Aalborg University Copenhagen

Semester: Lid 04

Title: A sphere of light in a home working environment

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Abstract:
This thesis was made with the aim of creating a lighting design concept with a sphere of light that allows the user to be immersed in work activities inside the home without taking away its homely quality. Through this report, an analysis of different home environments was made and several problems were encountered that were centered on two topics: distractions and blurred boundaries. Therefore, the vision of this project is: Imagine a homely working environment supported by a light that allows you to be comfortable and at the same time improves your work engagement. Based on this vision a hypothesis was proposed: A sphere of light can serve as a tool to create an atmosphere that allows us to be engaged with work, having a better time awareness without taking away the home's qualities. The design concept is supported by state of art, study cases and research about color temperature, intensity, directionality, and distribution of the light. Two tests were carried out inside a home office space in order to support the concept idea and to evaluate the design proposal. Through the evaluation of the results, there was a strong preference for warmer CCT for task lighting in home office environments because they were related to the same atmosphere of the space and it felt natural and comfortable. There is an indication that participants felt a part of the sphere of light while being tested. Moreover, they would like to have the possibility to control the light at home to create boundaries between activities.

0. Table of content

1. Introduction

The past couple of years caused difficulties for our society due to the pandemic COVID-19. We experienced working from our own home, instead of going to work in an office. This has been quite challenging for several reasons. Even though the situation has been improved, the possibility of working from home will always be available. Many people still prefer to work from home from time to time. However, a home workplace can be distracting; therefore, it is essential to create an atmosphere that allows us to be engaged in our work. This thesis will elaborate on the combination of different shapes and layers of light to support the perfect setting for working purposes.

Home is an intimate environment where people feel safe and comfortable. It is a space for different activities, but its primary function, mainly in Denmark, is to provide a cozy atmosphere for the user. On the other hand, working spaces are usually focused on keeping us motivated and concentrated, which almost achieves the opposite effect. This thesis aims to find a balance between these two environments and contribute to work engagement with the right light setting, and at the same time, preserve the home’s most outstanding qualities.

This thesis is based on previous research about home atmospheres, working environments, and the role of light in home offices, and it also focuses on previous studies and research about task lighting, light for work, home lighting, and health effects of light. The methodologies include qualitative analysis based on experiments with the goal of creating a final design proposal as a tool for home working environments. It is important to mention that the analysis is based in Copenhagen, Denmark.

This report will attempt to find solutions to existing problems through real-life pilot testing with several participants. The aim is to come up with a lighting design proposal where the users are able to be immersed in work engagement in their home spaces.

Keywords: atmospheres, home office, work engagement, task lighting, sphere, bubble

2. Motivation for choosing the topic

The motivation for addressing the topic started from the consequences of the pandemic of COVID-19, specifically the effect on the way people work and study. Our work and study life have been altered, making people adapt to a new reality and shaping new habits around it. The authors of this report, like many other people, have faced the challenges and difficulties of working from home and wished to address this topic within the lighting design field. As an educational background, both authors are trained architects who are constantly working with different people and spaces. Therefore they desired to dig into this topic and examine how other people managed and still manage to work from their homes and find the difficulties or challenges they have encountered.

In addition to this, after two years of education, it was important to research the topics that will always bring awareness to the design world and are related to work and home environments. Moreover, the aim was to find out the possibilities of experimenting with light in home environments as something that could change the perceived space as a differentiator of activities. The presented thesis compiles our topics of interest: it focuses on human beings, working environments, light, and our desired personal space called home.

3. Acknowledgements

Bego:
First of all, I would like to thank my parents and my sister for believing in me all the time. You are my cheerleaders, my support, and I would not be here without you. I would also like to thank my boyfriend for loving me unconditionally and giving me an incredible amount of positive energy during this process. I would like to thank my biggest company this semester and my dearest friend: Eszter; this thesis wouldn't exist without you. Thank you for your love, patience and support through this whole process. For listening to me when I had the craziest ideas, for our many laughs and for all of the moments we shared from day 1 of this Master´s degree. You have a big heart, and I'm so grateful to have you as a friend and write this with you.

Eszter:
At first, I would like to thank my family, who supported me, believed in me, and pushed me forward. I would also like to thank my boyfriend who was always there, in good and bad, who listened to me and loved me unconditionally. To my biggest support of all, I would like to say a big thank you to Bego, my dearest friend. Without you, I would not have been able to write this thesis and have so much fun at the same time. You made this process easier and enjoyable together with many laughs. You are such a kind, sweet soul that I am so grateful for. Life has crossed our ways for a reason, and I know that this friendship is meant to last for a lifetime.

Both of the authors would like to thank Ellen for the whole master's process at Aalborg University. Thank you for supervising us and giving useful guidelines and feedback for writing this report. To Mette, for supervising us with patience and kindness when Ellen was absent, thank you. Lastly, a big thank you to Mikkel Bille and all of the participants for sharing their home working spaces with us.

4. Vision

Imagine a homely working environment supported by light that allows you to be comfortable and at the same time improves your work engagement.

5. Research question

How can light support work engagement in a home workplace and at the same time preserve a homely atmosphere?

6. Hypothesis

A sphere of light can serve as a tool to create an atmosphere that allows us to be engaged with work, having a better time awareness without taking away the home's qualities.

7. Background

7.1 Pandemic COVID-19

At the end of 2019, a worldwide epidemic began that caused the coronavirus disease (COVID-19). The virus was spreading rapidly globally, therefore it was declared a pandemic by the World Health Organization in 2020. There have been many re-co-mmended practices in order to stop the spreading of the virus, along with the implementation of home offices. Millions of people were forced to work from home during these lockdowns. Luckily, modern technology has made it easy for the employees to carry out their professional work remotely under these circumstances (Siqueira et al., 2020).

The demand for working from home has significantly increased since 2020 due to the global pandemic COVID-19. This unforeseen situation has forced companies to rapidly train their employees in the online working style. Maintaining the same level of work engagement from home is a high priority. While many people enjoy working from their home and it eases their lives in many aspects, others struggle to stay motivated and focused for several reasons, including lighting conditions. In this report, the aim is to find answers to existing problems concerning light settings and give recommendations as a form of solution (Siqueira et al., 2020).

Figure 1 & 2: Being at home during the pandemic (Freepik, 2022), (McCutcheon, 2022)

Figure 3 & 4: Working from home (Antoniadou, 2022), (Benois, 2022)

There are positive characteristics of remote working, such as saving time by not having to use transportation and being able to take care of house chores during breaks. On the other hand, there are many negative aspects and risks as well such as work overload and time management, which could lead to stress-related issues that can affect health. (Al-Habaibeh, Watkins, Waried & Javareshk, 2021).

A recent international study made in 2021 during the pandemic found that there are some factors that affect the comfort of being at home while working. Aspects such as having control over shading devices, being close to the window, and having an unobstructed view to the outside were crucial for increasing participants' satisfaction (Vasquez et al., 2022)

The study also showed the importance of daylight and electrical light as factors that influence the way people worked at home. The research was carried out in many different countries (Brazil, Colombia, Denmark, Italy, Poland, and Japan) and provided information about the associations between the home office daylighting, window view, electric lighting, lighting levels, perceptions, and design features (Vasquez et al., 2022). The base of the study led to an understanding of the need for further research and measures to improve the visual environment and overall indoor environmental quality of the space (Vasquez et al., 2022)

7.2 Survey

Before starting the research on the topic, an online survey was created to get knowledge from people about their experiences during the pandemic in home office environments. Since home offices are becoming available to everyone in the long term, the purpose was to find out whether there is a need for improvement or not.

The online survey was conducted about the lighting conditions in home office environments from the 10th to the 15th of February 2022. There were 13 questions included about the difficulties of working from home, preferences and the lighting conditions they created. The types of homes were not mentioned; it was more focused on the home office and not the home itself. A total of 63 people have filled out the survey and given information for addressing the existing difficulties within their home office. There was no specific age group or nationality involved, and there was no question about the location or residency. Most of the answers came from residents of Copenhagen and the rest from all around the world. The survey did not focus on one season or time of the day; instead, it is more general.

92% of the participants claimed that lighting conditions are essential for their home office environments. 68% are still working from home, either part-time or full-time. Some of the challenges they have been facing are lack of concentration, lack of suitable working space, negative emotions, different sound distractions, no difference between home and workplace, and lack of socializing.

79% of the participants claimed they had difficulties working from home, 54% prefer daylight, and 44% choose between daylight and electric light. Moreover, the majority of the people (84%) noticed the light conditions and answered that the light conditions were important to them. The participants' answers showed that people used different light sources, such as floor lamps, pendant lamps, desk lamps, and some other fixtures that they already had in their homes.

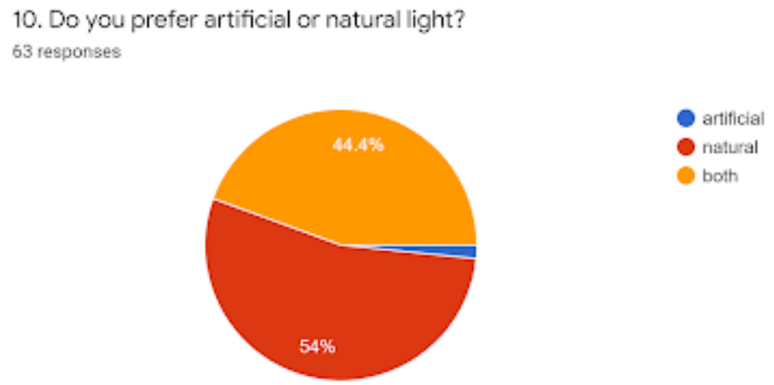


Figure 5: Pie chart results from the online survey

Despite the location was not specified in the conducted survey, the focus area in this report will be Denmark, more specifically Copenhagen.
Some of the statements from the participants describing daylight and electric light:

"Natural light can be difficult to control"
"Natural light is more beautiful"
"Natural light feels good"
"Natural light keeps me energized"
"Artificial light can be invasive"
"Artificial light helps to see during dark hours"
"Artificial can be controlled"
"Artificial light can be damaging for the eyes"

From the survey, it was clear that there is a missing gap between work engagement and home environments. There is a need for improvement since most participants had a hard time working from home. The answers explained the problems and gave a starting point for the topic. The location has not been specified in the survey, which could lead to different answers. Studying one location with the same climate and weather conditions is important. Therefore, the next chapter will discuss the chosen location for this report.

7.3 Location and daylight variations

This analysis is made to get a better understanding of the climate of Denmark, more specifically Copenhagen. Copenhagen is located at 55,67° North of the Equator. On the 1st of January, the Sun is at its minimum height of 15 degrees, and its maximum reaches 57,5 degrees. Because of this, we always see the sunlight coming from the side and never above. In Denmark, the sky is overcast for 2/3 of the year. Therefore, the focus of this report will be on rainy days and days when the sky is overcast.

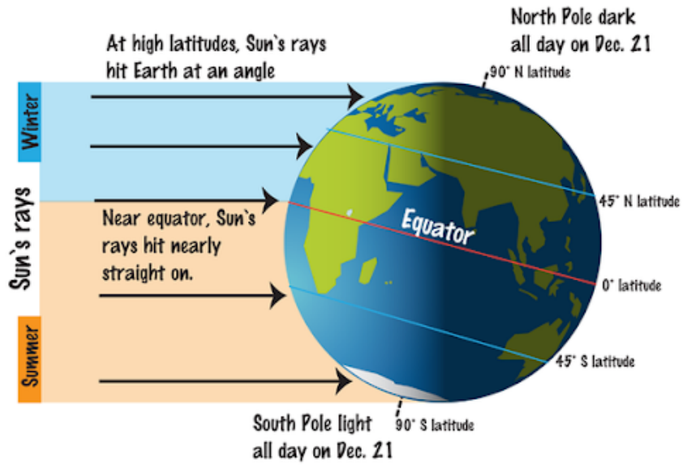


Figure 6: Earth at winter solstice - 21st of December (ABP News Bureau, 2021)

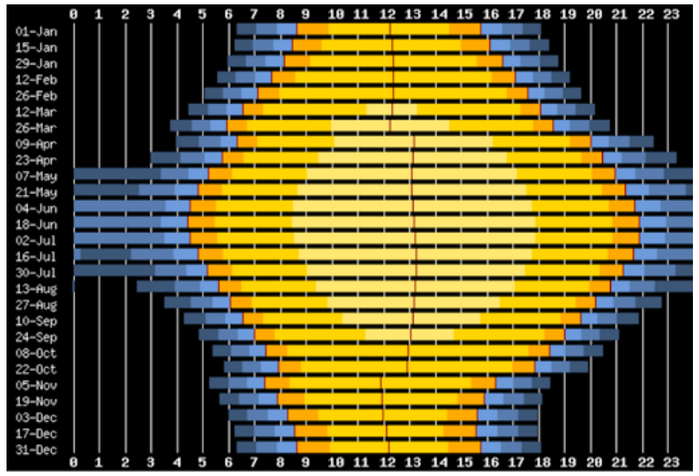


Figure 7: Light and dark hours in Denmark (Suninfo, 2022)

This image shows the light and dark hours during an entire year in Denmark. It is clear to see that the shortest day of the year has 6-7 hours of daylight, and the longest day has 17 hours. It can be concluded that the daylight hours in Copenhagen vary dramatically and that there is a need for more electric lighting during wintertime. Therefore, in this report, the main focus is on dark seasons, such as autumn and winter when there is much less daylight.

