooms and the respite space, were investigated in terms of atmosphere and luminous environment. The chosen space for creating an atmospheric lighting design was the respite space located at Rigshospitalet in Copenhagen. The choice of this space was due to practical reasons, such as the size of the spaces. The two waiting rooms were very small, which limits the ability of working with layers or zones in the design proposal. The respite space on the other hand had a bigger area. The functions and use in the two waiting rooms were also multiple. One was a waiting area and treatment area during the day, and during the night it was a living room for the hospitalised patients. The other was a waiting area as well as a heavily trafficked hallway, with patients being pushed around in hospital beds. Because of these reasons the respite space was chosen to be the space to create a lighting design for, based on the developed Light Experience Model.

Waiting room at Sjællands Universitetshospital, Roskilde

Waiting room at Sjællands Universitetshospital, Roskilde

Respite space at Rigshospitalet

Waiting rooms and respite room investigated
Fig. 3.1 Potential spaces

The space and its purpose

The respite space is located at Rigshospitalet, near the foyer and main entrance. This area has undertaken a major redesign in terms of the interior design, meaning the furniture and lighting. The redesign, that has taken place in the foyer, the waiting area near the reception, the cafe and the canteen, was conducted by Spacelab Arkitekter in 2013. The new design has created a welcoming first impression of the foyer area and lifted the quality of the space. The interior design has also been applied in the respite space. Here, it is not fully supporting the purpose and desired atmosphere of a space for calmness and resting. The design of the respite space can be seen in figure 3.2 and figure 3.3. The plan view illustrates the furnishing of the space and where the light fixtures are mounted. As it appears from the plan view there are two types of light fixtures in the space. These are linear fixtures between the ceiling lamellas and pendants over the tables. However, only the pendants were turned on during the time anyone used the space. Although the space has been cared for and been modernised, the design is not developed for this particular space. Rather the design has been developed for the busier and more frequently visited areas around the foyer and the cafe. The design has then been applied to the respite space, without any changes to it. This results in the respite space being experienced as a space one does not want to stay in or visit for a longer time period. Therefore, the design of the respite space, especially the lighting in the space, does not support the purpose of the space.

In creating a design proposal it is important firstly to determine what the purpose of the space is. The word respite creates associations to resting, stillness, and to pause and repose. These are states which are important for hospitalised people and their relatives, but can often be difficult to experience in a busy medical context.

When looking up respite is the dictionary, it is defined as:

“a pause or rest from something
difficult or unpleasant”
(Cambridge University n.d.b)

The respite space can be seen as a supplement to the hospital bed room or living room, where the users can seek peace and calmness. The purpose of the space is therefore defined as a space to gather one’s thoughts and to reflect upon a situation. The aim is that the users, whether patients or relatives and whether alone or together, will use the space as a breathing space in the hospital. The lighting design should support this purpose.

Plan view showing the existing furniture and the location of the light fixtures

Fig. 3.2 Plan view of the respite space

Fig. 3.3 Images from the respite space

Criteria for the lighting design

To ensure the lighting design supports the purpose of the space, criteria must be set up for the lighting. These are formulated based on the developed Light Experience Model. The criteria are formulated and defined so the conditions for an atmosphere to appear are present. The criteria are illustrated in figure 3.4. The green colour indicates where on the scale the lighting design should be located for it to support the purpose of the space. The placement of the green gradient will be motivated in the following.

The level of light

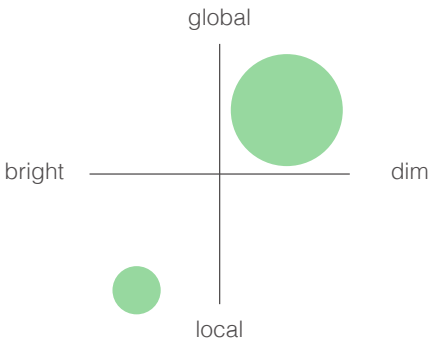
The level of light can be considered both as the level of light globally, meaning the overall experience, and the level of light locally, meaning in defined areas. The criteria indicate the level of light both overall and locally. The overall level of light should be dim. A low level of light is often associated with both calmness and passivity. This is described in the literature study, and so a dim light level supports the purpose of the space. Dim light and shadow also stimulate our imagination and ability to daydream, as described by Pallasmaa (Pallasmaa 2007). Another aspect of the dim light is that it tends to lead to lower conversations (Veitch and Newsham 1996), which invites people to reflect upon their situation with relatives, without disturbing others, as well as without being overheard. The level of light should not be too low however, since it might compromise the feeling of safety in the space, in terms of moving around and registering obstacles, as well as making the users feel more tired. Locally the level of light should be brighter than globally to accommodate conversations and so people sitting close can see each other. By locally having a brighter environment, little light realms are created in the dim luminous environment.

Spatial distribution of brightness

The spatial distribution of brightness is an important factor in generating an atmosphere. This is highly dependent on the shape and structural elements of the space. Louis Kahn described structure as the giver of light. Thus, the order of structure results in light, no light, light, no light and so on. This light structure is very much influenced by the space's shape and structural elements, such as the pillars located outside the windows of the respite space. Based on the criteria, the spatial distribution of brightness should be uneven. This will create visual stimulation and variation, which allows the eye to move in the depth of the space. The spatial movement of the eye results in one being mindful physically present, as described by Böhme (Böhme 2013a). As an atmosphere is given as a space of mindful physical presence, an uneven spatial distribution of brightness will contribute to the production of an atmosphere. Furthermore, homogeneous lighting is described as paralysing our imagination, thus nonuniformity is preferred. Besides creating visual variation, it can also create a hierarchy of a space, by highlighting important information or creating intimate spaces. Relaxation is also cued by nonuniformity, in particular nonuniform

The Light Experience Model of reality

Level of light



Spatial distribution of brightness

even — uneven

Shadows

non-noticable — noticable

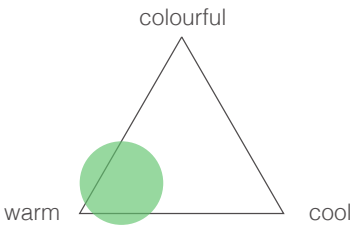
Reflections

calm — aggressive

Contrast

low — high

Colour of light



Colour of surfaces

natural — distorted

Criteria for the lighting design to support the purpose of the respite space
Fig. 3.4 Criteria for the lighting design

lighting of walls (Veitch and Newsham 1996). Hence, the spatial distribution of brightness should be uneven to support the purpose of the space.

Shadows

The theme of shadows is closely linked to the spatial distribution of brightness. Shadows are important in creating depth in a space, revealing the space and the spatial relationship between the objects. The criterion for the shadows is therefore, that they should be noticeable in the space. This supports the possibility of the eye's spatial movement due to the creation of depth, as described above and in the Light Experience Model. The shadows also contribute to highlight the tactile qualities of an object or a material, stimulating our senses and create a multisensory experience. The absent of light holds a great potential, as we find beauty in the pattern of light and dark.

Reflections

Reflections have a liveliness and make what we see come alive, in the sense that they are dynamic and interacting with the viewer (Liljefors 1999). Thus, reflections hold dynamic and active properties. Ideally the reflections in the space should be calm or not disturbing. Since reflections holds such dynamic properties and possibly can cause glare, their appearance should be limited to support the purpose of calmness. Reflections are difficult to control though, as they are the interplay between light and a surface in relation to the location of the eye.

Contrast

The contrast is in the Light Experience Model understood as the cause of glare, since glare is caused by too big contrasts of brightness in the visual field. The contrast level in the space should ideally be low, to avoid glare. Hence, the difference between brightness and darkness should be within an acceptable level, which the eye can adapt to.

Colour of light

The colour of light is defined as the experienced tint of a space. It can be experienced as warm, cold or colourful. The desired colour of light in the respite space is indicated as warm. A warm colour is often associated with words, such as welcoming and embracing, and is often used in the Nordic culture, as a mean to create a cosy ambiance. Also, as the level of light should be dim, a low CCT will appear white, whereas a higher CCT tends to appear bluish, which is not pleasent. This is described by the Kruithoff curve.

Colour of surfaces

The colour of surfaces is given on a scale between natural looking or distorted. Since the respite space is located in a hospital, the desired colour of surfaces

is as natural as possible. The users of the space should look natural under the light. The light should not make the skin look wrong and thereby make the user look ill. To ensure the surfaces look natural, a high CRI of the light is requested. This can also enhance the materiality of the surfaces, supporting the tactile qualities, and thereby a multisensory experience.

Based on the Light Experience Model and the motivation for the criteria, an analysis of the space and the existing lighting can be conducted. The analysis will review the atmosphere and the luminous environment of the respite space. Furthermore, the analysis investigates if the connections in the Light Experience Model are correct. Also, it points to which aspects contribute to an atmosphere of calmness, and which do not. Based on the analysis and the criteria, a vision for the respite space is formulated.

Analysis of the space

An analysis of the luminous environment and the atmosphere of the respite space was conducted on the 17th of April 2019, between 16.00 and 18.00. The point of departure for the analysis was the developed Light Experience Model. As mentioned, the respite space is located near the foyer in Rigshospitalet. The entrance to the space is situated in the main hallway, where there is much activity and a large flow people. This can be seen in appendix B, where a flow analysis of the space, based on Kevin Lynch, has been conducted. The flow analysis shows the main entrance and information counters as landmarks. This, of course, generates a big flow of people in the surrounding foyer area. The pace in respite space is therefore in contrast to the pace of the hallway. A smoking area is located right outside the respite space and a cafe area is located on the opposite side. This also functions as landmarks. The space has large daylight openings, oriented towards the NW and NE. They are facing the smoking area and a small entrance to the hallway. This is apparent from appendix B and C. The curtains in the space were drawn during the whole time, which may be a result of the quite busy smoking area just outside the windows. As already mentioned, the space has two different types of lighting fixtures, a pendant and a linear ceiling light, but only the pendant lighting was in use. The pendants cannot be controlled or dimmed, but the linear fixtures can be dimmed by a dimming button on the wall. It is suspected though, that the linear fixtures are only turned on during cleaning. Images illustrating the two lighting scenarios can be found in appendix D.1 and appendix D.2.

In understanding and analysing the atmosphere of the space, we firstly sat down for 20 minutes and experienced it. By doing so, we exposed ourselves to the space and engaged in it. During the 20 minutes notes were taken, regarding what was experienced. The notes can be found in appendix A, and an excerpt of the notes are summed up in figure 3.5. Amongst others were the notes, that the space felt monotonous and colourless. It was experienced as dull and grey. When sitting in the space, we did not feel relaxed or calm. On the contrary, a restlessness was experienced. The space felt like a waiting area, where one had to look at one's feet not to intrude on others in the space. The furniture was placed along the edges, making one face others in the space, and thereby enhancing the experience of intruding on others. The shadow play on the drawn curtains was however pleasing and calming to watch. There was no or very little talk in the space, and it did not feel appropriate to have a conversation in the space. Summing up the analysis of the atmosphere, the space did not succeed in creating a calm and pleasing atmosphere. Rather it felt like a quiet waiting area.

Based on the analysis of the atmosphere, the luminous environment was examined. The examination was based on the experience of the luminous environment using the Light Experience Model. The result can be seen in figure 3.6.

Fig. 3.5 Excerpt of the atmosphere analysis

The dark gradient on the figure indicates where on the scales, the luminous environment was experienced to be.

The level of light

The general light in the respite space consisted of daylight, coming through the curtains, and pendants hanging from the ceiling. Although the pendants created a focal glow locally, the level of light was experienced as dim, both locally and globally. When measuring the illuminance level in the space, at a height of 0,80 m., the illuminance was between 20 lx – 80 lx, which in itself is a dim light level but reasonable when considering the purpose of the space. When turning on the linear ceiling fixtures, the light level was between 150 lx – 400 lx, which is appropriate for other tasks such as cleaning. The illuminance distribution for both the pendant lighting and linear ceiling lighting can be found in appendix E.1 and E.2 respectively.