Figure 8 & 9: Difference in the weather in Copenhagen between winter and summer (Strøget Square, 2022) (Lasry,2022)

8. Methodology

8.1Mixed Research Methodology

The method applied in the thesis is based on qualitative and quantitative analysis. The quantitative method involves an online survey to get people's preferences about the light settings in their home working environments.

Followed by this, interviews were conducted in actual home working environments of different participants living in Copenhagen. As for the qualitative observations, several photos and some sound recordings were taken in order to define and compare different light settings in home working environments.
In addition to this, an interview was conducted with social anthropologist Mikkel Bille, one of Denmark's leading researchers on home atmospheres and the social light context. The purpose of the interview was to get an insight into the differences in the home and working atmosphere and get his input as a researcher on how these two environments can coexist without taking away their qualities. These interviews served to define the problems that led to the research question presented in the thesis.

The research question is about supporting work engagement in a home environment and at the same time preserving a homely atmosphere. It was supported by the research of existing literature, state of the art, and the Double Dynamic Design approach to create a lighting design concept made of layers of light. The lighting design concept is a combination of work and home spaces.

A pilot test was designed to combine all of the knowledge obtained in the research, the previous analysis and to develop the concept idea. For the test, a light fixture prototype was made to implement the new design solutions. This prototype creates different layers of light mentioned through the design process and supports the idea generation. These layers of light are based on different parameters like CCT, intensity, distribution, and direction of the light. As a final part of the pilot test, quantitative and qualitative data were collected about the mentioned parameters to validate the proposed lighting design solution.

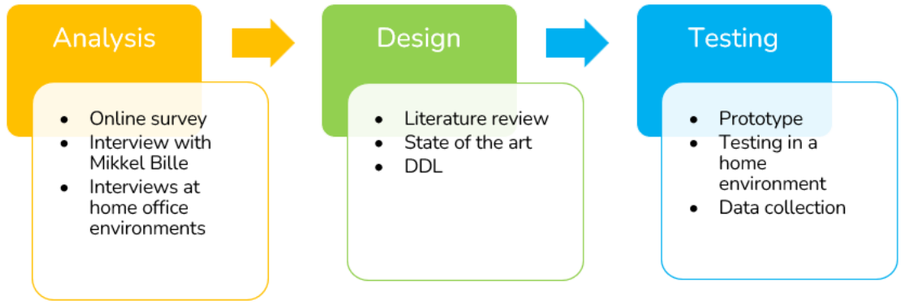


Figure 10: Self-made image showing the Mixed Research Methodology

9. Analysis

9.1 Introduction to the analysis

To address the areas that need to be improved on this topic, personal interviews were conducted with six individuals who have been working from home since the pandemic and still work from home from time to time. This analysis is not only to find out the struggles of home working environments but also to get a real insight into how people manage their work from home. By the end of the thesis, a proposal of a lighting design concept in a home environment will be tested and evaluated by the interviewees.

The analysis was made to get a better understanding of the atmosphere of light in home working environments and to see how people manage using their own light. A way to explore the interaction between a home environment and the user was to see it in person and conduct interviews with different people. With these interviews, we expect to get answers regarding the user's needs and individual perceptions about their home working environments.

9.2 Reaction cards

Previous research on Double Dynamic Lighting was considered and used for the experiment to ask the participants how they felt about the light in their working environments. "Previous studies have shown that office workers who perceive lighting positively also recognize visual comfort and perceive the atmosphere as more attractive. The positive lighting also led to better mood, higher work satisfaction, and greater overall engagement in their work" (Hansen, Bjørner, Xylakis & Pajuste, 2021).

Two approaches were used to visual appearance and perceived atmosphere based on this. Reactions cards were used in the interviews to evaluate the current light settings of the space. The cards included negative and positive statements and provided selective words that the participants could choose to describe the space. Using the cards was a clear conclusion of positive and negative opinions about their current light settings at home.

Table 2. Overview of reaction cards, in categories of visual appearance and perceived atmosphere.

Reaction cards	
In relation to visual appearance:	In relation to perceived atmosphere:
Comfortable	Cozy
Sufficient	Motivating
Task-focused	Personal
Pleasant	Intimate
Natural	Formal
Contrasting	Stimulating
Dim	Relaxed
Bright	Lively
Glary	Detached
Uncomfortable	Boring
Insufficient	Lifeless
Disturbing	Depressing
Unpleasant	Clinical
Unnatural	Demotivating
Tense	Dull

Figure 11: Overview of reaction cards, in categories of visual appearance and perceived atmosphere (Hansen, Bjørner, Xylakis & Pajuste, 2021)

9.3 Sun path and artificial light

This section considered different factors such as daylight, location, and existing fixtures to analyze the space's functionality. For presenting the daylight scenarios, the existing openings were considered: windows and doors. A floor plan has been created together with the sun's position in different scenarios. There are two months analyzed (22nd of July and 22nd of February) and 3-hour scenarios, the first one at 9.00, the second one at 12.00, and the third one at 16.00. For the artificial light, a floor plan with the position of the fixtures was made to understand the user's interaction with the light and see the type of atmosphere it creates.

9.4 Interviews

Csilla

Profile

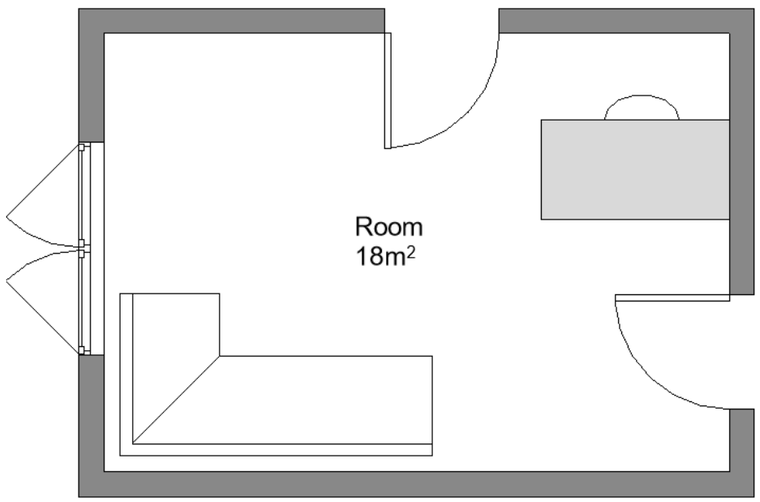
Age: 27

Gender: Female

Nationality: Hungarian

Lives in: Frederisksberg

Profession: Financial analyst



Visual appearance

Task-focused, Comfortable, Natural

Perceived atmosphere

Relaxed, Personal, Cozy

When I wake up, I go to the kitchen to get a glass of water and depending on how early I wake up, I either have time to make breakfast or I come straight to the living room and start my call for work. I open the curtains if my boyfriend is not sleeping anymore. Then I prepare my working space for the day.

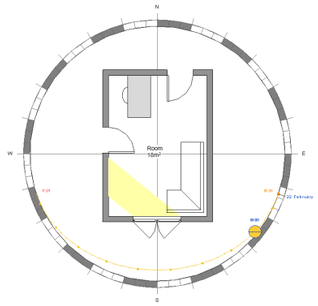
I have my second monitor and my laptop on my desk. We do not have curtains in the living room, just these white ones that we do not use them. I would usually open the windows to air out the room.

When it is a grey day, I turn on my small lamps beside the sofa. We do not have a ceiling lamp so I just turn on those ones for some extra light. Sometimes when I need to focus more on my work, I would use another light next to my computer, but I do not have that in this apartment yet, because we just moved here.

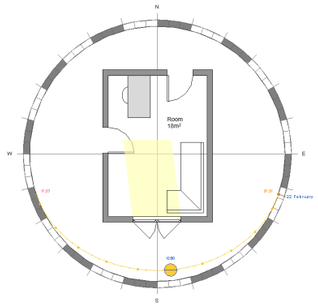
I very much recognize the daylight in my room. Even though it is a grey day, I have enough daylight entering my room. I do not change my setting du ring the day. I don't have enough lights in the space.

Natural Light

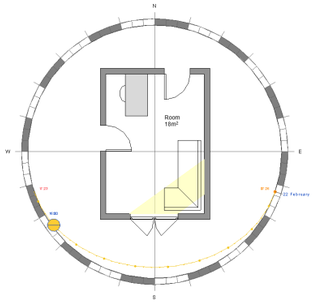
Wintertime, February 22nd



Morning 9.00 AM

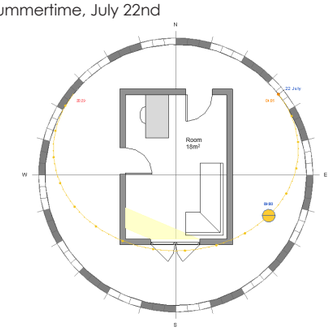


Noon 12.00 PM

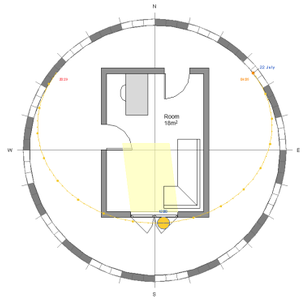


Afternoon 16.00 PM

Summertime, July 22nd



Morning 9.00 AM



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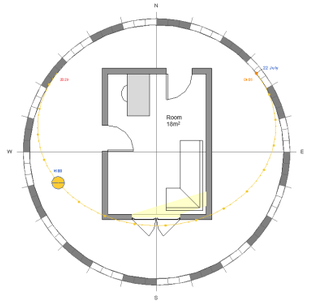
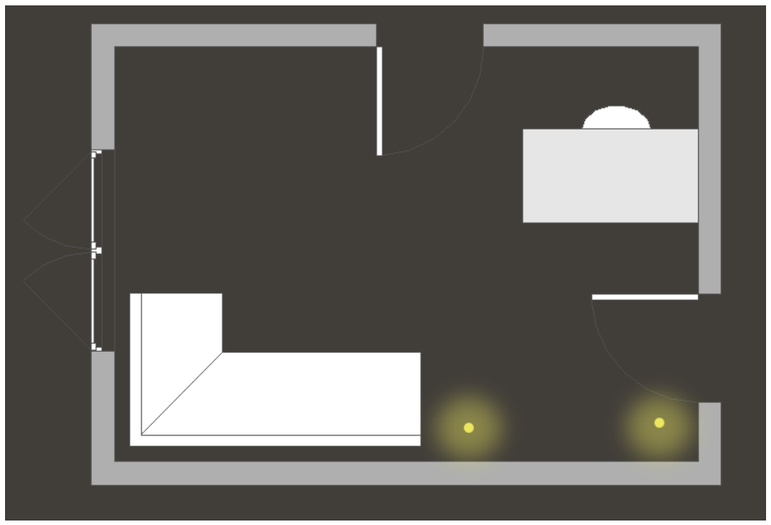
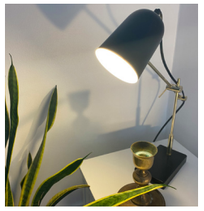


Afternoon 16.00 PM

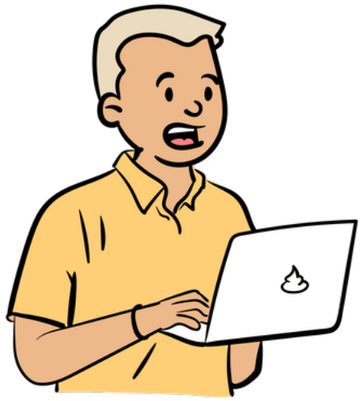
Artificial Light





"I very much recognize the daylight in my room. Even though it is a grey day, I have enough daylight".

Florian



Profile

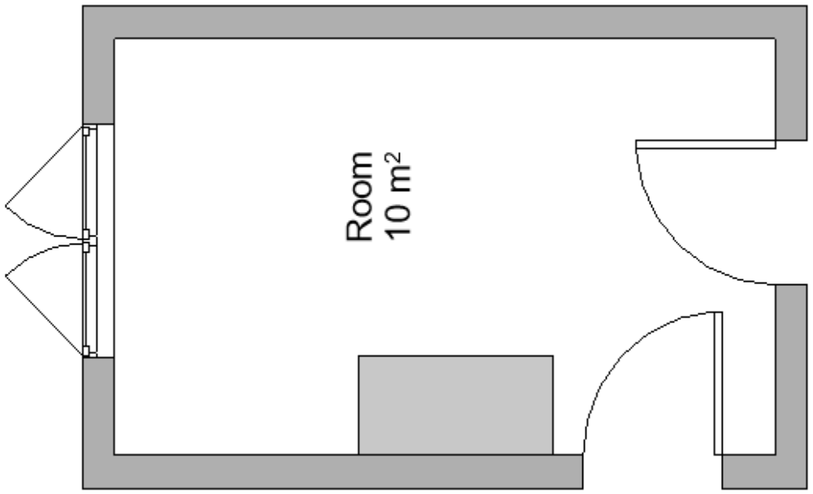
Age: 29

Gender: Male

Nationality: German

Lives in: Frederiksberg

Profession: Supply Chain Manager



Visual appearance

Task-focused, Comfortable, Natural

Perceived atmosphere

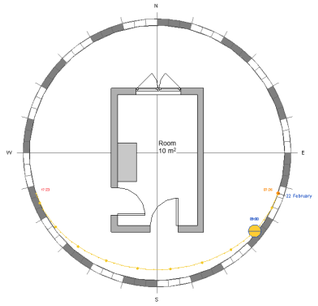
Motivating, Personal, Cozy

When I wake up on a rainy day and go to my office space, there is a short preparation I do, such as turning on the light and airing out the room. If it is a sunny day, I might not need the light,I have a ceiling light and a small task light that I use every day.

The ceiling lamp can change the colour and the intensity as well. I either choose a cold or a warm colour for working but I mostly choose the cold ones because they are the brightest. I like the blue because I feel like the difference between the outside and inside is less.

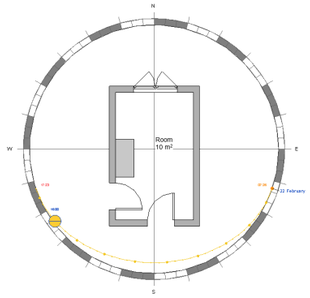
Natural Light

Wintertime, February 22nd



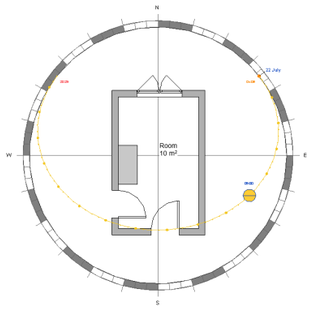
Morning 9.00 AM

Noon 12.00 PM

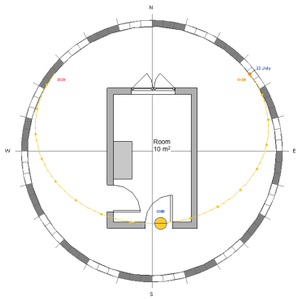


Afternoon 16.00 PM

Summertime, July 22nd



Morning 9.00 AM



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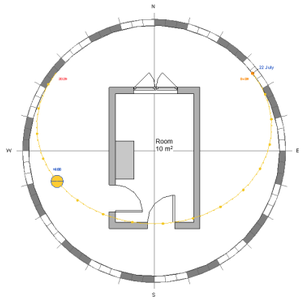
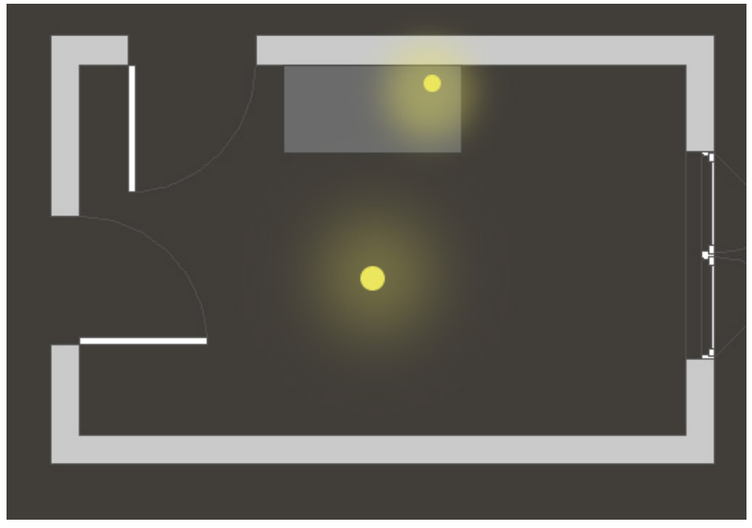


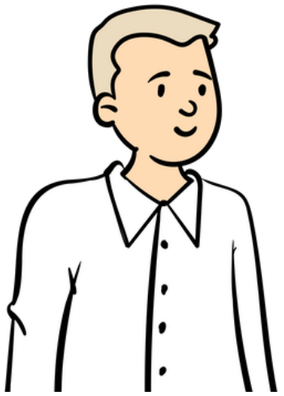
Afternoon 16.00 PM

Artificial Light



“I like the blue light because I feel like the difference between the outside and inside is less”.

Andreas



Profile

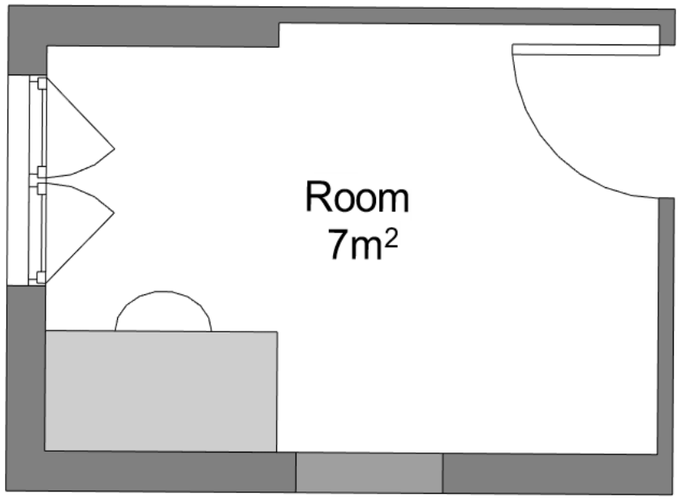
Age: 28

Gender: Male

Nationality: Danish

Lives in: Vanløse

Profession: Client Manager



Visual appearance

Task-focused, Uncomfortable, Natural

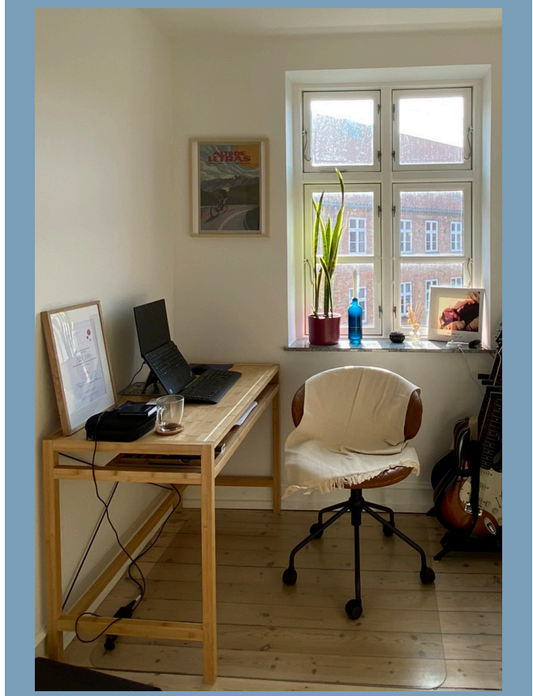
Perceived atmosphere

Motivating, Personal, Cozy

I typically wake up from our alarm clock which lights up gradually and in 30 minutes it fully illuminates the room. So I get up to turn that off, because I can not reach it from the bed. After that I dress up and go to the gym. After I am back, I have breakfast and a shower.

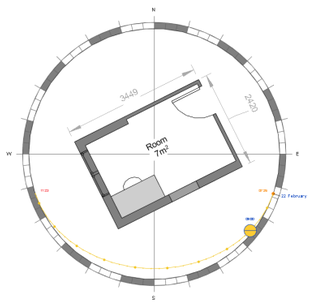
Then I go to my office/hobby room and get to work. I have a small desk and a chair with a blanket on it to make it cozy. There is a fairly large window where I get the natural light. I use artificial light when it is darker. But when it is a sunny day, I do not use any other light source. The light of the screen is not enough for me and I know for a fact that if I have only that then it affects my eyes and my concentration. So I need another light source than the screen itself. I need the surroundings to be lit up.

Sometimes I have problems with the glare on my computer but it is not so bad, because it is in the corner and I can move it around. It is a little bit annoying sometimes but I just deal with it because we do not have curtains.

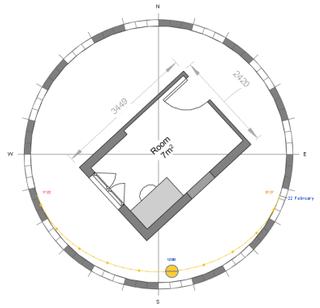


Natural Light

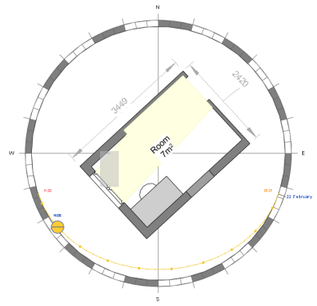
Wintertime, February 22nd



Morning 9.00 AM

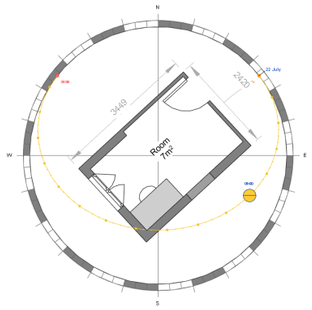


Noon 12.00 PM

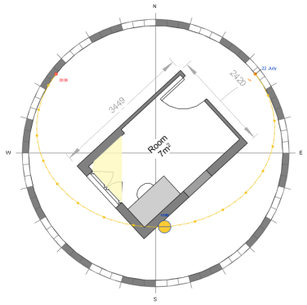


Afternoon 16.00 PM

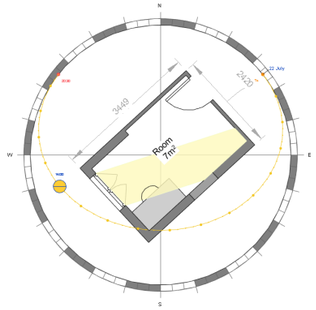
Summertime, July 22nd



Morning 9.00 AM

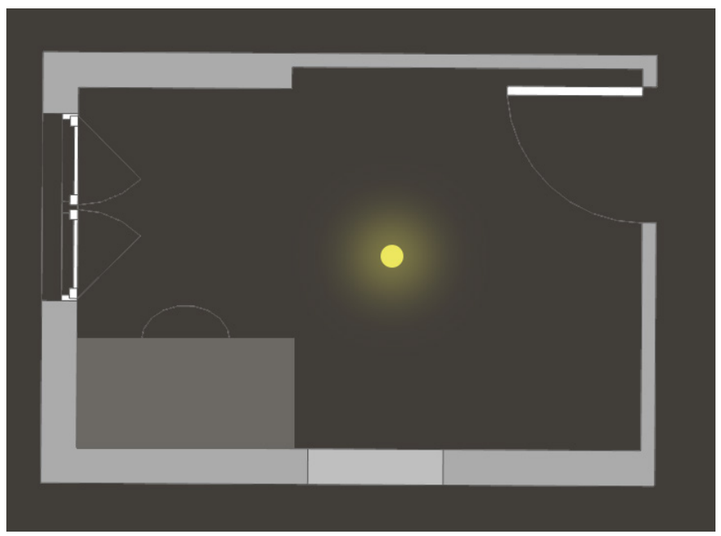


Noon 12.00 PM



Afternoon 16.00 PM

Artificial Light



“ I use artificial light when it is darker. But when it is a sunny day, I do not use any other light source”.