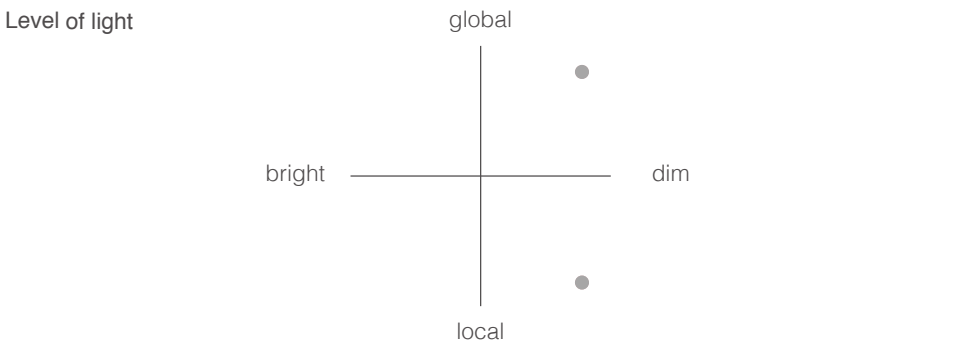
As stated in the literature study, reflectances are of great importance in regard to the level of light. It can easily make a well-lit space appear dark. The reflectances in the respite space can be found in appendix F. The reflectance of the floor and white walls is respectively 60 % and 95 %, which are high reflectances. These contribute to the level of light by reflecting a large amount of the light reaching the surface. The floor area is large and takes up a big part of the field of view. However, the white walls are limited to a small area, and the reflectance of the concrete wall with visible aggregate facing the windows, is approximately half of the white wall. The other materials in the space, such as the furniture, over which the pendants are placed, have reflectances lower than 30 %. Especially the couch and chairs have a low reflectance, which supports the experience of the furniture and the space around the furniture being dark. This contributes to the experience of a dim sitting area.

Furthermore, the light level is influenced by the CCT. With a low level of light, as in the respite space, the experience of the space appearing dull or dim is enhanced by the CCT being high. The CCT of the pendant lighting is above 3400 K and the CCT of the linear ceiling lighting is above 3200 K. This is evident in appendix G.1 and G.2. If the colour temperature was lower, then the space would be experienced as brighter.

Spatial distribution of brightness

The spatial distribution of brightness was experienced as even, meaning the brightness was distributed monotonously. A monotone brightness distribution with little variation, as experienced in the respite room, leads to a less relaxed ambience, as described by Veitch and Newsham. This supports the ambience experienced in the space as documented in figure 3.5. The uniformity of the lighting also results in the light being considered less bright, than an unevenly

The Light Experience Model of reality



The experience of the luminous environment of the respite space
Fig. 3.6 Analysis of the luminous environment

distributed lighting, supporting the experience of the space being dim. The uniformity was confirmed by luminance measurements of the respite space, which can be found in appendix H.1 and H.2.

With daylight penetrating through the windows and curtains, an ambient luminescence is provided to the space. Since the windows are facing the NW and NE, only little direct sunlight reaches the space during the year. At the summer solstice, when the sun is the highest on the sky and we experience the longest period of daylight, the sunlight does not reach the space before 16.00. At this time, it mainly reaches the area around the entrance and a little on the chairs close to the window. This can be seen in the daylight simulation in appendix I. This results in the luminous environment being dim and uniform, and without a dynamic character, such as direct sunlight.

Shadows

The shadows in the space were not noticeable. As the lighting in the space is mainly the diffuse daylight, penetrating through the curtains, it has no direction. That results in no clearly defined shadows, in terms of edges, colour or intensity. The pendants of course provide a directed light towards the floor creating a shadow, but the ambient daylight dissolves the shadow into a non-distinct shadow. The texture of the concrete aggregate wall, facing the windows, is quite interesting. However, it is not noticed in the sense that the light creates no shadow or depth to the wall, resulting in the detail shadow not existing. To enhance the texture a directed light from one side should be applied. The lack of shadow in the respite space, enhances the uniform distribution of brightness in the space.

Reflections

The reflections in the space are indicated as calm. This is due to the fact, that no noticeable reflections were detected in the space. The floor created a little reflection, as well as the world map on the wall. The interior windows, between two interior spaces, also created a little reflection, but only when the ceiling light was turned on. There was no play of brilliant in the space, and the space was experienced as less lively due to this.

Contrast

The contrast in the space was experienced as low, as indicated in figure 3.6. This is in line with the uniform distribution of brightness. No glare was experienced in the space, whether discomfort or disability glare. It is suspected tough, that if one was to use a computer or other kind of screen, near the windows, disability glare may be experienced. However, since this does not fall within the purpose of the space, it is not of big concern.

Colour of light

The colour of light in the respite space was experienced to be grey or blueish. It felt cold, especially when comparing to the hallway and foyer of Rigshospitalet, which was experienced as warm. This difference in colour of light, does not support the purpose of the respite space, which is to rest and find calmness. The CCT of the pendant lighting in the space was measured to approx. 3450 K, whereas the CCT of the ceiling lighting was measured to approx. 3200 K. This can be seen in appendix G.1 and G.2. A low illuminance level and a high colour temperature, as found in the space, leads to the lighting appearing blueish. This is described by the Kruithoff curve. This confirms the experience of the space being cold and achromatic. The uniform distribution of brightness also influences the experience of the light, as it tends to appear more greyish and creates a flat and gloomy experience of the space.

Colour of surfaces

The colour of the surfaces in the space is indicated as distorted. The reason for this indication is, that the space and the furniture was experienced to be dark and achromatic, although they actually were different shades of green, which was evident under the ceiling lighting. The CRI of the pendant and ceiling lighting is respectively 83 and 89, which should support a reasonable colour rendering in the space. However, the colours still looked dark. This could be due to the fact, that as brightness decreases our scotopic vision takes over from the photopic vision. The scotopic vision only uses the rods in our visual system and no cones, which are responsible for our colour vision.

The vision for the space

After having applied the context-independent Light Experience Model on a specific context-dependent space, many observations found in the literature study were confirmed. The validation of these findings was strengthened by the fact that, the actual appearance of the space in some cases differed from what was found through quantitative measurements, illustrating the discrepancy between what is measured and what is experienced.

Furthermore, the Light Experience Model, as a tool to conduct an analysis, showed its ability to generate a strong fundamental understanding of the specific space. This now functions as a platform to build upon, when approaching the initial design phase.

Based on the analysis and the criteria evolved through the Light Experience Model, a vision suiting the purpose of the respite space was formulated:

> *Imagine if, the respite space becomes an attractive part of Rigshospitalet for people who are in need of a breathing space, accommodating private conversations and private spheres, while supporting different types of calmness for the users.*

Ideally, the respite space offers the users a break from a difficult situation. It strives to offer a space for reflection, calmness and rest, which is described as the purpose of the space. By fulfilling the criteria for the lighting design, the vision is considered fulfilled as well.

With this vision in mind and the approach to the design defined through the criteria, the conceptual design phase could begin.

Chapter 3

Initiation of conceptual design phase

Based on the Light Experience Model and the space analysis, a conceptual design proposal for the respite space is developed. This proposal should fulfil the criteria stated, based on the purpose of the space. In doing so, the lighting design will fulfil the vision by introducing a calming atmosphere to the space. The conceptual design proposal functions as a specific and concrete manifestation of the knowledge gained from the Light Experience Model and the space analysis.

When approaching the design, it should be driven by the vision, and the outcome should reflect this. This process is described by Louis Kahn in:

> *"A great building, in my opinion, must begin with the unmeasurable, must go through measurable means when it is being designed, and in the end must be unmeasurable." (Lobell 2008, 48)*

The quote by Louis Kahn describes the process of designing a building. This is, nonetheless, also true for a lighting design. The design must take its starting point from the unmeasurable, the idea and the will to express. As the design evolves it must go through measurable means, such as specific luminaires, beam angles, directions etc. to end up as unmeasurable, evoking unmeasurable qualities and letting the spirit of its existence take over. This meeting between unmeasurable, which Kahn calls Silence, and measurable, which Kahn calls Light, happens where inspiration and art is free to flow, a space Kahn calls the Treasury of Shadow (Lobell 2008). Thus, inspiration serves as basis for the idea and vision meeting the specifications and detailing of the lighting design.

Investigation of lighting principles

The conceptual design proposal should fulfil the criteria, to ensure it supports the purpose of the space and fulfil the vision. Thus, it was firstly important to investigate some of the lighting principles, introduced in the Light Experience Model and based on which, the study of the respite space and the criteria for the space were built. The purpose of the investigation was to test and illustrate differences within the lighting principles. The investigation demonstrates how the expression and the experience of the lighting varies when doing small changes in the lighting. Besides this, the investigation serves as basis for the development of a conceptual lighting design, as it ensures well-informed choices, regarding the design, are made.

Through the investigation different principles and their correlation have been explored. Investigated is:

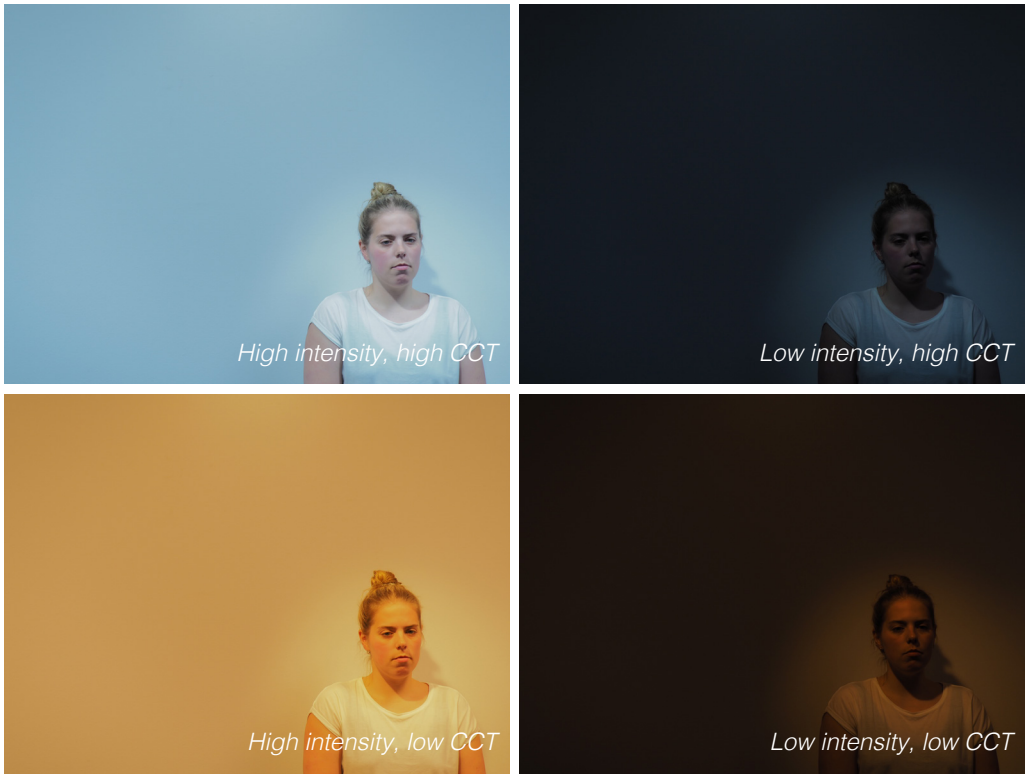
- The level of light in relation to the colour of light
- How the spatial distribution of brightness changes the experience of a space and its objects
- How the shadow of an object changes with different lights and different directions of the lights
- The visualisation of texture, through depth created by light and shadow

The following elaborates and describes the approach to the investigation, the equipment used, and the experience created by the investigation.

Investigation of the correlation between level of light and colour temperature

The investigation of the level of light in relation to the colour temperature was conducted in a completely darkened room. A spot light was mounted in the ceiling, which could be controlled both in terms of colour temperature and intensity. The colour temperature ranged from 2800 K to 7300 K, and the illuminance, as a result of the intensity, ranged from 20 lx to 720 lx.

The space was experienced as brighter under the high CCT, compared to the low CCT, when the intensity of the lighting was high. However, it should be noted that the illuminance decreased with approx. 150 lx when changing the CCT from 7300 K to 2800 K. At a low intensity, with the same illuminance level for the two CCTs, the space was experienced as brighter under the low CCT, than under the high CCT. This supports Liljefors when he states, that under a moderate flux, a room appears brighter with low CCT. Besides the space looking brighter under the low CCT and low intensity, the high CCT and low intensity also made the skin look weird and dank, and made the space appear clammy. The experience of this was not pleasant. Images summing up the investigation are shown in figure 4.1.



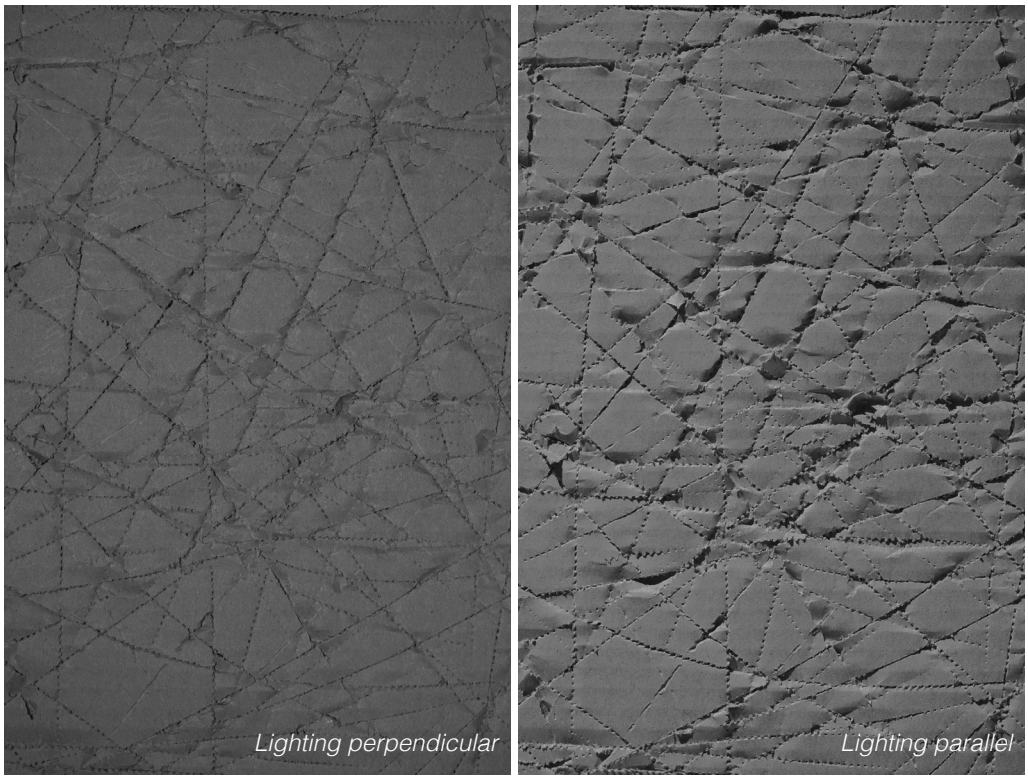
High and low CCT, and high and low level of light

Fig. 4.1 Investigation of correlation between CCT and light level

Investigation of the correlation between texture and direction of light

The tactile qualities of a space and honouring the materials are important aspects in creating an atmosphere. Thus, the correlation between texture and light was investigated. A flat piece of cardboard with many slits and cracks was used to examine the importance of the direction of the light in relation to enhancing the texture, and thereby the detail shadows of the material.

Again, the space was completely darkened, and a spot light with a beam angle of 24° was used to illuminate the cardboard. The intensity of the spot light did not change during the investigation. First, the spot light illuminated the cardboard perpendicularly. From this direction little texture was detected and the lines in the cardboard were less visible. This is evident in figure 4.2. By changing the angle of the light in relation to the cardboard, the texture became more visible. When the angle between the direction of the spot light and the cardboard was close to 0°, meaning the light was almost parallel to the cardboard, the texture was most dramatic. This is shown in figure 4.2. From this investigation, it can thus be derived, that to enhance a texture the light must be directed so it has a small angle in relation to the texture. The angle depends on how much or how little a texture should be enhanced.



Texture illuminated perpendicular or parallel

Fig. 4.2 Investigation of correlation between enhancing texture and direction of light

Investigation of the spatial distribution of brightness

As described in the literature study, the spatial distribution of brightness offers visual stimulation and variation in a space. The experience of the composition of bright and dark in a space, is linked to whether a space is experienced as pleasing or not. If there is no variation in the distribution of light in a space, the luminous environment is often considered gloomy or boring. The investigation of the spatial distribution of brightness was conducted in a space with no daylight. An object, in this case a plant, was used to setup and direct the lighting and as reference to evaluate the distribution upon.

Different scenarios of spatial distribution were examined. These can be seen in figure 4.3. Firstly, a diffuse distribution of brightness was investigated. This caused the space and the plant to look flat, without any noticeable shadows or depth. It did not stimulate any senses or the imagination. By dimming the diffuse light and adding two spot lights to the scenario, the spatial distribution resulted in a more interesting composition. The plant had more variation and became more interesting and colourful to look at. It also created shadows from the leaves on the floor, as well as the cone from the light being visible. Enhancing the light level near the plant and decreasing it in the surrounding space, created a more varied expression and a more interesting view. The uneven distribution still allowed the viewer to see the rest of the space, while emphasising the middle. By turning off the diffuse light and only using the spot lights, the space became more dramatic. This distribution of light and dark, resulted in the plant being emphasised and the rest of the space being neglected. Under this brightness distribution it was difficult to see the rest of the space. It resembled a scenography or a space to look at, rather than a space to be in. Lastly, leaving the diffuse light off, and illuminating the object perpendicularly with a spot light, resulted in the space being experienced as uniform. The plant appeared to be flat and unnatural, and the shadows seemed to be convergent with the plant itself. This distribution created no variation on the floor, and little on the wall, and did not result in an interesting and stimulating environment.

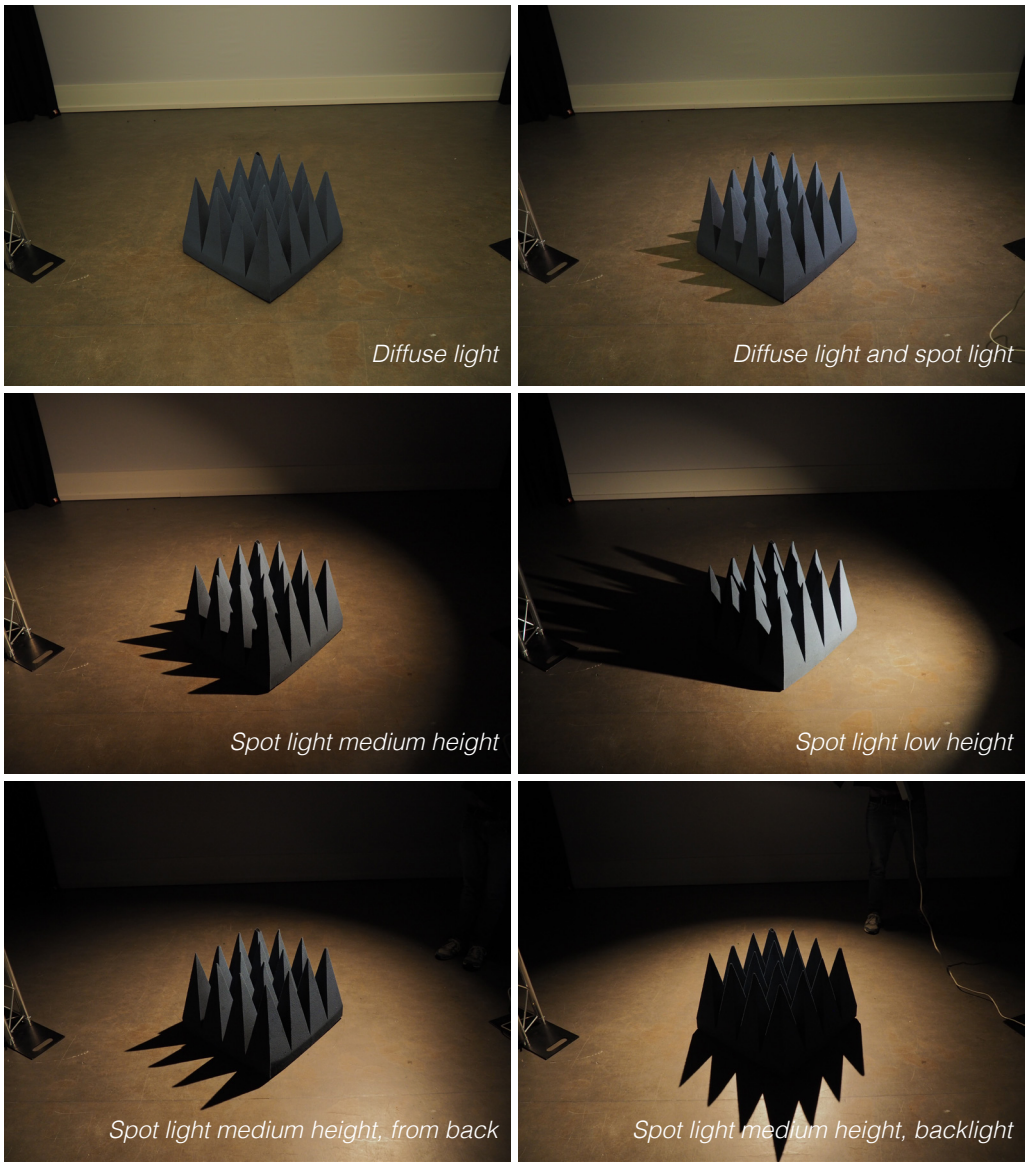
Variations in spatial distribution of brightness

Fig. 4.3 Investigation of the spatial distribution of brightness

Investigation of the correlation between shadow and direction of light

The last investigation was the correlation between a shadow and the direction of the light. Shadows reveal spatial relations and contribute to creating depth in a space, thereby creating an interesting space. The importance of the shadow has been underlined by many of the philosophers and architects referred to in the Light Experience Model. Investigating the shadow took place in the same completely darkened space, as used in the other investigations. An object was placed in the middle of the space and illuminated with different light fixtures and from different angles. This is apparent from figure 4.4.

It is obvious that a shadow changes depending on the direction of the light. By illuminating the object with only diffuse light, which has no specific direction, no shadows were seen from the object. This resulted in the object not being interesting and looking flat. When supplying the diffuse light with a spot light, which has a specific direction, dark shadows with sharp contours appeared. The spot light was placed high, which resulted in the shadow being short. The diffuse light softened the intensity of the shadow. More dramatic shadows were created by only using the spot light. During these variations, the importance of the light direction was underlined, as a fixture placed low, created very long shadows, that blended into the darkness in the space. The details on the side of the object, which was not illuminated, also became more difficult to distinguish, with a low placed fixture. Finally, a fixture placed behind the object, and thereby creating backlight, resulted in only the outline of the object being visible. The shadow cast by the object was very dark, which resulted in the object and shadow blending in together. The shadows created with just the one spot light, were all more dramatic, than the shadows created with interplay between the directed light, from the spot light, and the diffuse light. It was difficult to distinguish between shadow and object with only the spot light, and it created a rather big contrast between the bright and dark areas.

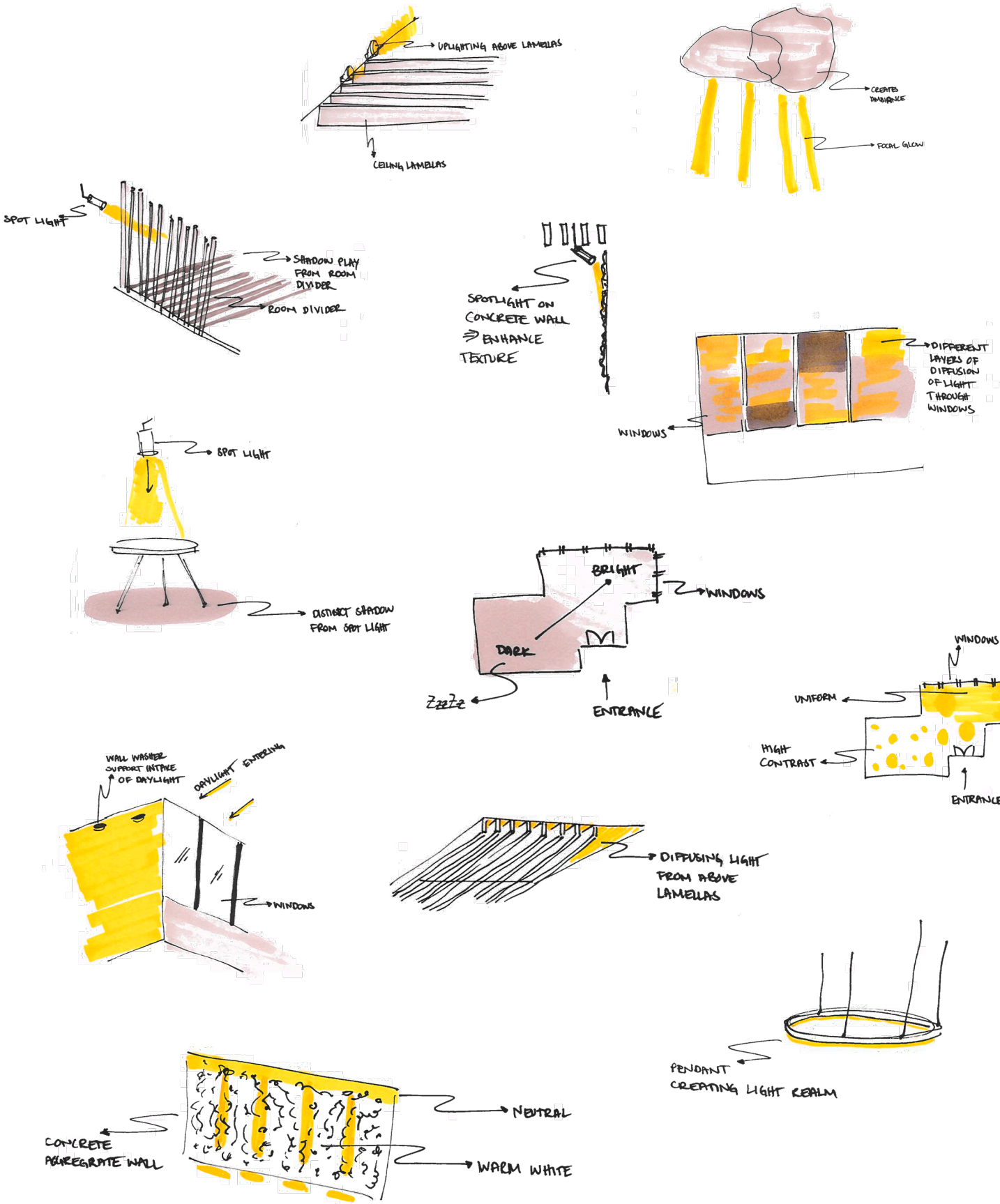


Different fixtures and different angles creates different shadows
Fig. 4.4 Investigation of correlation between shadow and light