Laura

Profile

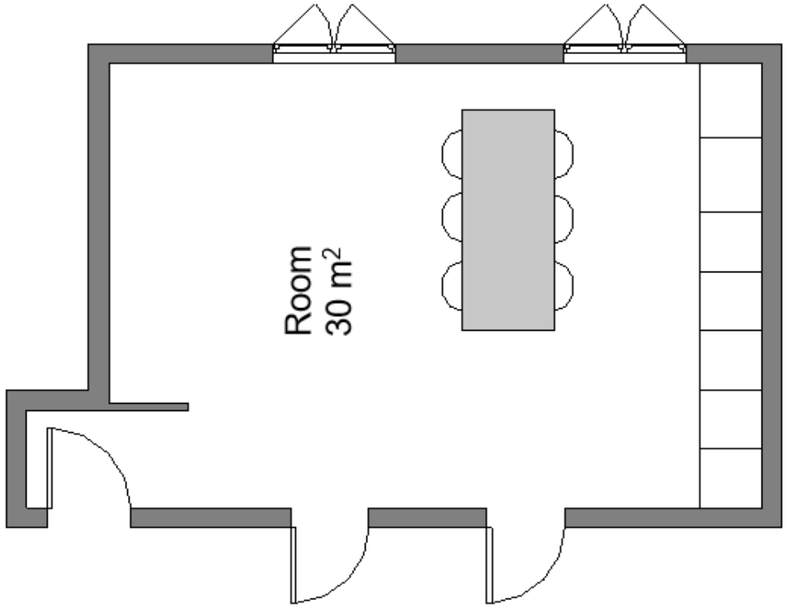
Age: 30

Gender: Female

Nationality: Colombian

Lives in: Vanløse

Profession: Client Manager



Visual appearance

Task-focused, Uncomfortable, Unnatural

Perceived atmosphere

Relaxed, Personal, Cozy

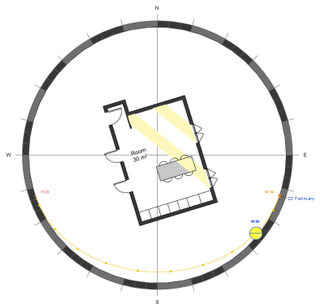
When I wake up to our alarm, I go straight to shower. Then I take my computer to the living room/kitchen. I usually work 1 day from home and 1 day from home. I have my work setting on the dining table. When it is a grey day, which is 90% of the year in Denmark, I turn on the ceiling lamp and the lights at the kitchen cupboard. Even though those two lights are on, I feel like they're still not enough.

When it is sunny, I have the sun in this room in the mornings, but not in the afternoon. The reason why I sit here is because I like sitting close to the windows. Light is very important to me, mostly because if it is a rainy, grey day and there is not enough light, it gives me a headache. It is very rare that I can work without artificial light. Probably during spring and summer I will not use that much, but during winter I pretty much used it every day.

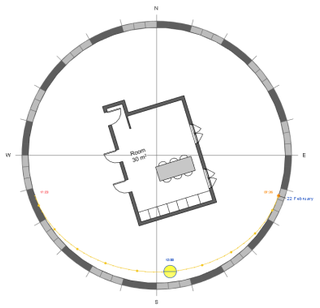
I work in a space connected to the living room area and the entrance, so it is easy for me to get distracted when someone else walks into the room. Currently, I dont think that the lights are enough for my working setting

Natural Light

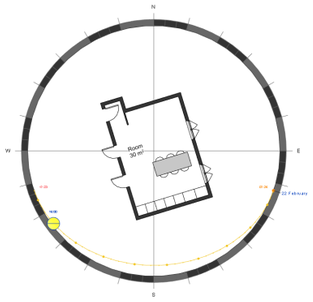
Wintertime, February 22nd



Morning 9.00 AM

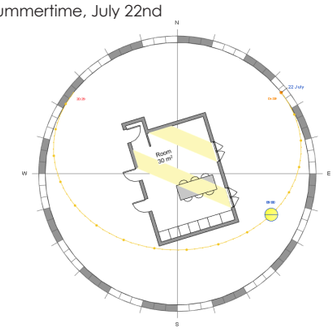


Noon 12.00 PM

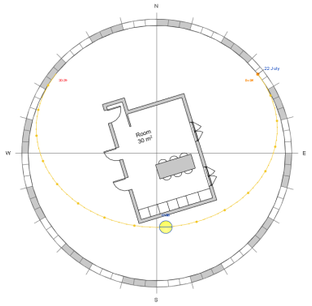


Afternoon 16.00 PM

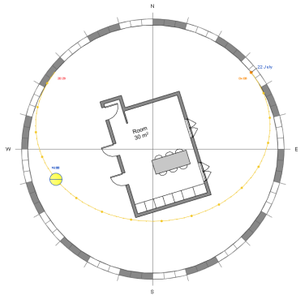
Summertime, July 22nd



Morning 9.00 AM

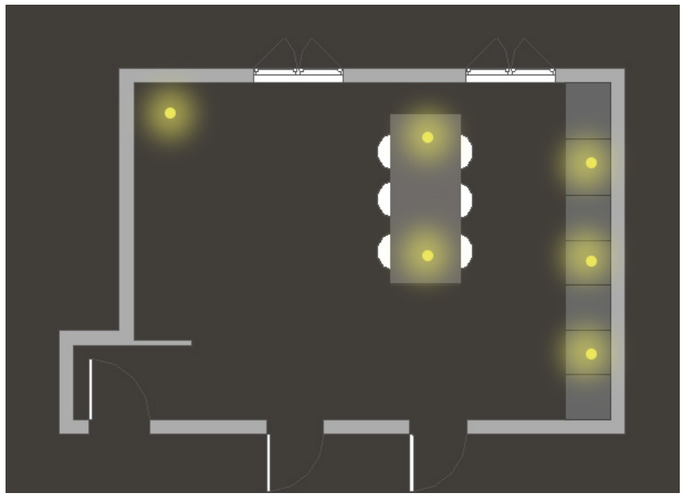


Noon 12.00 PM



Afternoon 16.00 PM

Artificial Light



“Light is very important to me, mostly because if it is a rainy, grey day and there is not enough light, it gives me a headache”.

Devin

Profile

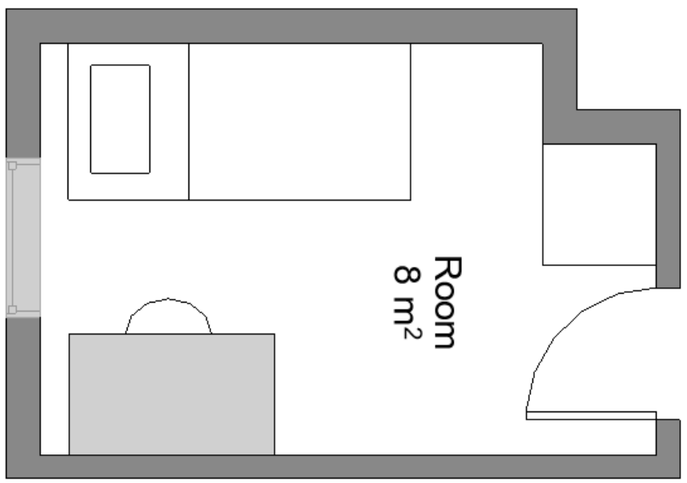
Age: 29

Gender: Male

Nationality: Danish

Lives in: Lyngby

Profession: Google Assistant



Visual appearance

Disturbing, Uncomfortable, Unnatural

Perceived atmosphere

Relaxed, Personal, Cozy

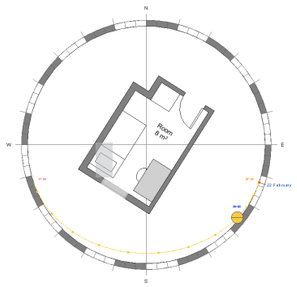
My daily routine might be a bit extreme to some people, but I am very much used to it and I find it working for me so well. I wake up at 4 am every day, whether it is summer, winter, rainy day or sunny day.

I do not have curtains in my room so I prefer summer because the sun is already rising at this hour and it helps me to get out of bed and start my day. It takes me an hour to fully wake up, so I go to shower, have breakfast and get ready for the gym. After the gym I sit in front of my computer in my room. I do not like working from home, because I have a tiny room with a wardrobe, bed and a desk with a chair. It is harder for me to stay focused and motivated when I work from home.

Office is definitely better for me, because I can talk to my colleagues, I do not have to make lunch there and I can ask for help whenever I want to. My desk is positioned beside the window so most of the time I have an adequate amount of daylight for working. Also, I have a second screen which gives me enough light during the day. When the weather is grey I turn on my floor lamp and my small task light as well. I think that I do not have the right settings for working at home, that's why I always preffer the office.

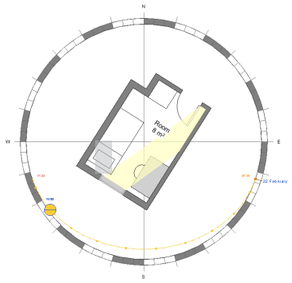
Natural Light

Wintertime, February 22nd



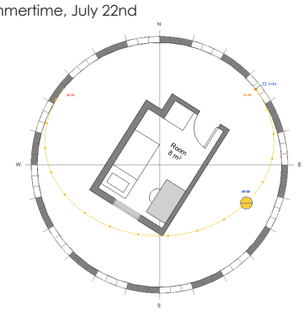
Morning 9.00 AM

Noon 12.00 PM

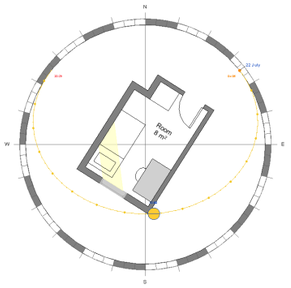


Afternoon 16.00 PM

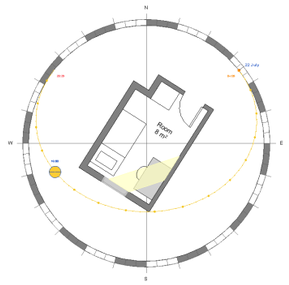
Summertime, July 22nd



Morning 9.00 AM

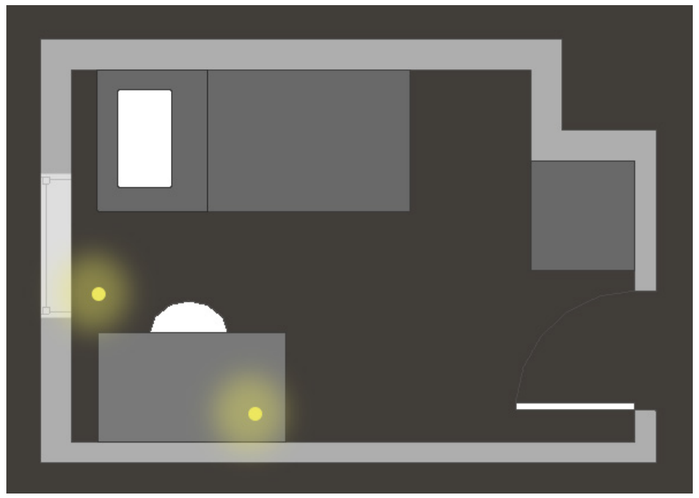


Noon 12.00 PM



Afternoon 16.00 PM

Artificial Light



"When the weather is grey I turn on my floor lamp and my small task light as well".

Magnus

Profile

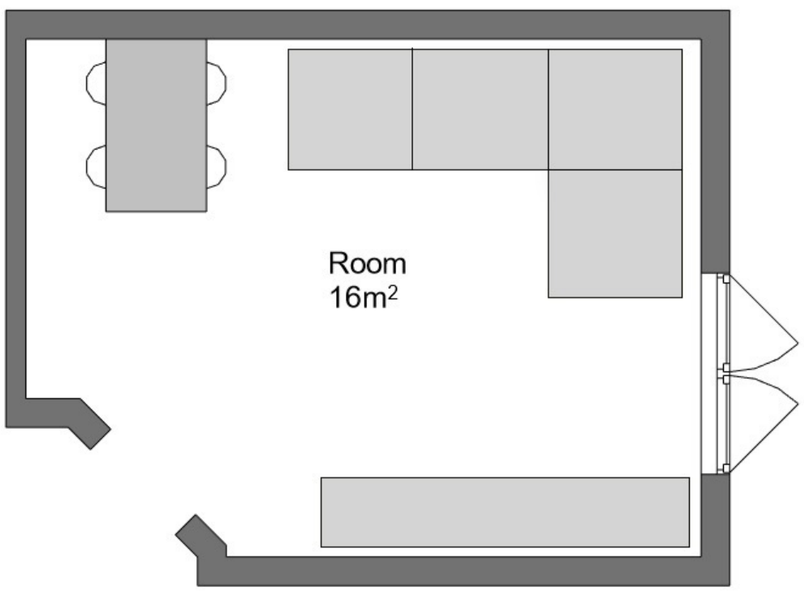
Age: 32

Gender: Male

Nationality: Danish

Lives in: Vanløse

Profession: Security Awareness Specialist



Visual appearance

Comfortable, Contrasting, Insufficient

Perceived atmosphere

Relaxed, Personal, Dull

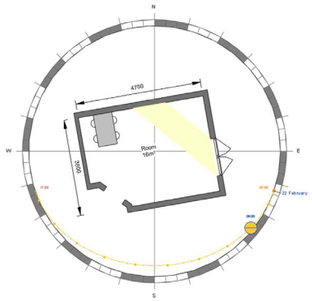
In the morning when I wake up, first I like to have a coffee and take a shower. When I work from home, I have 2 spaces I use for working. It changes because of the light conditions. Sometimes it is in the living room at the dining table and sometimes in the afternoon I move into the bedroom. It is because the light feels stronger in the afternoon in the bedroom and not so much in the living room.

For work, I just use my computer with open curtains. If it is too dark, I would turn on the ceiling LED spots that are dimmable. I need the light for my mental state, I would say. I also have a desk light but I usually do not use that for work. I like the dinning table because it's an open space.

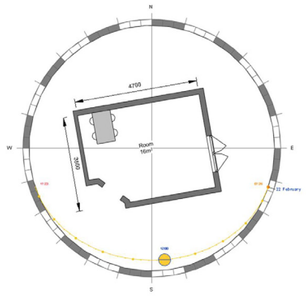
Sometimes for me, is not so easy to work from home because I get distrac ted by different things in my environment. The presence of my colleagues is unavailable and then I forget about my lunch time.

Natural Light

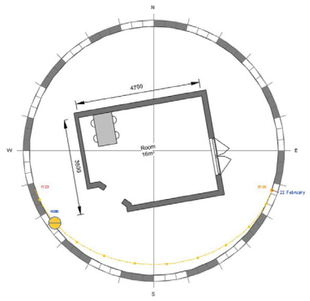
Wintertime, February 22nd



Morning 9.00 AM

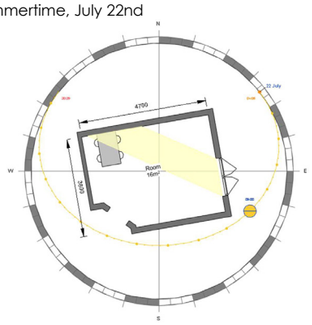


Noon 12.00 PM

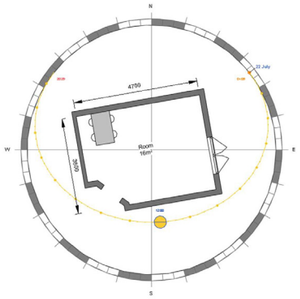


Afternoon 16.00 PM

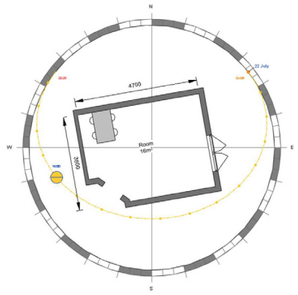
Summertime, July 22nd



Morning 9.00 AM



Noon 12.00 PM



Afternoon 16.00 PM

Artificial Light

"I need the light for my mental state".

Eszter

Profile

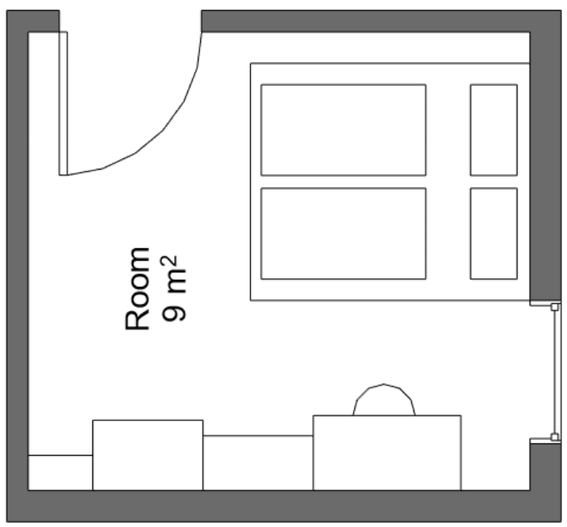
Age: 26

Gender: Female

Nationality: Hungarian

Lives in: Amager

Profession: Student



Visual appearance

Comfortable, Unfocused, Insufficient

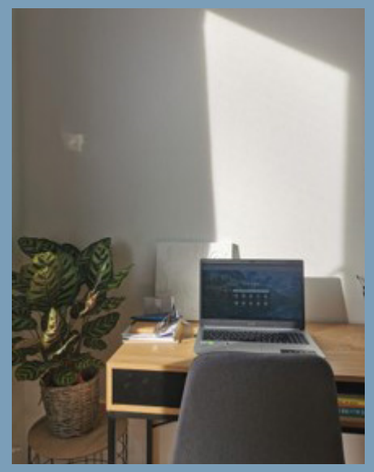
Perceived atmosphere

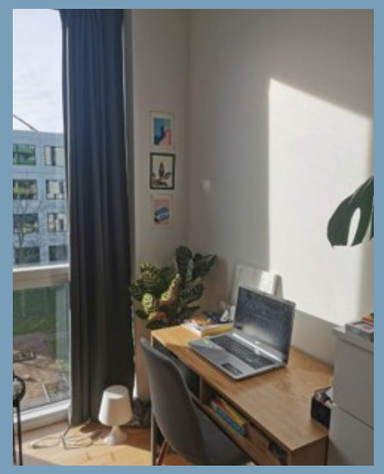
Relaxed, Personal, Cozy

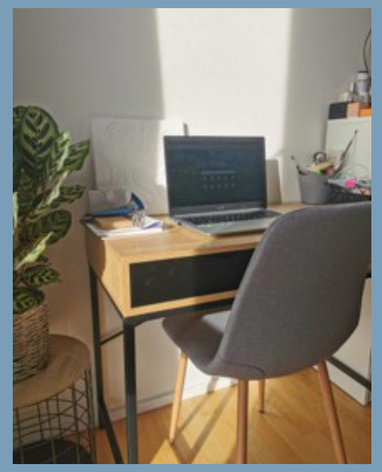
When I wake up, the first thing I do is open the curtains, so I get some daylight into my room. I am a student, so I study from home most of the days. On a rainy work day, I normally prepare my breakfast and coffe, sit by my desk, and turn on some warm desk light. Light always puts me in a better mood and motivates me to do more

Since I live with my boyfriend who goes to work every day at 7 am and comes home at 4 pm, I am pretty much alone the whole day. I get started on my work and studies, but unfortunately, I easily get distracted at my home. My working space is right beside my bed, so it makes it difficult for me to concentrate on my task because there is no visible distinction between leisure time and work time.

Although, when I have to put a lot of effort into focusing on my work, I tend to forget about time. At home, there is nothing and nobody to remind me to take a break. Sometimes my hunger will alert me that I have worked too much and it is time for a lunch break

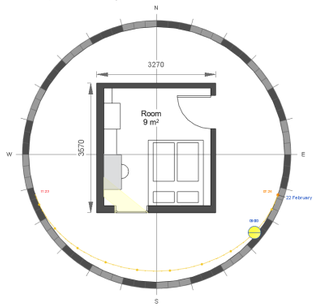




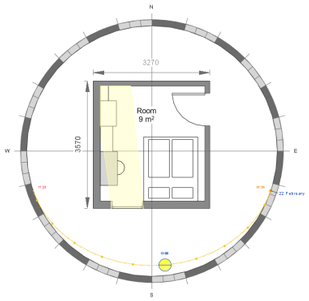


Natural Light

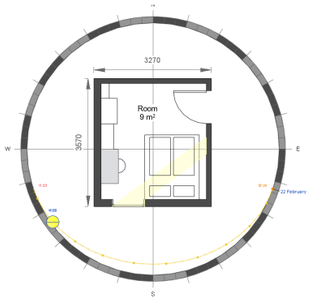
Wintertime, February 22nd



Morning 9.00 AM

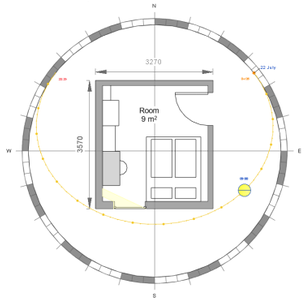


Noon 12.00 PM

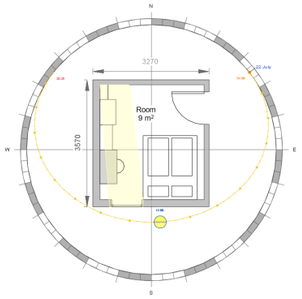


Afternoon 16.00 PM

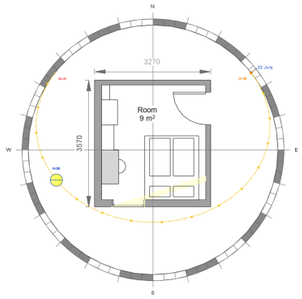
Summertime, July 22nd



Morning 9.00 AM

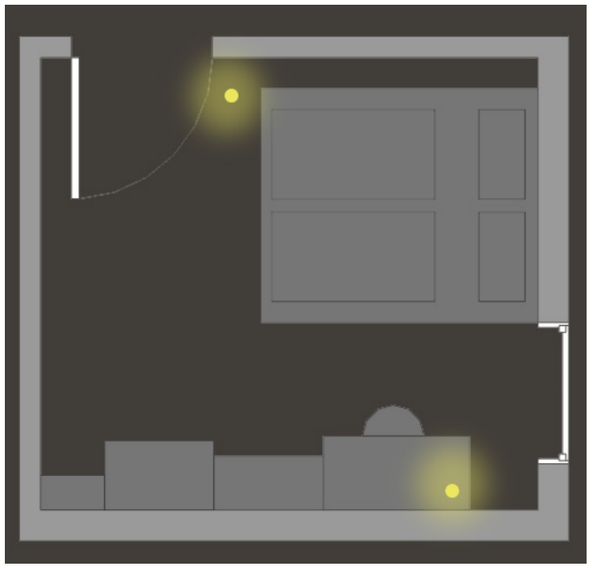


Noon 12.00 PM



Afternoon 16.00 PM

Artificial Light



“Light always puts me in a better mood and motivates me to do more”.

9.5 Unmet needs

Laura: She struggles with blurred boundaries and distractions because she works at the dinner table in their kitchen. It is a shared space connected to the living room area and the entrance, so it is easy for her to get distracted when someone else walks into the room. Currently, the lights are not enough for her working setting.