Initial sketching of ideas

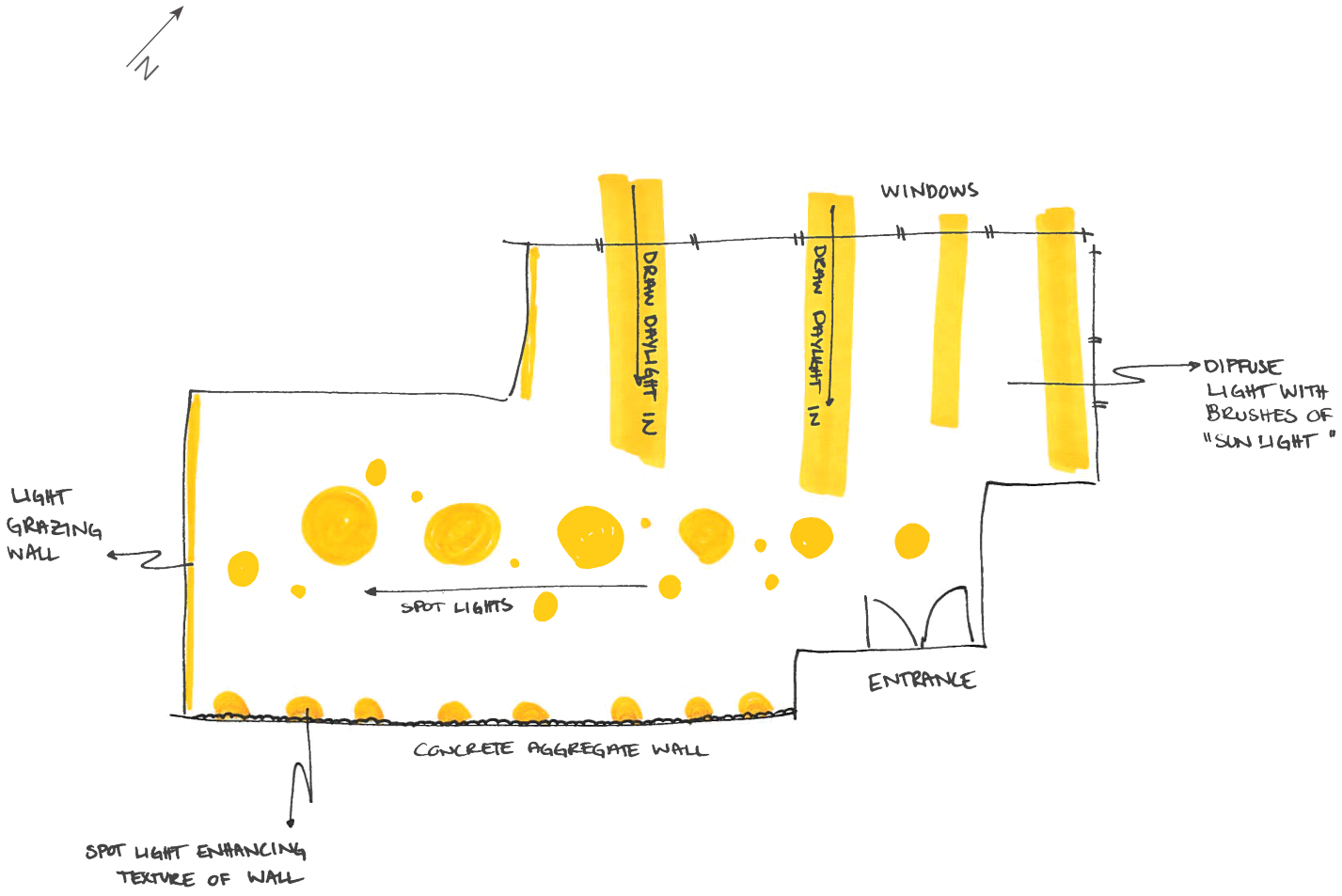
After having formulated a vision for the respite space and having conducted investigations of the different lighting principles, introduced through the Light Experience Model, initial sketching of ideas began. The ideas took their starting point from the criteria setup in the Light Experience Model and from the investigation of different lighting principles. The sketching concerned everything from overall conceptual ideas to very specific ideas. Some sketches were concerned with one specific lighting principle, while others reflected more. The process of sketching many different ideas, ensured a thorough investigation of possible solutions for the lighting design. Different sketches from the process can be seen in figure 4.5.

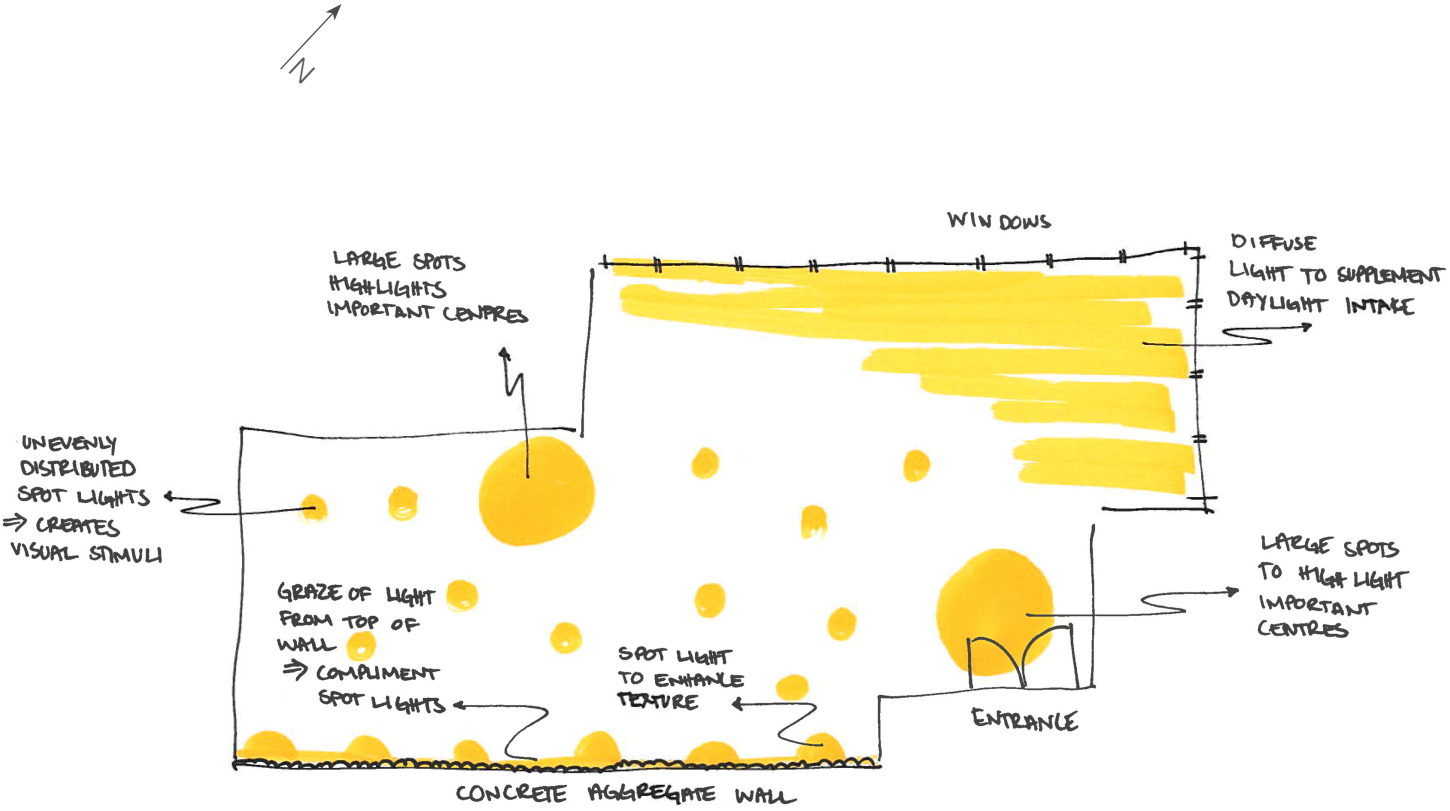
Based on different constellations of the many ideas, different overall concepts were discussed. During the discussion of ideas and concepts, the importance of the different criteria was also discussed, as not every criterion necessarily is equally important for the lighting design to contribute to the production of a calming and restful atmosphere. Initial concepts were also sketched, combining some of the initial ideas. These can be seen in figure 4.6. From the discussion and the development of the initial concepts, an essence of the lighting design was be elaborated. The design should utilise the intake of daylight from the windows to create a brighter zone. It should also enhance the texture of the concrete aggregate wall with spot lights, creating a more contrasted area in the far back of the room. Based on the discussions and the initial idea generation, an overall concept was developed.



Sketches from the initial idea generation

Fig. 4.5 Initial ideas


N
WINDOWS
DRAW DAYLIGHT IN
DRAW DAYLIGHT IN
DIFFUSE LIGHT WITH BRUSHES OF "SUN LIGHT"
LIGHT GRAZING WALL
SPOT LIGHTS
ENTRANCE
CONCRETE AGGREGATE WALL
SPOT LIGHT ENHANCING TEXTURE OF WALL



Initial concept suggestions based on ideas

Fig. 4.6 Concept suggestions

The overall concept

As a result of the investigation of the lighting principles and the initial sketching of ideas, an initial overall concept for the lighting has been developed. The development of the design has been completed simultaneously with the testing through renderings and simulations.

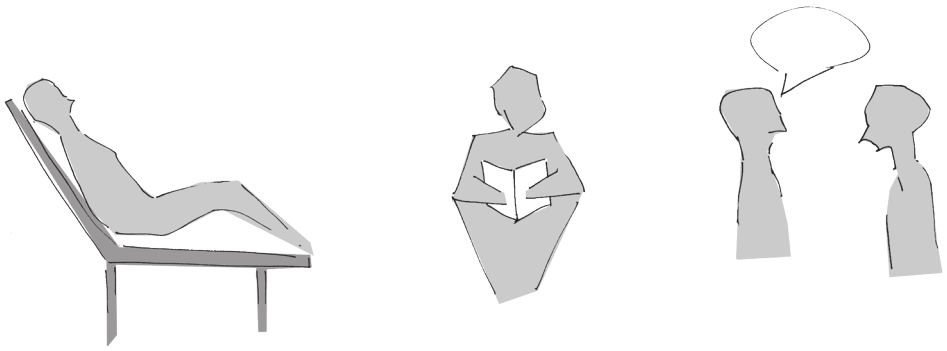
Firstly, it has been important to determine different zones in the space with different activity levels. The purpose of the space is to offer a space for rest and calmness. However, this can be provided in different manners and in different paces. The separation of the different levels of calmness will support use of the space and influence the design of the lighting.

In the respite space three different levels of calmness are identified. The levels, which are illustrated in figure 4.7, range from passive to subtle active.

1) The first level is the most passive state. At this level, the user uses the space to rest or to reflect in silence over a personal situation. The user appreciates the silent and calming surroundings and withdraws oneself from the otherwise busy hospital context.

2) The second level is a medio active state. At this level the user does not mind a little more activity. This active state fits both the active and passive zone, suiting a momentarily user need. Here the user can be reading, or maybe just taking in the view from the respite space to the outside. The user can be lost in one's own thoughts, drinking a coffee or just experience the subtle flow of life.

3) The third level is the most active of the three levels, although it's still calm. At this level two or more relatives might have a quiet, private conversation, reflecting upon their specific situation.

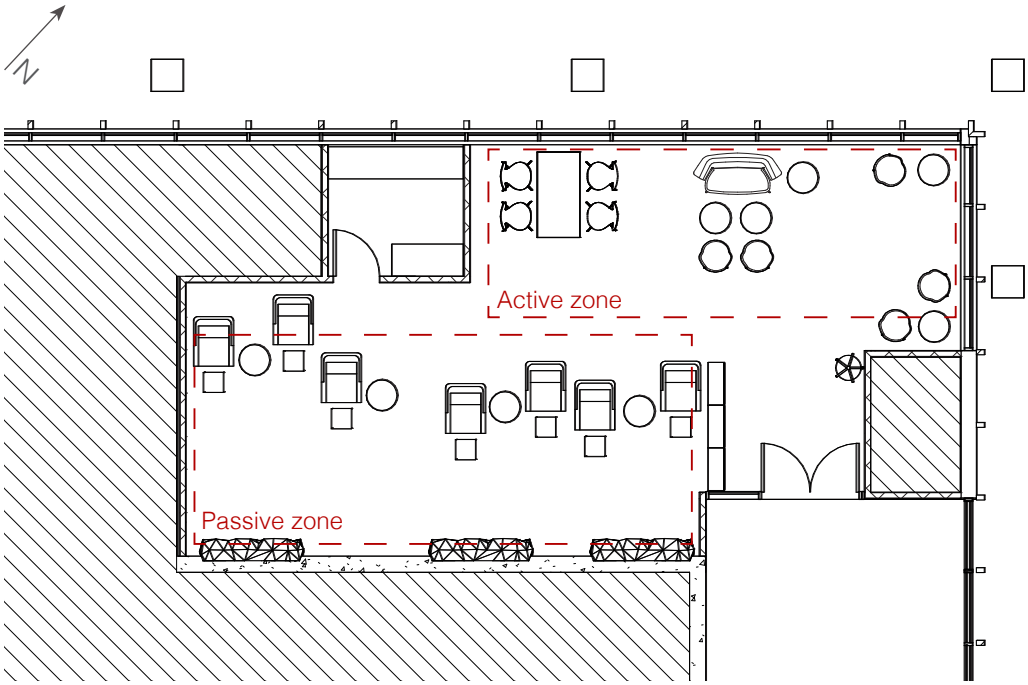


Resting/reflecting in silence *Reading* *Conversations with relatives*

Different levels of calmness ranging from passive to subtle active

Fig. 4.7 Levels of calmness

Based on the three levels of calmness the design of the interior of the space was approached. The existing placement of the furniture did not support the three levels of calmness, and as experienced during the investigation of the atmosphere, the space did not create a relaxed ambience, where we wanted to rest. It was also experienced that the placement and orientation of the furniture, resulted in the users facing one another. Thus, the feeling of having to look at one's feet arose. A new plan for the interior was therefore developed, which can be seen in figure 4.8 and in appendix J. The plan was developed based on the daylight intake and with Jan Gehl's 12 quality criteria in mind. The plan shows two zones of the space. These supports the different levels of calmness. The active zone is located near the windows, to utilise the intake of daylight in the design. Furthermore, the zone is in close proximity to other active areas in the hospital, such as the yard and smoking zone, the busy hallway and the café area. The furniture here are table and chairs, as well as a couch and low chairs. The passive zone is located near the concrete aggregate wall, where the intake of daylight is minimal, and the light level therefore is dim. The furniture here is rotating acoustic chairs and little side tables. The location of the active zone, shelters the passive zone from the busy areas.



The new plan and placement of furniture based upon the levels of calmness

Fig. 4.8 New plan for the respite space

Gehl's quality criteria were developed for designing the urban space. Thus, in applying the criteria in an interior space, some of the criteria are not relevant. The quality criteria are divided into three sections, which are prioritized. Firstly, and most important are the criteria for protection. With reference to these, the more open furniture, in the active zone, is placed near the edges to give the users a protection against feeling insecure. The acoustic chairs, in the passive zone, already have *"protection"* by being winged armchairs. Thus, they can be placed more freely in the space, creating a separation between the two zones. This contributes to breaking the scale of the space, meaning it appears smaller and more private. The next section of the quality criteria is comfort. These criteria are, amongst others, the opportunity sit, see, talk and listen. The opportunity to sit is an important criterion. This is supported by the design by having different zones for sitting and for resting. The different zones are supported by the view to respectively the outside and to the decorative concrete aggregate wall in the space. The views cooperate with the opportunity to see, as users in the active zone, has a view to the outdoor and the sky. The users in the passive zone has a view to the interesting concrete aggregate wall, which is supported by lighting. The opportunity to talk and listen is also supported by the design, by the furniture being placed so they provide *"talkscapes"*, where the users feel comfortable talking about private matters. The last section of Gehl's 12 quality criteria is delight. This very much contribute to the users experiencing the atmosphere in the space. The criteria are related to the scale of the space, to the opportunity to enjoy positive aspects of the climate, and to having positive sensory experiences in the space. As already mentioned, dividing the space into smaller zones, creates a smaller scale in the space, which fit the human scale. The placement of furniture at the windows provides the users with the opportunity to experience the daylight, to take in the view to the sky and the green area outside the windows. This contributes to the creation of a delightful space. These considerations are the basis for the new plan for the respite space.

The details of the concept

The lighting principles within the two zone of the respite space are introduced in the following. As the zones contains different degrees of calmness and thereby vary in their use, different lighting situations are developed suiting the *"micro"* purpose of each zone.

The seven criteria for the lighting design, set up through the Light Experience Model, should of course be fulfilled in the design. The criteria are represented through gradients, which illustrates the range within which, the design should be. This points to the fact, that the degree of fulfilling the individual principle may vary within the design, and still be acceptable. Thus, the criteria are not conclusive or unequivocal, but flexible within a certain range. This creates a space for differentiation within the lighting design for the two zones. It also underlines the fact, that an experience of a luminous environment is not unequivocal. It varies depending on the users. Thus, it is reasonable to have room to manoeuvre for the design.

As aforementioned, not all parameters are equally important. It is necessary to reflect upon the Light Experience Model, and consider which parameters of the model, are important for the specific design in the respite space. In order to create a calm and restful atmosphere, the important parameters are especially the spatial distribution of brightness and the level of light. This is due to the importance of creating spatial depth and stimulating the vision, to ensure the conditions for an atmosphere to appear are present. Especially within the spatial distribution of brightness, the principle lighting for the two zones differentiate. In the active zone, which has a large intake of daylight, the senses do not have to be stimulated to the same degree as in the passive zone. This is because the users in the active zone primarily are engaged in more active matters, where they might be occupied with other elements. Contrary, the users in the passive zone primarily are engaged in individual and silent matters, why the sensory experience is of greater influence on the users. Thus, the active zone has a more uniform distribution, compared to the passive zone. This, however, does not mean the spatial distribution in itself is uniform. It only underlines the room for manoeuvre within the design criteria.

The active zone

As mentioned, the active zone is placed near the daylight. This means that the zone, during the daytime, is brighter and enhances the colour rendering, due to the high CRI of daylight. The zone is characterised by a high CCT, also due to the daylight, which supports a more active use. The lighting principle for this zone, besides the daylight, consist of pendants and wall washers. Due to the diffuse daylight coming from the windows, the spatial distribution of brightness is not as uneven, as in the passive zone. The active zone is dynamic in the sense, that the daylight entering the zone, influence the experience over time. Thus, the experience of the zone varies during the day.

Primarily during the night time, the pendants hanging from the ceiling, functions as focal glows, highlighting smaller zones that enhances the feeling of privacy. This creates small realms for private conversations, where the users feel comfortable speaking to each other. This sensation is created by hanging pendants just above the tables, clearly mapping out these private spheres. The focal glows support the level of light being bright locally, and dimmer globally, as stated in the criteria. It also supports the spatial distribution of brightness being uneven. The height of the pendants ensures, that the pendants primarily light up the table. Light reflected from the tables softly illuminates the faces of the users and does not expose them. The soft, reflected light from the pendants, ensures the facial expression does not looking skewed. The intensity of the pendant lighting should be dim, not to create glare for the users, and the light should be a warm white colour, to create welcoming atmosphere, make the light look brighter and avoid the skin looking weird and dank, as described in the investigations of the lighting principles. A high colour rendering is also important, so ensure the skin of the users look natural.

Furthermore, a gentle wall wash on the two white walls neighbouring the windows, creates an ambient luminescence to support the composition of the pendants. The importance of supporting a directed light, is illustrated through the investigation of the spatial distribution of brightness. The wall wash will also soften the shadows created by the pendants, as described in the investigation of the shadows. They are not considered an additional task lighting, but they should support the use of the space by gently marking the border of the active zone, as well as supporting and extending the daylight from the windows. Enhancing the brightness of the active zone, and thereby enhancing the contrast between the active and passive zone, makes the passive zone appear dimmer. By doing this, the passive zone almost functions like a play of brilliant in contrast to the more ambient luminescence in the active zone.

The passive zone

The passive zone is located in the darker part of the respite space. This zone

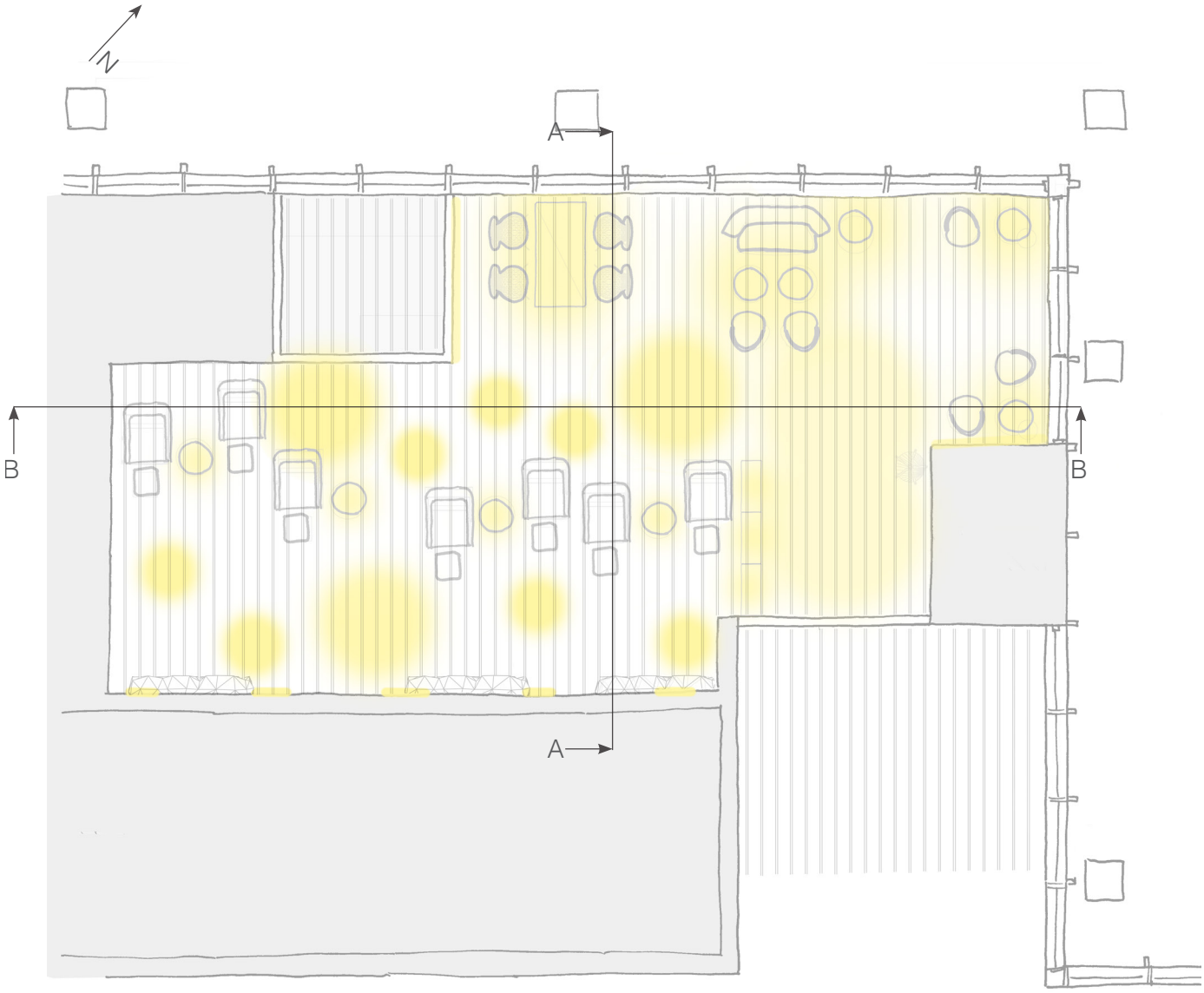
exploits the dim day and night time situation, as it under both circumstances is easier to control and form the luminous environment because of the darkness in this part of the respite space. The lighting should activate a sensorial experience by enhancing tactility, objects and lighting patterns across the zone, as described in the Light Experience Model. The lighting principle for this zone consist of pendants and different spot lights.