Magnus: He works from home from time to time and finds it hard to manage his time and home activities because he tends to forget about time. The presence of colleagues is unavailable, creating this "blurred boundary" between work and home.

Eszter: She is a student and works from home every day. It is difficult for her to have a daily routine or schedule because the home atmosphere is monotonous, and there is nothing to remind her that it is lunchtime or time to run some errands. She is home alone until 4 in the afternoon, and sometimes during work, she does not perceive the time, and only her hunger reminds her that it is time for lunch.

Csilla: She works in the corner of the room, which is not the most lit area. Even though she is good at working from home and concentrating on her work, the light settings could help her set up a routine for breaks and work time. On grey days, Csilla does not have enough light around her, so she has to move her light fixtures.

Devin: With the right setting, Devin could have the possibility of working from home, making him feel more comfortable in his own working space. He is aware of his lights, but he only uses them to get a brighter room but not to create the right setting for working.

9.6 Problems

1. Blurred boundaries:

During the interviews and research, blurred boundaries became a popular topic. People seem to struggle with not knowing when their work ends or when it is time for a break when they work from home. Since the office environment with colleagues is no longer present, sometimes it is easy to forget about time, and before you know it, you have spent the whole day working. Hybrid working can also cause this issue. It is easy to go home from the office, open your laptop and finish a task you left undone. One task follows another, and suddenly it is time to go to bed. That is why it is so important to set boundaries and have some rules and a routine. Light can help with finding this balance.

2. Distractions:

Another common issue is caused by getting distracted. This is perhaps the most popular struggle in home offices. People working from home can experience loud neighbours or family members, house chores, pets, or the television running in the background. Indeed, it is not possible to prevent all kinds of distractions with proper light settings. However, light can create a "bubble within a bubble" that could give indirect information to the people around you that you are busy and should not be disturbed—light functions as an indicator of working space.

Figure 12 & 13: Difficulties to do breaks and distinguishing the time of the day (Lopes, 2022), (Rabkina, 2022)

9.7 Conclusion of the analysis

After visiting people's homes, it was noticeable that all these homes had something in common: the warm light and cozy candlelight. It gave an idea of what a Nordic home atmosphere is like, especially in Denmark. In conclusion, the light in these homes depends on many factors like furniture, objects in the space, orientation, time of the year, time of the day, and the space's configuration. Some of the participants do not have a dedicated place to work, so they work in a shared common space such as the living room or dining room.

During the interviews, several problems were discovered in home working environments. Common answers to the perceived atmosphere were found; most participants thought their current space was cozy and personal. This point gave the idea of the importance of preserving the home feeling. When talking about the visual appearance of their task area, some of the participants would find their working space unnatural and uncomfortable or insufficient and disturbing. Only a few participants will find it task-focused since they manage to create a working space in their homes. While conducting the interviews, several participants mentioned their struggles with distractions and time awareness. Therefore, the main two problems explored in this report are: being distracted and having blurred boundaries around a task area.

The thesis aims to develop a lighting design concept that can address these problems within the topics of home working environments. Therefore, to find more answers about Danish homes and their environments, this report will discover and touch on several topics.

10. Literature review

10.1 Home atmospheres

The atmosphere is an important word to describe how a space is experienced, more than the functionality, the atmosphere works to create an environment of possible things to see. It is about individual experiences and has to do with our backgrounds and our perception. A space thus does not contain an atmosphere as a property of the space, but it holds a temporary possession of atmospheres as the entanglement of attunements and the affecting presences and ecstasies of things. (Bille, 2015). The atmosphere can only become a concept if we succeed in accounting for the peculiar intermediary status of atmospheres between subject and object (Böhme, 1993).

Two years ago, the way that we interacted in our homes changed, a pandemic started and people were forced to work from home. The atmosphere of home transformed and became a place to work, have meetings, and attend calls.
In order to understand the atmosphere as a concept that unfolds through, and impacts people's lives, one has to understand the particular kind and character of the atmosphere that people want. (Bille, 2015) The way people perceive something is intrinsically connected to the atmosphere. The atmosphere is the common reality of the perceiver and the perceived (Böhme, 1993).

Home is a personal space where people create a refuge, is a safe space to be out of the world and disconnect, it's a place where different activities take place and where we also live. Mexican architect, Luis Barragan will use a short description to define his home (Ambasz, 1989): "My house is my refuge, an emotional piece of architecture, not a cold piece of convenience"

The atmosphere of our home is unique, it has to do with everything that we put into it, the things we like, our photos, our chairs, our special objects, the floor, the color of the walls, etc. The light in our home has to do with the activities we perform in each of our spaces, light can create atmospheres and shape the way we see things.

Therefore atmospheres are the haze, the mediums, the elements through which perception, and hence human action and understanding take place (Böhme, 1993).
Light is a central element in creating an atmosphere, variations of luminosity, the color of the light, contrast, and different characteristics can make a space change and create particular moods. When it comes to working home environments, light has been shaped, adjusted, and adapted to create a working environment. In the first round of interviews presented in this report, the results showed that most of the participants noticed the light and used it to create a "setting" for work. For them, the home became something else than just a place to live, it transformed into a working station.

Light is about individual perception and the appearance of spaces, symbolism, and significations (Bille, 2015). In the first experiment performed in this thesis, for some of the participants, natural light was one of the desired elements to create a work environment, for some others was the placement and position of artificial light. What is interesting to see is how the answers vary but share a common sense in noticing the light and how people created their own working atmospheres at home.

Light is used for so many things, to guide the moods around an activity; it shapes one's attachment to the activity, whether it is something simple or complex (Bille, 2015). Light is more than the sun, the clouds, the sky, or the fixtures, it is continuously used to shape our lives.

Figure 14,15,16: Images of home atmospheres (Freepik, 2022), (Choi, 2022), (Buck, 2022)

10.1.1 Home lighting

Light in our homes is shaped by everything we do and the activities that take place there. Light in our home creates social bonds and becomes a way of visually separating and carving out spaces that are not physically separated by, say, walls. (Bille, 2019).

Cozy light, especially in countries like Denmark, is an integral part of the identity of the domestic realm as home, a relationship between the quality of light and the identity of the space (Bille, 2019). Research on light has found that it is important to have different sources of light in a room, creating a mix of lighting in order to have different atmospheres. (Higgins, 2022)

The most common way homeowners think is to pay attention to picking out the right furniture and they spend less time focusing on lighting. They care more about the appearance of their light fixtures than their quality. For achieving a professionally designed interior with lighting, there are 3 layers of lighting or types of lighting that should be considered: ambient, task, and accent (ProQuest, 2022).

The ambient light provides general illumination for the home with uniformity. Typically it is a soft light that is dimmable and it can be found in almost all types of rooms. Task lighting, as it says in the name, provides light for specific tasks that need to be carried out, for example, a reading lamp. Accent lighting is used for accentuating some elements of the home, such as wall-mounted pictures or lighting underneath the bathroom or kitchen cabinets. Using all these layers will allow the home to be aesthetically pleasing and functional at the same time (ProQuest. 2022).

Lighting control systems function as a tool to adjust lighting and to create flexibility and preferred settings in space. (Higgins, 2022). Dimmers are a must in every home. It gives you great flexibility and full control over your lighting. You can adjust the light according to the weather, occasions, or time of the day and they are also very affordable (ProQuest. 2022). Dimmable light sources are also a good way to save energy and create different luminous environments. (Higgins, 2022)

Homes present different lighting challenges to workplaces. In a home there are no regulations on lighting, only needs to have sufficient intensity and the correct luminance in order to be adequate.

In Scandinavia it is more common than when you move into your new apartment, the only existing luminaires are the ones in the kitchen and bathroom. So, residents usually take their fixtures with them when they move and move out. People know what lighting they want, but sometimes they are limited by their physical home setting or product availability (Gerhardsson, Laike and Johansson, 2020).

Also, there are cultural factors that need to be considered when it comes to homes or workplaces. In Scandinavia, mainly in Sweden, people choose to leave their lights turned on in unoccupied rooms. Another commonly used light source mainly in the dark season by Danes and Swedes is the candlelight which is considered “cozy”. People’s preference for light is also influenced by the social context, where romantic partners would use lower brightness than a group of friends (Gerhardsson, Laike and Johansson, 2020).

The importance of creating an atmosphere with light has been shown in many studies. The most critical factor for people’s homes was to create a cozy atmosphere (Gerhardsson, Laike and Johansson, 2020).

Figure 17: Illustration of a Scandinavian home (Reddit, 2022)

Richard Kelly presented a different way to understand the role of light. He described three types of light effects central to visual beauty or visual comfort: (1) focal glow, (2) ambient luminescence, and (3) type of brilliants. The first one is related to making the user see, the second one is called the interrupted light, and the third one is the type of light or detail that stimulates the spirit (Kelly,1952). Kelly used these three elements to create an interplay with light and to create an experience out of it (Schielke, 2022). Very often we see that people living in Scandinavian countries like to use light even though they are not in that specific room. They like the lights on because it makes their dwelling homelier. It also allows them to walk from one end to another easier. The most important good lighting factor for homeowners is the ability to see, for example, their food on the dining table or clothes in the wardrobe (Gerhardsson, Laike and Johansson, 2020).

We can say that every human being and every household is different. However, culturally we do things in similar ways. Studies show that Scandinavian countries pay attention to their light fixtures and consciously choose luminaires according to their visual appearance and functionality, such as creating an atmosphere, facilitating visual tasks, providing general lighting, displaying objects, etc.

As stated in this chapter, the light in our homes is fundamental for creating atmospheres, and it is shaped by the social context, the way people interact, and the activities that develop there every day. The atmosphere of our home is unique and personal, and therefore the atmosphere is the element where understanding and perception take place.

Light is one of the central elements for creating atmospheres, has different meanings, and the interaction with it has to do with necessities and personal experiences. Light is about individual perception and therefore is personal. The way people relate to the light in their house after the pandemic has changed, and it has become a process of adaptation to a home working environment. Research on the topic has shown that using a mix of lighting between indirect and direct and dimmable sources can create different settings for a room.

10.1.2 Homey life with Mikkel Bille

As an essential chapter of this thesis, the authors conducted an interview with social anthropologist Mikkel Bille to understand the differences in the home and working atmosphere since the pandemic and get his input on how these two environments can coexist without taking away from each of their qualities.

According to Bille, the home has a lot of personal elements that make your home unique. One of the things he has found is that people create working atmospheres with their objects, transforming the space momentarily.

"The home has become something different when you have your books, your chair or the elements that make your home a home, and suddenly it has to change to a working space." (Mikkel Bille)

One of the questions that we asked Bille had to do with the importance of the home and the working environment coexisting in the space. Bille stated that this can depend on the type of work you have and with this comes a process of adaptation to it. People can adapt the elements to their home, like a comfortable chair, but a chair that has to do with your home and not your work.

Bille personally has been working from home and thinks that the way we relate to it has changed because of the activities going on around us. These activities have to do with the other people that you share the house with. And since we spend so much time there it is easy to see how it constantly changes.

Figure 18,19,20,21: Self-made images of cosy home environments

“I think one way of looking at it, it’s to realize that it’s not a fairytale home, the actual home where people live is also a place of chaos. I’m not saying that it should influence the design but it’s just to think about it. It is nice and good with candlelight and nice designer lamps but that doesn’t mean that it is cozy because people may also be shouting.” (Mikkel Bille)

During the interview, questions about creating the balance between home and work were asked and one of the answers was to create a division between your home and work feeling. His answer to this question was that instead of blending the two atmospheres, it might be a good idea to box them off instead, where the home stops at some point and becomes something else. He thinks the problem comes when you have office-like furniture because it will never become the home again. So, the question here is how we can make a design that supports homeliness except when you work.

Bille also talked about the difference in the intensity of light depending on the activity, and that this can create an atmospheric life inside the house. He mentions the importance of framing these activities to create a distinction between the home and work time.

“In a home, there are different spheres, where at one point it acts as something, and at another point, it is something else. Even though it is the same infrastructure and the same objects, people manage to create different atmospheres and transform the space from private to the work-related atmosphere.” (Mikkel Bille)

Figure 22: Illustration of Danish hygge (Peet, 2022)

To sum up the interview, it is desired to have the ability to transform a space from one atmosphere to another without changing the surrounding elements and leading to significant flexibility for the users. This could also mean that the luminaires placed in our homes, the elements around them, and the possibility of having a setting could create both cozy and work-related atmospheres.