Firstly, the great and beautiful concrete wall with visible aggregate, which is a characteristic building material of Rigshospitalet, is highlighted through gentle brushes of light produced by narrow spot lights. In doing so the tactility and the depth of the wall is enhanced. The narrow spot lights are mounted between the lamellas in the recessed ceiling. The narrow spot lights are placed close to the wall, pointing towards the very bottom of the wall. In this way the tactility and material depth are strengthened through small shadows created by each stone, giving the material the tactility and texture it deserves. The placement and orientation of the narrow spot lights are determined based on the results from the texture enhancing investigation. The nonuniform illumination of the wall, also supports relaxation as described by Veitch and Newsham (Veitch and Newsham 1996).

Furthermore, lighting dots on the floor are created by narrow spot lights mounted in the recessed ceiling, oriented perpendicular to the floor. These create a soft edge between the passive and active zone, while ensuring an uneven spatial distribution of brightness. The light/dark composition, created by the spot lights, is not so dramatic that it potentially could be challenging in identifying objects, obstacles etc., as described in the investigation of the spatial distribution of brightness. The spot lights also create an interesting and unpredictable light pattern, stimulating the vision, and they shape the flow of the respite space. The light dots act like an indicator, making it clear when people move around in the area, as light glimpses will appear on the user's bodies moving through the light beams. The spot lights are placed so that they do not hit people sitting down in the passive zone. Furthermore, flood lights mark out nodes within the space, helping the users to orientate.

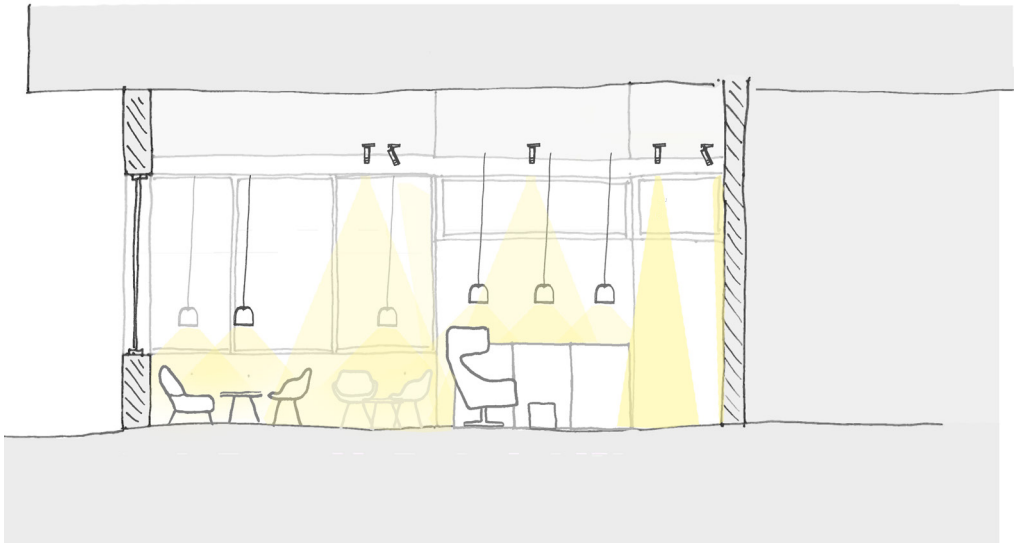
The pendants assist in guiding people where to sit and relax by highlighting these zones. Not to expose people's faces, the pendants are hung low, so the faces are kept in the dark. In this way the pendants create an enclosed space for people to relax or maybe close their eyes. This enclosure is strengthened by the rotational acoustic chairs, in which the users can orientate towards or away from each other, looking at what they want to look at.

The figures 4.9, 4.10, 4.11 and 4.12 show the lighting plan for the respite space, in terms of brightness distribution and through specifications of the lighting.

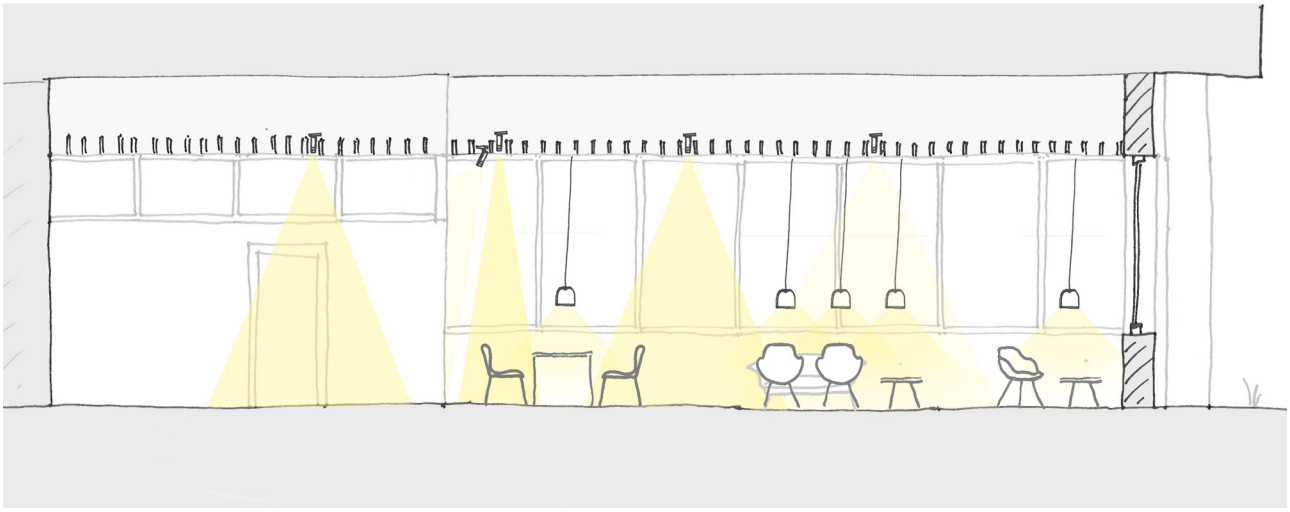


The lighting plan with pendants, wall washers and spot lights

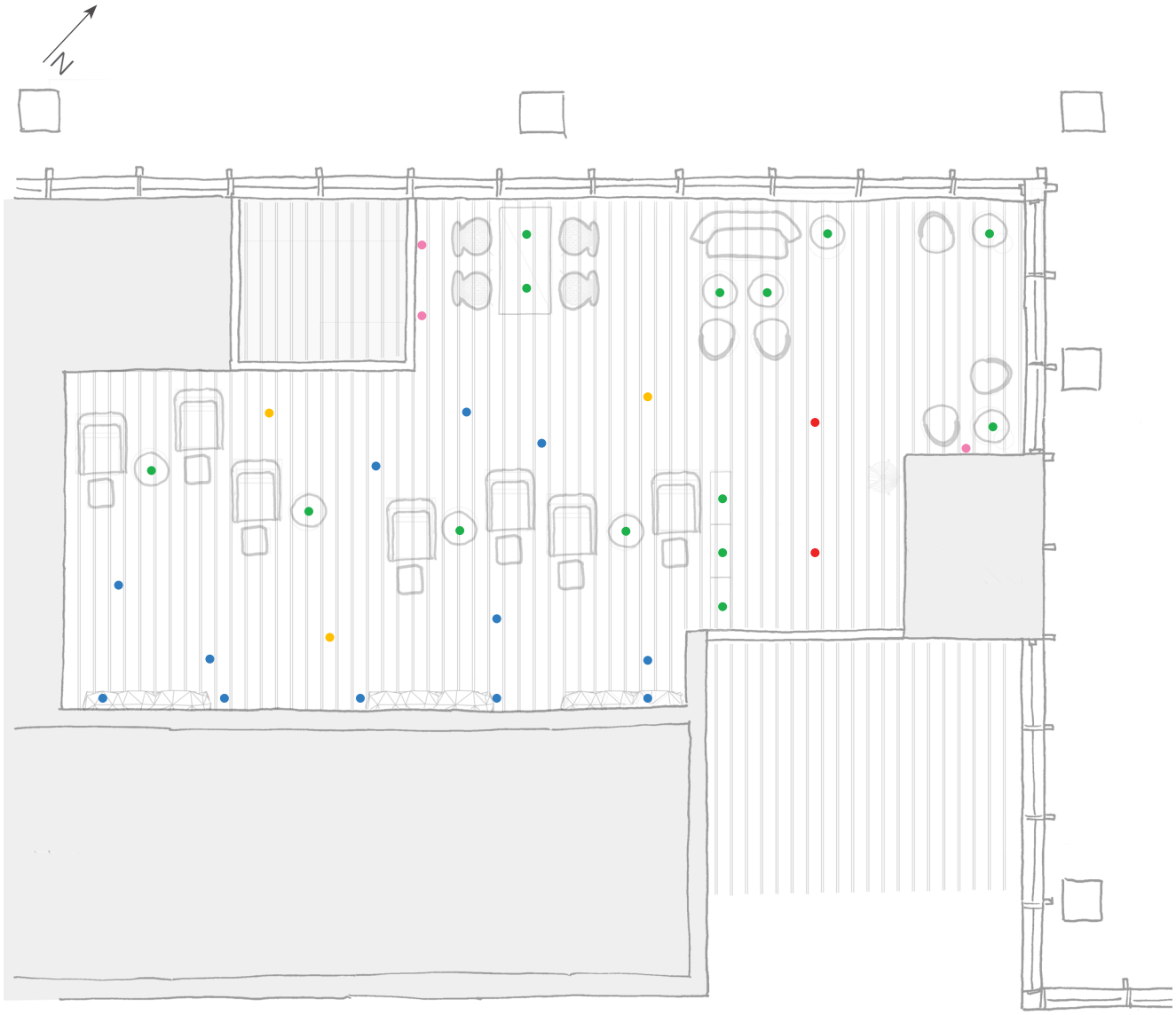
Fig. 4.9 Lighting plan for respite space



Section illustrating the lighting principle
Fig. 4.10 Section A-A



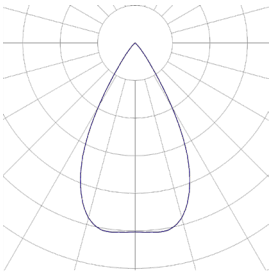
Section illustrating the lighting principle
Fig. 4.11 Section B-B



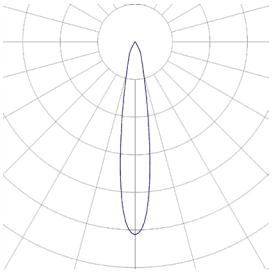
The lighting plan with pendants, wall washers and spot lights

Fig. 4.12 Lighting plan for respite space

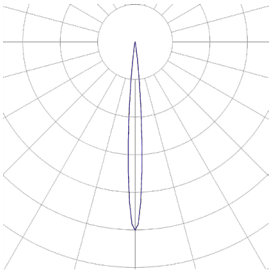
Flood light
Beam angle (optics): 56°
Lumen source/lumen system: 1800 lm/1421 lm
Dimmed to approx. 50 %
CCT: 2700 K
CRI: 90



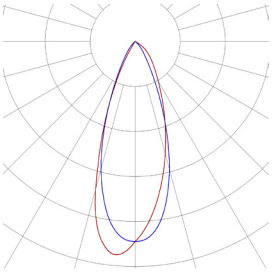
Spot light
Beam angle (optics): 16°
Lumen source/lumen system: 1800 lm/1403 lm
Dimmed to approx. 30 %
CCT: 2700 K
CRI: 90



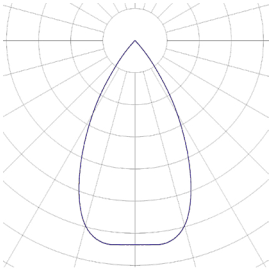
Narrow spot light
Beam angle (optics): 8°
Lumen source/lumen system: 510 lm/275 lm
Dimmed to 40-80 %
CCT: 2700 K
CRI: 90



Wall washer
Beam angle (optics): -
Lumen source/lumen system: 860 lm/189 lm
Not dimmed
CCT: 2700 K
CRI: 90



Pendants
Beam angle (optics): -
Lumen source/lumen system: 350 lm/ -
Dimmed to 55-70 %
CCT: 2700 K
CRI: 90



The conceptual design proposal for the lighting was simulated in DIALux to adjust the design, and to ensure the desired luminous environment was achieved. Through the DIALux simulations, small changes were made to the design. This created iterations of the design in line with the procedural model. Simulations of the developed design proposal can be seen in figure 4.13, 4.14 and 4.15.