The interview outcome has served as a reference to understand how the interaction between home and work has changed since the pandemic. A home is not only a personal space but a space where there is chaos, and different activities are going on. People have been adapting to a way of living and creating their working environments. The interview also showed an interesting idea of combining the home and the working environment by creating different “spheres” or “bubbles” that could let the user adjust and create the setting for both scenarios. Light, in this case, could create a division between the atmosphere and frame the activities to create a distinction between the home and the work time.

The interview was conducted on the 24th of March, 2022 at Roskilde University. More information and the transcript can be found in Appendix.

10.2 Light and work

To understand the relationship between light and work, it is necessary to understand three main aspects that affect human performance: the visual system, circadian timing, and mood and motivation (Boyce, 2003). The visual system generates images that can produce emotional responses and affect our mood and motivation. Lighting conditions are part of this world of images and for that, they should be suitable for different activities.

Studies have demonstrated that lighting conditions can alter task performance, giving a base for designing appropriate lighting recommendations. Exposure to bright light for 5 hours has been shown to increase alertness and improve performance on tasks (Boyce, 2003). Other studies have shown that exposure to 2000 lx provided by daylight for 30 minutes in the afternoon can increase alertness but has no effect on the performance of a cognitive task (Boyce, 2003).

Research on the alertness of people showed that the effect of two 1 hour exposures at different times (morning and afternoon) to two illuminances (200 and 1000 lx) provided by light sources with a CCT of 4000K on the performance of a vigilance task and on feelings of alertness and visibility was measured (Boyce, 2003). The results showed that at the higher illuminance, people felt less sleepy and more energetic at both times and had shorter reaction times at the vigilance task, particularly in the morning (Boyce, 2003).

So far there is no real evidence about scheduling times for light, the study of the role of light depends on many factors like circadian timing system, vision, background, conditions, space, and so on. To state what lighting conditions are necessary requires extensive and careful study before any definite conclusion (Boyce, 2003).

Recent research made in the last year about the pandemic found that task lighting is important for creating the right environment for working both in the office and at home. Lighting environments are significantly associated with concentration at work, creative tasks, and the ability to relax and refresh with ease (Umishio et al., 2022). The same study showed that workers felt lower satisfaction with lighting environments at home than in the office. One of the main reasons is that home is typically a place for rest and relaxation, and standard or home fixtures may be unsuitable for work (Umishio et al., 2022).

As a starting point, lighting does not produce work, it simply makes work requiring the use of the visual system possible. How much work is done and the quality of it depends on many variables but one of the most important is motivation (Boyce, 2003). If the light causes visual discomfort or introduces distraction through glare or flicker it is likely to generate negative feelings and change the mood or the motivation (Boyce, 2003).

Light can serve as an element to generate positive effects on people and as a part of the physical environment, the lighting conditions such as illuminance and CCT can help to improve the mood. Light is one of the factors that can influence the environment but not the only factor to consider as well.

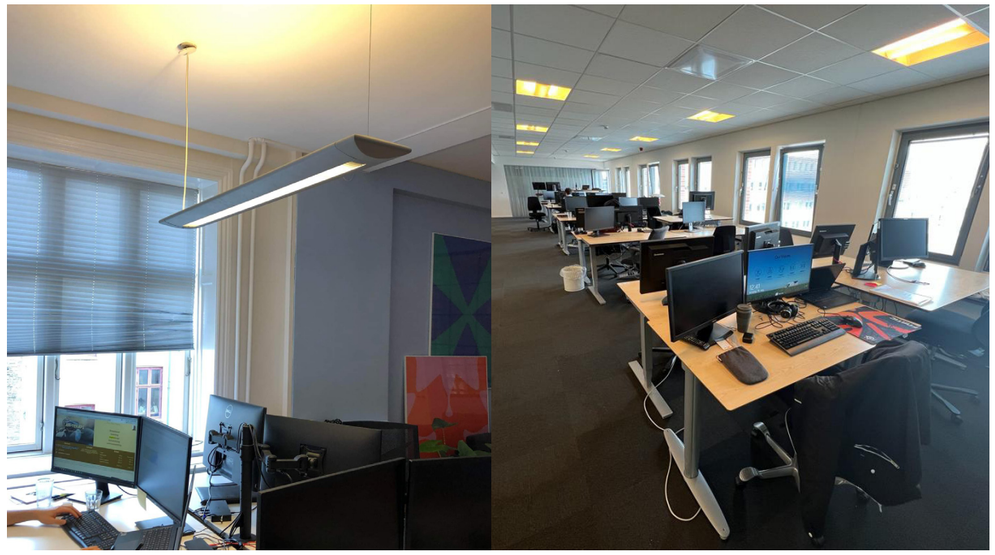


Figure 23 and 24: Self-made images of office space lightings located in Copenhagen

10.2.1 Review of office lighting

There have been many changes in the offices over the years when it comes to lighting. Back in the day, when people used to carry their work out on a horizontal plane, the increased amount of light in the office made the surface more visible. However, today in the computer-based office we can not light up the room too much, otherwise, the screen would become less visible. This change in technology made a change for lighting an office.

Back in the day, when the technology was not very evolved, daylight from windows had to be tightly controlled in order to avoid reflections on the computer screen. Usually, the office had a lot of light on the horizontal work plane and little light on the walls and ceiling, which created a cave-like appearance. Fortunately, today's computer technology is more advanced, where the screen is rarely affected by light. Today there are illuminance recommendations for the work plane, vertical plane, walls, and ceiling in the office.

The European Standard DIN EN 12464-1 recommends the following illumination parameters:

- Work area: 500 lux
- Direct surrounding: 300 lux
- Background: 100 lux

Every human being has different needs and different preferences when it comes to light. To ensure that the office workers have their desired illuminance, they need to be provided with individual dimming control.

One of the most essential factors for lighting up an office is the balance between daylight and artificial light.

10.2.2 Light in working environments

Daylight

Daylight is the external cue that helps us synchronize our biological rhythms, like hormone production, temperature regulation, alertness, mood, and sleep cycles. Daylight allows us to see better and impacts our mental health and well-being. It is an important regulator in our everyday lives.

Recent research on daylight at the home office suggests that people desire daylight more than artificial light and the possibility of being next to a window has been one of the key elements of working from home. People relocate their workstations near a window and have more tolerance for glare and visual discomfort (McKee & Hedge,

Electric light

The disadvantage of daylight is that it fails every day for a long period of time. Therefore, electric lighting is essential in every office after dark hours or when the light levels from daylight are not sufficient enough.

Colors in offices are very important for several reasons. The color difference between a task and its immediate background plays an important role in visual performance. When the luminance contrast is on a low level, a strong color difference between task area and background can increase visibility. Moreover, different colors enhance the speed of visual search or certain colors can have a strong meaning such as warning signs (Boyce, 2003).

For this exact reason, it is important to use light sources with high CRI.
The most commonly used light source in an office used to be the fluorescent lamp and the range of CRI is 50-98 while the CCT is between 2700 and 17000 K. However, today LED's have taken over the working environments and become very popular. High CCT should not be used at low illuminances and low CCT should not be used at high illuminances according to Kruithof's work. High CCTs can be considered unpleasant when high illuminances are used.

The CCT can vary according to preferences and it has a minor factor in determining satisfaction in an office. However, the illuminance is much more important than the CCT. When it comes to CRI, values above 80 are recommended, since they produce more saturated surface colors and a perception of greater brightness. A light source with a CRI lower than 65 will be unsatisfactory. The color properties of a light source can influence the space but it is important to keep in mind that the color content of the decor in the office can modify these properties (Boyce, 2003).

Figure 25: Color remperatures (Color temperatures, 2022)

The light distribution influences the perception of the office and it can be perceived to be primarily lit by daylight or by electric light. If the average daylight factor (DF) is more than 5%, the space will be perceived as daylit and anything less than 2% will be perceived as electrically lit (Boyce, 2003).

Electric lighting delivery systems

Regular offices are usually provided with a uniform illuminance across the horizontal work plane. This gives freedom to rearrange the furniture because the illuminance will be almost the same everywhere. The preferred office luminaires are either direct, indirect, or a combination of both. The arrays of them give different appearances to a room. When the light distribution is narrower, the flow of the light is more vertical and in this case, the luminaires are placed closer to each other. This type of luminaire will give a great amount of light on the working plane but very little or none on the walls around. Not only the walls and working planes, but the ceiling also needs to be lit up properly. Most luminaires give light to the ceiling by being reflected from other surfaces. It can lead to a cave-like feeling if the ceiling appears gloomy or it can lead to unappealing shadows (Boyce, 2003).

10.2.3 The Double Dynamic Lighting design approach

After experiencing the pandemic, it was easy to see how people would spend most of their time indoors, related to both the work engagement and the restrictions of being at home.
"Research on the psychological effects of light, including window access, has revealed effects of visual qualities on objects and the distribution of light in a space can impact work satisfaction and engagement" (Hansen, Bjørner, Xylakis & Pajuste, 2021)

Part of this thesis refers to a new approach to lighting developed at Aalborg University called Double Dynamic Lighting. This approach considers daylight and artificial light as two important components of creating an interaction between directional task lighting and diffuse ambient lighting. The method uses different intensities and color temperatures of light to create variations in the working environment.

The Double Dynamic Lighting uses two daylight components: the direct warm sunlight and the diffuse cool skylight as the main source of light combining electrical light in the interior of a space. Research on this approach experiments on using color temperatures between 2000 and 3000K for warm colors, 3000 and 5000K for neutral colors, and 7500K for cool colors. This selection of CCT is based on the reflected daylight from a clear blue sky perceived as cool white in appearance. In an overcast sky, the colors are perceived as more neutral like white daylight. The warmer colors are the variations of transition hours where the sun rays are more scattered depending on the hour of the day. (Hansen, Bjørner, Xylakis & Pajuste, 2021)

"The direct task light has warm and neutral color temperatures with reference to the direct sunlight, whereas the diffuse ambient light has a neutral or cool color appearance referring to the skylight". (Hansen, Pajuste & Xylakis, 2020)

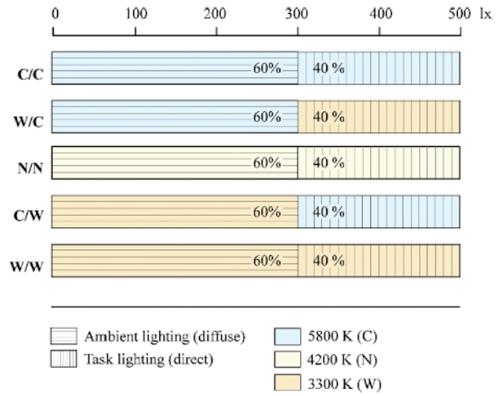


Figure 26: Settings withe with corresponding CCTs and combination of ambient and task lighting (Hansen, Bjørner, Xylakis & Pajuste, 2021)

The concept of double dynamic lighting has different approaches such as the ability to change the intensity and the color of the light by using a controlled setting or dimmer. This has served as a reference to create different settings for studying CCT and illuminance levels in work environments. The result of this method has the potential to create customized and individual settings for task lighting combined with the dynamics of the sky. This method uses the light for different tasks and allows the users to control the intensities and colors of the light helping them to meet their individual needs.

"The positive lighting also led to better mood, higher work satisfaction, and greater overall engagement in their work." (Hansen, Bjørner, Xylakis & Pajuste, 2021)
Following the DDL method, this thesis evaluates visual comfort and the perceived atmosphere in different participants as a tool to understand the importance of how people relate to their own home workig spaces and how light is affecting the space and the surroundings. Also, it takes into consideration the different direct/ diffuse ratios between 40/60 to create a better visual appearance and avoid uncomfortable contrasts. (See figure *26*)

As described in the method, the visual appearance is defined by the following light qualities: a directionality of the electrical lighting, an uneven spatial light distribution establishing an illumination hierarchy, and different light zones. The perceived atmosphere is defined as the subjective experience and effect of being in the space, relating to psychological well-being and motivation, such as the space being motivating, personal, natural, cozy, and stimulating. (Hansen, Pajuste & Xylakis, 2020)

10.2.4 Preferred CCT and illuminance for work engagement

The light in a working environment may differ from person to person. It has to do with different things and differs depending on biological rhythms, work content, individuals, and their health condition (Miki, Motoya, Ikegami & Fujimoto, 2013). Previous studies and tests made on color temperature and illuminance suitable for working engagement have shown that there is a relationship between how people set their lights: preferred color temperature and illuminance have to do with the time of the day. (Miki, Motoya, Ikegami & Fujimoto, 2013). Therefore it is important to create a suitable lighting environment where people can control and dim the lights according to their mood, task, and time of the day.