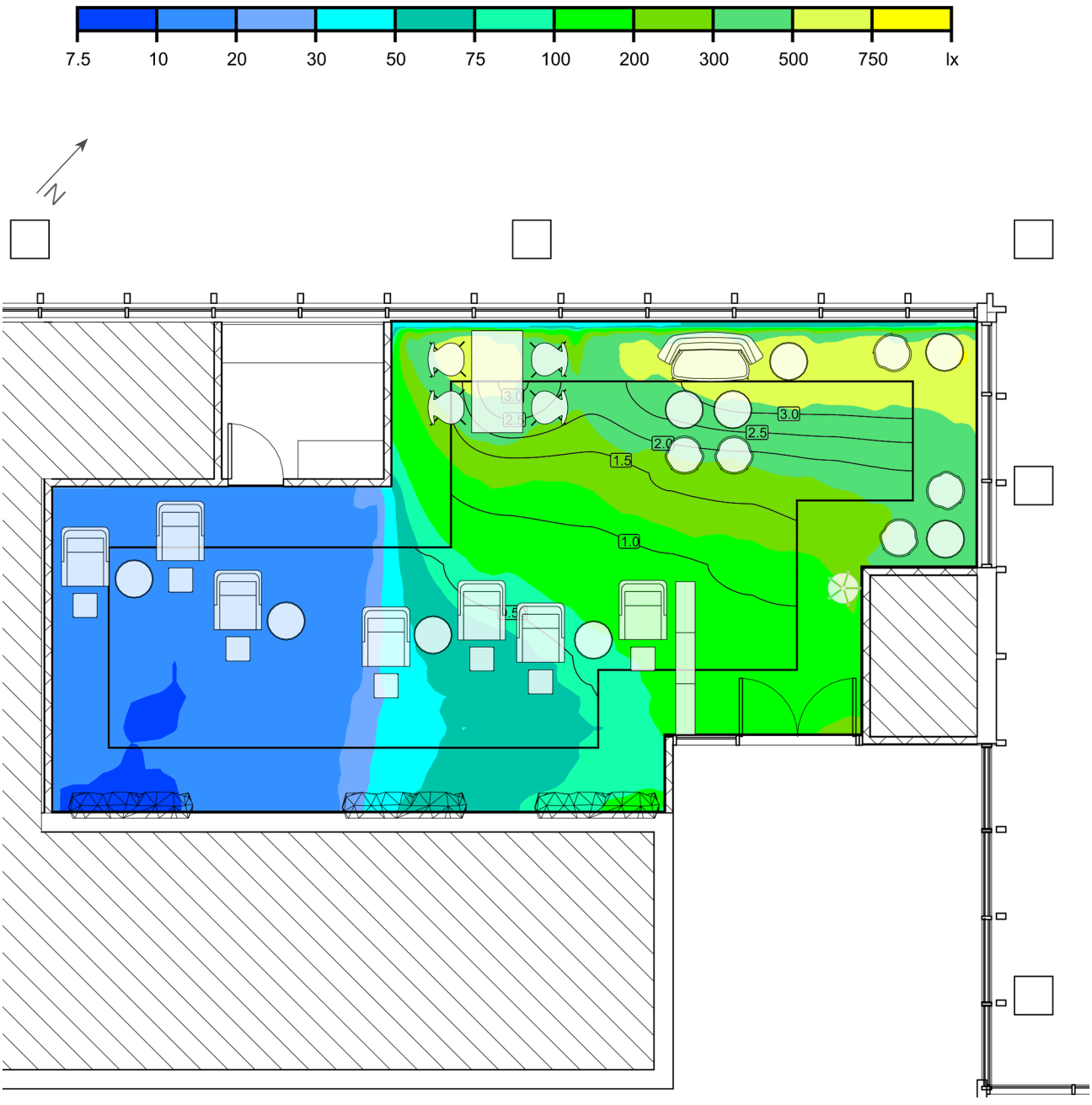
Figure 4.13 show the daylight intake in the respite space. From this simulation it is clear to see the difference in light level in the active zone compared to the passive zone. The illuminance vary between approx. 10 lx to 500 lx. Thus, the passive zone is easier to control in terms of luminous environment, and the active zone experience a variation over time.

From figure 4.14 it is evident that the spatial distribution of brightness is, as described earlier, more uneven in the passive zone, compared to the active zone. In the passive zone, the illuminance varies primarily from 20 lx to 100 lx, but near the back wall the illuminance is approx. 10 lx. The distribution on the floor is very contrasted. This leads to the level of light being globally dim, but locally brighter, as described in the criteria. The distribution of the brightness is arranged, so it leaves the chairs in the dark, and thereby avoiding the users being exposed by the light. When considering the active zone, the spatial distribution is less uneven, however it is not uniform. The overall level of light in this zone is brighter than in the passive zone, supporting a more active use. The illuminance levels range within the same levels as in the passive zone, but with a larger area being brighter. From the simulation it can be seen, how the lighting is distributed to create the small light realms, as described in the design. This supports the feeling of having a private sphere surrounding the sitting arrangement.

Figure 4.15 show a luminance simulation of the vertical elements in the respite space. The first simulation show the difference in luminance level in the passive zone compared to the active zone. The contrast ratio between the two wall elements in the space is more than 1:6. This ensures a visible contrast between the two zones. The passive zone is thereby dimmer, supporting the design of the zone. The second simulation in figure 4.15 show the variation of the luminance on the concrete aggregate wall. From this, it is evident, that the lighting creates a nonuniform wall lighting, supporting relaxation and creating visual stimuli.

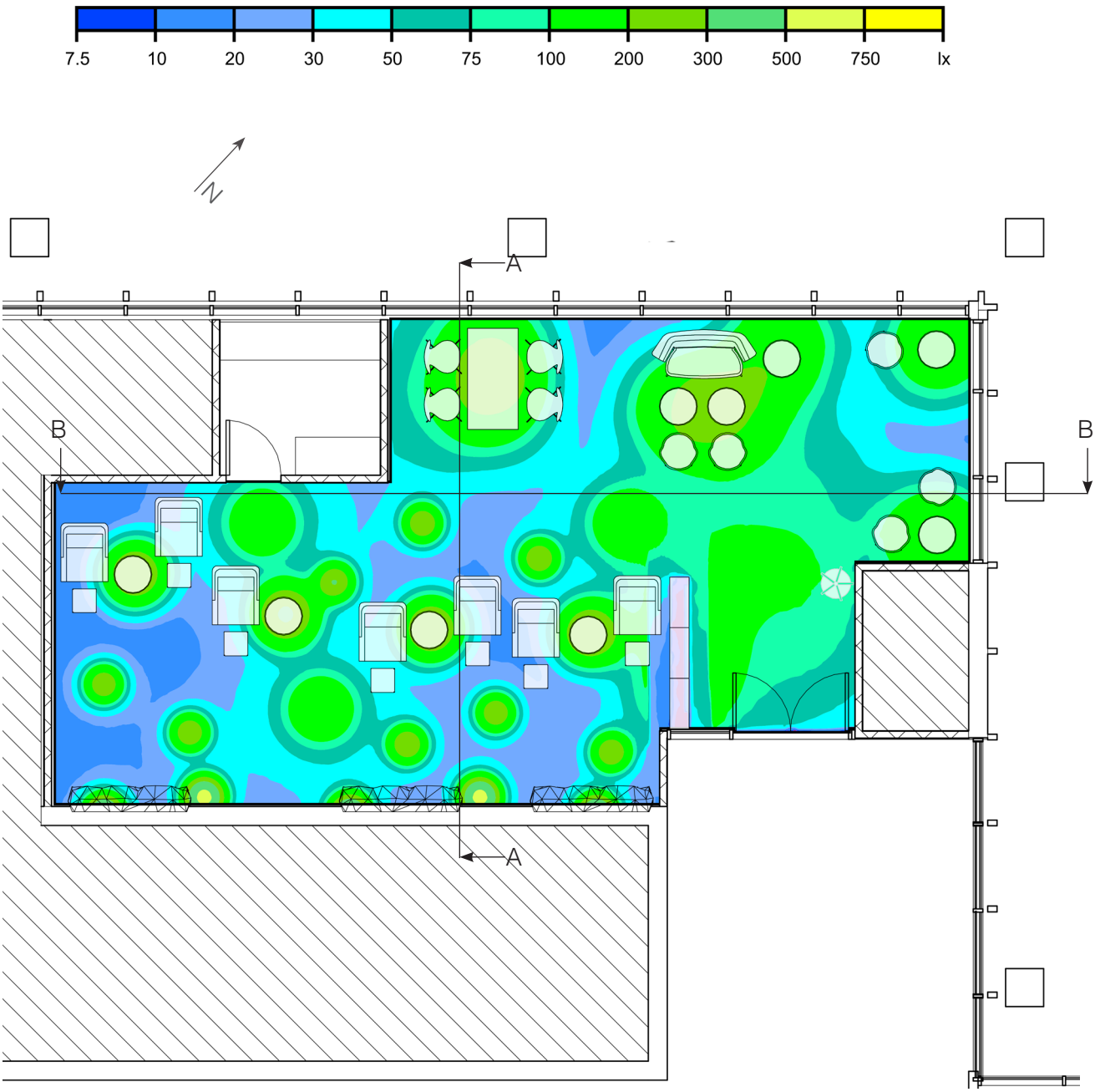
The lighting design for the respite space has an emphasis on creating depth in the space, by having an uneven spatial distribution of brightness, and by enhancing the materiality and tactility of the space. In doing so a space of mindful physical presence is created, with the opportunity for spatial movement with the eye. This contributes to creating an atmosphere. By employing a warm

white light of 2800 K, as described in the specifications in figure 4.12, the colour of light supports the welcoming ambience, and fulfils the criterion stated. The high CRI of the light, also described in figure 4.12, ensures the colour of the surfaces are rendered naturally. As no reflecting materials are introduced to the space, the reflections of the light in the space are considered still to be calm.



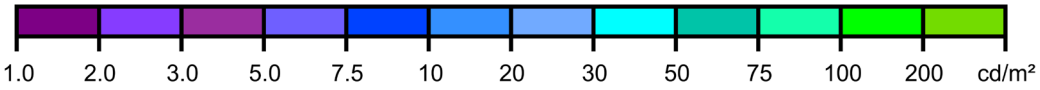
Illuminance simulation of the daylight intake in the respite space, 0,8 m.

Fig. 4.13 Simulation of daylight through DIALux

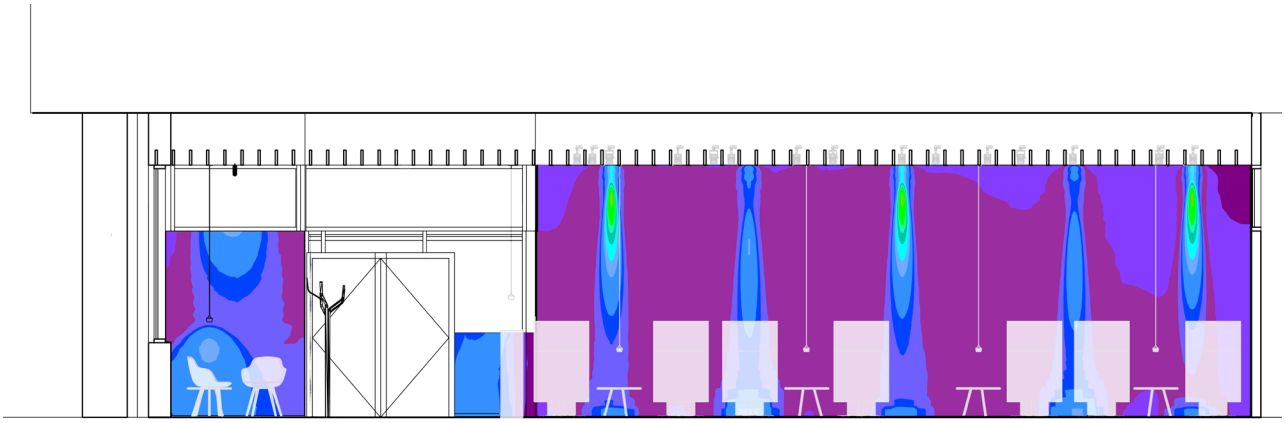


Illuminance simulation of the conceptual lighting design for the respite space, ground level

Fig. 4.14 Simulation of electrical light through DIALux



Section A-A



Section B-B

Luminance simulation of the conceptual lighting design for the respite space

Fig. 4.15 Simulation of electrical light through DIALux

From the renderings, in figure 4.16, 4.17, 4.18 and 4.19, it is evident that the passive zone is dimmer than the active zone, supporting the different use of the zones. It is also evident, that the lighting is distributed more uneven in the passive zone, creating visual stimulation and spatial depth. The unevenly distributed light is visible even at noon. The spot lights on the concrete wall are also visible at noon, but less dominant. However, at the evening they emphasis the concrete wall and the plants introduced to the space, and thereby support tactility of the material and the multisensory experience of the passive zone. The rotational, acoustic chairs in the passive zone, provides the users with a sheltering, and thereby supports the private sphere. The active zone is more uniform in the distribution and creates a social ambience. The shadows are noticeable, without being too dramatic, as experienced in the investigation of shadows. The wall washers in the active zone, encloses the zone and contributes to creating an invisible boundary around the zone, thereby indicating where to go. From the active zone, the users have a view to the passive zone and the variation of the distribution of light on the floor and on the concrete wall.

After this description of the design proposal and its details, the design proposal is found to fulfil the criteria setup through the Light Experience Model. The vision for the respite space was, that the respite space would be an attractive part of Rigshospitalet supporting different types of calmness. As the criteria are considered fulfilled, the vision is also considered fulfilled. Thus, the lighting design supports the purpose of the space and contributes in producing a calm and restful atmosphere.

Visual representation of the respite space during the summer solstice at noon
Fig. 4.16 Render E, summer solstice at 12.00

Visual representation of the respite space during the summer solstice in the evening
Fig. 4.17 Render E, summer solstice at 22.00

Visual representation of the respite space during the summer solstice at noon
Fig. 4.18 Render SW, summer solstice at 12.00

Visual representation of the respite space during the summer solstice in the evening
Fig. 4.19 Render SW, summer solstice at 22.00

Round-off

Discussion

The thesis has been concerned with the influence of lighting on our spatial experiences, and thereby how lighting can support the purpose of a given space. The methodology used to approach these questions was based upon the procedural model, developed by Hansen and Mullins, where transdisciplinary knowledge informs a design process. This transdisciplinary knowledge was based upon a context-independent literature study, regarding phenomenology and luminous environment.

The context-independent literature study was approached from two different angles. These where named actuality and reality. Actuality was investigated primarily by studying Gernot Böhme and his thoughts about phenomenology, aesthetics and atmosphere. Reality was investigated through the study of Anders Liljefors and his lighting principles. This of course meant, that the Light Experience Model was developed within the limitations provided by these two fields of knowledge.

In the development of the model, it might have been useful and interesting to look into other philosophers, who have a different approach to the topic of aesthetics and atmosphere. This could have ensured a more comprehensive Light Experience Model. An investigation regarding anthropology, architecture, urban spaces or art, might also have contributed to the development of the model, since the model is concerning the topics of aesthetics and atmosphere. It could also have been beneficial to have conducted a case study, where a number of atmospheric spaces were studied. By investigating such spaces, and extracting information based on the spaces, a practical aspect could have been applied to the model. Especially within the field of phenomenology, the literature contains many stances regarding the production of aesthetics and atmosphere, but little examples or practice. A phenomenological methodology describing a specific and concrete case of atmospheric production is difficult to find. The descriptions tend to be of a philosophical and abstract manner. Thus, the Light Experience Model could have been supported by practical knowledge.

The phenomena aesthetics and atmosphere have been studied in this thesis through phenomenology. Phenomenology studies phenomena by taking one's personal experiences into account, and engaging the self, in one's observations. This differs from natural science, where observations are conducted by the observer distancing oneself from the observations. Natural science seeks objective results, with little or no biases. Thus, it can be discussed whether the methodology of phenomenology is a valid, scientific method. The strength of the method is the observer engaging in the observations using personal experiences. However, this might also be the weakness of the method. Because, how do we ensure that our experiences are not illusions and that two individ-

uals actually experience the same thing? Böhme states that a phenomenon such as atmosphere is quasi-objective, and that individuals can communicate intersubjectively about the phenomenon. This presupposes a homogeneity between the individuals. Thereby Böhme argues that the science of phenomenology is valid as a methodology. However, in engaging oneself in the phenomenological observations it follows, that the observations have a subjectivity to them. This subjectivity can be limited by having more observers experiencing the same atmosphere, and then comparing the observations, to find independent and autonomous observations. The observations in this thesis, are based upon our experiences. The space was experienced similar by us, but it cannot be dismissed that it might be experienced differently by others, eg. elderly, people with disabilities etc. Thus, the phenomenological observations of the atmosphere in the respite space cannot be denied but may not represent the experience of other people. In addition to this, the observations made in the respite space was based on one day of studying the space. This might not illuminate all potential problems or uncover the atmosphere of the space fully.

The reality section of the thesis is mainly derived from Anders Liljefors and his lighting principles. Other literature could have been investigated as a supplement to Liljefors and his views on lighting. This might have provided a more thorough investigation of the lighting principles and have drawn attention to flaws or shortcomings. The reality section can therefore not be seen as exhausted, but well visited.

The design of the lighting in the respite space was developed based on the criteria, which were set up based on the Light Experience Model. With the design fulfilling the criteria, it should succeed in creating a calming and resting atmosphere. It can be discussed though, whether the criteria satisfy the purpose of the space, and whether a lighting design in general, is only described by the seven criteria presented in the model, or whether others might be appropriate to include. The Light Experience Model, however, resembles the PERCIFAL tool developed by the research group for interdisciplinary spatial studies, SYN-TES (SYN-TES 2011). It has also come to our attention, that the lighting manufacture Fagerhult has developed a lighting assesment application for smartphones, called Fagerhult Visual Assessment. This also resembles the Light Experience Model. Thus, it reasonable to assume the model is adequate.

The design does not consider the age difference of the users in the respite space. It can be assumed, that the majority of the users are elderly people, who's vision is impaired due to age. However, this has not been considered during in design. For the design to be improved, the impaired vision should be considered, and measures should be taken to accommodate it. It could be approached by having local control over the pendant luminaires, so the users

locally can adjust the lighting. It can be discussed whether the users should have complete control over lighting. However, this requires that the users are capable of controlling the lighting. If this was the case, the role of the lighting designer would be unnecessary.

Another aspect of the design, which could have been approached, is the duality of the design. The duality of the design describes the different functions the light must accommodate. The lighting has been designed for and focused on the purpose of the calmness and rest, and how to support this. However, although it is not the purpose of the space, the space regularly has to go through cleaning. When the space undergoes a cleaning, the light should be uniform and bright, so the employees have the optimal working conditions. This could either be provided by integrating a cleaning light in the design or by supplementing the design with a cleaning light, as it is today. Another aspect is emergency light, such as in case of fire or if a user suffers a heart attack etc. Emergency lighting should be present in the space for such situations. This could be integrated with the cleaning light.

For future works it would be interesting to investigate and validate the design through different tests or likewise. This would contribute to the iterative process of a design, which is also described by the procedural model. The essence of iterations is to continuously gain more knowledge, through for instance testing, and then applying this knowledge to the design and thereby improving the design. Iterations can be everlasting, however one should be aware whether the iterations contribute significantly to the design when conducting them. It would also be interesting to conduct an on-site test. In this test the design proposal would be tested on-site, to validate the specifications of the light sources, as well as the placement and orientation of the luminaires, the dimming level and so forth. These tests often result in adjustments to the design, which otherwise might not have happened. An on-site test also has the advantage of revealing problems of a practical character, such as structural element limiting the mounting possibilities or aiming of the light. These are especially difficult to foresee.

Another aspect for future works, would be to test and evaluate the Light Experience Model, e.g. against other models or through the design of more spaces. This evaluation could improve the model and prove its relevance.

One might argue that the cost of a lighting design is prioritised higher than the purpose of the lighting design. It could therefore be interesting to conduct test, trying to uncover the actual gain from *"lighting with a purpose"* in the respite space. In the hospital settings, this could be tested e.g. by examining the respite space' influence on patient's health, both mentally and physically. This

could be investigated through different tests, e.g. by counting the number of bed days, of patients who uses the respite space, before and after implementation.

The design proposal is developed with the atmosphere as the most important aspect. Thus, as described in the scope of the thesis, the design does not consider norms, standards or regulations. For the design to be implemented though, it must take these aspects into consideration. However, the standard might not be optimal when designing for a specific purpose, as it only considers purpose in a categorical, systematic and general manner. If considering the standard DS/EN 12464-1:2011, the respite space can be assumes to be considered a day room (Table 5.37.6). The requirements for a day room is an illuminance level of 200 lx, a uniformity of 0,60 and a Ra of 80 (Technical Committee CEN/TC 2011). However, this was found not to be ideal for the purpose of the respite space. Thereby, it can be discussed whether the requirements stated in the standard are optimal to evaluate a lighting design based on, as these quantitative measures do not reflect upon qualitative aspects, and to a degree restrict the design. The thesis has underlined the importance of designing lighting based upon the purpose of a space, to support the space.

Conclusion

The background for the master thesis was the discrepancy between the lighting understood visually and physically. Or more precisely, the discrepancy between our spatial experience and the measures, based on which, a lighting design is evaluated. By designing and evaluating a lighting design based on economic issues or regulations, standards etc., the focus of the design is on quantitative measures, rather than on our spatial and sensorial experiences. This is because these quantitative measures do not take our sensorial experiences into account. As a result of this, the design of the lighting does not necessarily support the purpose of the space. Based on this background the questions proposed in the thesis were whether the quality of a lighting design primarily should be defined through quantitative measures and how a lighting design can influence our spatial experiences. This resulted in a hypothesis being formed, which the thesis investigated.

The investigation of the questions and the hypothesis was conducted through a large literature study regarding aesthetics, atmosphere, architecture and lighting parameters. This led to a mapping of spatial parameters with the possibility to influence our spatial experience. From the literature study it was evident that our spatial experience is influenced by the atmosphere of a space, and that since atmospheres are quasi-objective they can be communicated about and produced. However, the production of an atmosphere can only ensure that the conditions for an atmosphere to arise are present in a space. As an atmosphere is an intermedia phenomenon, it depends on the exchange between object and subject. The subject therefore has to take an active part in experience an atmosphere. The literature study also emphasised that an atmosphere is generated by honouring materials, supporting the tactility of a space and the experience. This is in line with creating multisensory experiences, engaging the whole body, to create a space of mindful physical presence. Also, the importance of the shadow, as decorations and to unfold the spatial relationship between objects was accentuated. Following this, the importance of the brightness/darkness composition, to stimulate our imagination and allowing the eye to move in the depth of the space, was stressed. The literature study also elaborated important different lighting principles, and their correlations, which should be considered carefully when designing light. As evident from the design, the importance of the different principles change dependent on the space and its purpose.

The literature study resulted in the Light Experience Model. The model provided an overview and an understanding of the different parameters of a lighting design. From the model a clarity was gained regarding which lighting parameters, or composition of parameters, were suitable to support the purpose of a space and which were not. It turned out, that the developed Light Experience Model resembles tools developed by professionals, such as PERCIFAL and

Fagerhult Visual Assessment. Thereby it is reasonable to conclude, that the model provides a satisfactory and precise overview of the different parameters of a lighting design, which influence our spatial experience.

Based on the developed Light Experience Model, the spatial experience of the respite space was studied. From this study it was concluded, that the space did not succeed in creating a calming atmosphere to support its purpose. Rather it was experienced as a quieter and a less busy room for waiting. Using the Light Experience Model, it became apparent which challenges, concerning the lighting, were to be dealt with in the design. Criteria for a new lighting design were set up, to ensure the proposal would fulfil the vision for the respite space. Based on this, a lighting design was developed, which should succeed in creating an atmosphere of calmness and change the spatial experience of the space. Approaching the design process from the point of the Light Experience Model, made the designing easier, because the challenges of the space were illuminated, and the purpose of the space was clearly defined. This resulted in a conceptual design proposal which fulfils the criteria and thereby fulfils the vision. Thus, it can be concluded that the Light Experience Model is useful in assisting the analysis of a current space and the development of a new design proposal, and thereby bridging theory into practice.

The thesis has illustrated how the lighting can influence our spatial experience, by creating an atmosphere supporting the purpose of the space. The design proposal does not claim to be the only lighting design fulfilling the criteria and creating a calming atmosphere. The thesis has also underlined the importance of defining the quality of a lighting design based on more than quantitative measures. Rather the quality of a lighting design should be evaluated based on the atmosphere produced and thereby our spatial experience. The production of an atmosphere is dependent on carefully working with the parameters of a lighting design, described through the Light Experience Model, which draws references to quantitative measures of lighting. This leads to the hypothesis of the thesis which claimed, that a better environment, in terms of spatial experience, can be designed by working with the concepts of aesthetics and atmosphere and by understanding the purpose of a space. Since the hypothesis has not been tested, it cannot be rejected or accepted. However, the thesis indicates that hypothesis is true.

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Figures

References for figures in the thesis. Figures that are not mentioned in this list, are produced by Anna Lykke Thorup and Kasper Fromberg Støttrup.

Fig. 1.1 The five traditional senses
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Fig. 1.2 Optical illusion
Liljefors, Anders. 1999. “Lighting Visually and Physically.”
Stockholm: School of architecture, KTH Stockholm. Page 4.

Fig. 2.1 Vision as touch
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Fig. 2.2 James Turrell, The *Light Inside*
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Fig. 2.3 Traditional Japanese interior, changed to black and white
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Fig. 2.4 Optical illusion
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Anna Lykke Thorup
Kasper Fromberg Støttrup

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Aalborg University Copenhagen