Experiments related to preferred CCT and with fixed illuminance also showed that there is a relationship between the contrast of the screen (computer or laptop) and the fixtures placed. This study showed that people prefer changing the intensity of the light rather than the color temperature when setting the optimal environment when performing work. (Miki, Motoya, Ikegami & Fujimoto, 2013).

Studies on alertness and work engagement have shown that lower CCT, (<2000K) are not suitable for working. CCTs of about 3000 K might be useful for situations where melatonin suppression and shifts in the circadian rhythm should be avoided (Kraneburg, Franke, Methling & Griefahn, 2017).

According to different manufacturers of fixtures, the color of the lighting for working environments should be around 4000 K. This type of bright white light can help to support alertness and concentration (Ledvance, 2022). Research on this thesis showed that the preferred CCT for offices is around 3000-5000K. The illuminance is another factor preferred by the users and the distribution of the light has an impact on how people perceive space. From the different studies referred to here, it was possible to see that people preferred to control the illuminance of their work area.

For defining the color temperature for the home environment and the work environment a scale between 2000K and 5000K will be used throughout the works of this thesis. CCTs of 2000K to 3000K to represent the warm white colors and CCTs of 3000k to 5000K to represent the neutral white colors.

Figure 27: Self-made picture representing the scale of CCT intended to use

10.2.5 Task Lighting

The distribution of the light and the type of light are two important factors to consider to perceive and work in a space. In common office settings, light has to do with many things: standards, type of space, furniture layout, and some other limitations that don't allow the user to customize their own light. In a home working environment, this is different, the user chooses where to sit according to what they think is best (Boyce, 2003).

Task lighting is known as a non-uniform lighting concept. They are placed close to the work surface. It is an effective way to light up an area for a given task, but it can create unwanted reflections and shadows. To minimize this issue, indirect ambient lighting should be added (either daylight or electric light) which would give a more pleasing effect to the room and the task area as well. (Lighting methods FML, 2022)

Luminaires used in common office settings can be classified into three types: direct, indirect, and direct/indirect. The distribution of these lights can create different atmospheres and will depend on the luminous intensity that the fixture is emitting, the angle, and the distribution of the lights (Boyce, 2003).

In the case of direct lighting, the narrower the luminous intensity distribution, the closer the luminaires have to be next to each other to create a lot of light on the horizontal working plane but very little on any vertical plane. In this case, the light that reaches the ceiling is only reflected by the surfaces. For indirect lighting, the use of it will have to do if the light desired wants to be diffused and with very few reflections (Boyce, 2003).

A combination of direct/indirect lighting will help to create a contrast in the working setting. The indirect component softens any shadows and veiling reflections and provides some light on the walls. The direct component provides stronger modeling and offers some relief from the boring uniformity of indirect lighting. Direct/indirect lighting can be a possible solution to create a suitable environment for work, but there is another alternative that has the potential of creating an individual workstation and is task/ambient lighting. (Boyce, 2003)

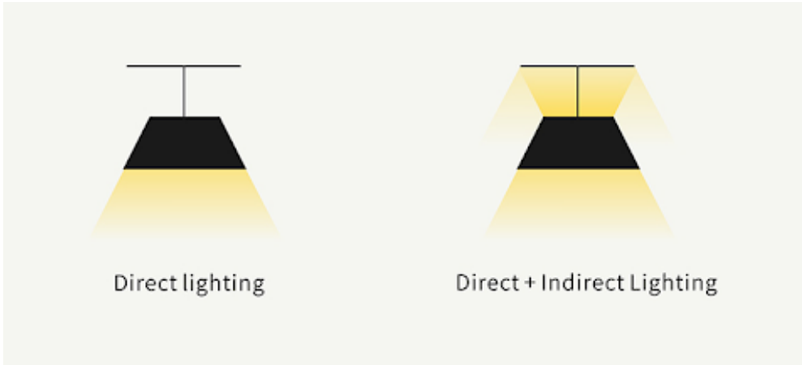


Figure 28: Direct and indirect lighting (Xiao Lei, 2022)

Task lights can have different forms, from the free-standing to the fixed under-shelf that allows the light source to be positioned in many different ways. All this task lighting can be suitable for switching on and off and also for diming, creating potential energy savings (Boyce, 2003). This consideration means that the light can be arranged in any way, letting the users control and adjust their own lighting according to their necessities. Standards in North America and in Europe recommend that the average illuminance of a task area should be around 300-500 lux (Boyce, 2003). Although, it is important to mention that this may not guarantee comfortable lighting without considering many other aspects around the space.

10.2.6 Light characteristics

Direction and Distribution

The desire to sculpt light into shapes and patterns is a timeless phenomenon that finds its roots in different constructions all over the world. These works have provided examples of how light can be channeled into novel forms to produce unexpected effects and serve specific purposes. (Descottes & Ramos, 2013)
One good example of this is the Pantheon of Rome. This building was designed to sculpt light into a powerful, independent form evocative of the divine spirituality it aimed to embody. Through the course of the day, there is a projected circle of light that emerges from the oculus and sweeps the circumference of the dome (Descottes & Ramos, 2013).
In this case, one principle of light is used to channel the light: the directionality and distribution. This principle creates a mysterious space of great atmospheric extremes. The channeled light calls attention to itself and the space illuminates, while the rest of the Pantheon´s interior remains in secretive shadows. (Descottes & Ramos, 2013)

“The careful control of distribution and directionality of light is a lighting designer’s most powerful tool in defining and revealing the limits of space.” (Descottes & Ramos, 2013)

Lighting designers are sculptors because they can determine the form of light. Light can have different directions, beam characteristics, and forms. The principle of light is direction and distribution which covers the shape, aim, and beam characteristics. A wider beam illuminates a greater area while a narrow beam cuts through space to highlight a specific area. There are three words to describe directionality: up, down, and multidirectional. The way it lights up an object is direct or indirect. The light distribution is either concentrated or diffused: concentrated is focused on a more narrow area and diffused is more scattered over an area. Diffuse lighting can be utilized to create shifting atmospheres and mystical backdrops, while directional light can create the illusion of stasis, of a concrete place revealed at a precise time (Descottes & Ramos, 2013)

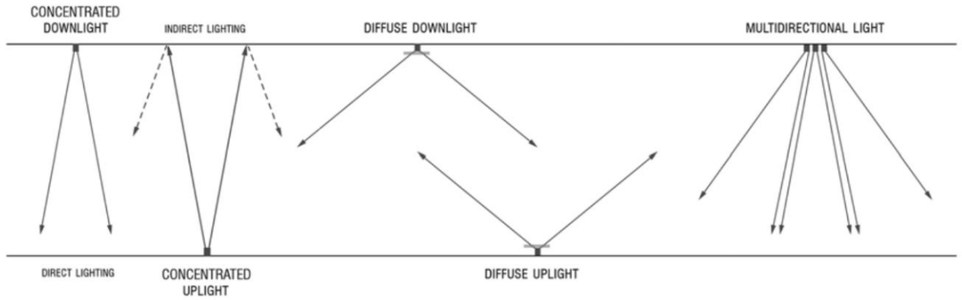


Figure 29: Direction and distribution of light (Descottes & Ramos, 2013)

In addition to its ability to visually expand or compress our perceptions of space, the direction and distribution of light have the capacity to accentuate or negate the presence of objects and form.“ (Descottes & Ramos, 2013)

A fixture is designed to focus light in different ways, depending on several factors such as activity. For a task-focused area, direct lighting is commonly used. Direct lighting shines 90 to 100% of its light on the work area. The area that is lit downwards on the horizontal plane depends on the characteristics of the luminaire. The light can be concentrated on a small area or spread evenly on a wider area. Although it is important to be careful with this lighting because it can cause glare on our task area. A good solution for this problem is the possibility to change the position of the fixture as well as to be able to change the intensity of the light. (Lighting methods—What works best for different situations - FMLink, 2022)

Height

The height of a fixture can affect the spread, intensity, and perceived brightness of a light source. Lower height has a narrower beam and illuminates a smaller area, while increased height has a greater diameter of beam and illuminates a bigger area. The height also ensures the space's functionality. Task lighting demands a lower height which illuminates the anticipated task so the activity can be successfully performed. (Descottes & Ramos, 2013)

As a partial conclusion of this chapter, light in working environments has to do with task performance, concentration at work, and the ability to relax. Light does not produce work but serves as an element that can change the mood and motivation in these environments. Many factors related to light should be considered to improve work engagement.

Several methods like Double Dynamic Lighting have been researched about the interaction between directional task lighting and diffuse ambient lighting; this method focuses on different intensities and color temperatures of light to create variations in the working environment.
Further research on the topic has helped to determine that direct and indirect lighting can create a contrast in the working setting. In order to achieve this, it is also essential to consider specific characteristics that the light has, like direction and distribution combined with the height and the illuminance desired in the task area.

10.3 Light effects on health

10.3.1 Non-visual effects

Back in the day, when natural light was the only light source, we depended on the sunrise and sunset. It controlled our day and the time we woke up and went to sleep. (Van Bommel, W.,2006)
Our eyes used to be known as an organ that is responsible only for our vision. However, there has been a discovery of a new photoreceptor cell, the ipRGC. They are responsible for our non-visual system and control biochemical processes in our body. The most important process is the biological clock and the regulation of the melatonin hormone. The production of melatonin is happening in the pineal gland and it depends on the light levels. When there is a lot of light coming into our eyes, the level of melatonin drops and it increases during dark hours. This is a very important cycle for us to stay healthy. In case our biological clock is disturbed, it can lead to serious health problems such as depression or dementia. (Van Bommel, W.,2006)

It has been estimated that today people spend 90% of their time indoors, where we are exposed to lower light levels. While the light levels meet the standards for visual tasks, it still impacts our health and well-being. (Hansen & Mathiasen, 2019). The lack of natural daylight and vitamin D can develop into seasonal affective disorder (SAD), which is a type of depression that has been common during winter times when there is not enough daylight such as in Denmark. (Zielinska, 2018)

10.3.2 Circadian rhythm

Every living creature has a biological clock that controls circadian rhythms. This rhythm has been majorly disturbed by the usage of artificial lights. The circadian system regulates our physical, psychological and behavioral functions such as alertness, mood, sleep, and even body temperature. These changes follow an approximately 24-hour cycle that primarily responds to exposure to light and darkness. (Zielinska, 2018)

To understand the circadian rhythm better, these two hormones have to be mentioned: melatonin and cortisol. They are responsible for our healthy daily rhythm. Cortisol is the stress hormone, which increases our blood sugar in the morning and therefore keeps us energized during the day. At night time, melatonin takes over our

Figure 30: Circadian rhythm (Yolanda Smith, B., 2016)

10.3.3 Blue light

Electronic screens such as laptops, computer monitors, phones, and tablets have become an everyday tool in our lives. These typical screens emit blue wavelengths meaning that people are exposed to a large amount of blue light most times of the day (McKee & Hedge, 2022). The importance of exposure to blue light has to do with the regulation of our circadian rhythm and maintaining a healthy environment. Blue light activates the intrinsic photosensitive retina ganglion cells (ipRGCs), cells helping regulate the body's internal clock (McKee & Hedge, 2022).

Blue light from screens can have a negative impact on the human eye and damage different eye cells. Research on visual performance has shown that blue light can lead to ocular damage such as dry eye, cataracts, and other forms of macular degeneration (McKee & Hedge, 2022).
Most of the exposure to blue light through screens has to do with reducing our melatonin production and having a huge impact on sleeping.

Although not necessarily only blue light has negative impacts on health, some research has focused on the relationship of using blue light in the morning, showing that it could help to reset the circadian rhythm (McKee & Hedge, 2022). Blue light can help to dictate awake sleep cycles and regulate the internal clock, regarding the time of the day.

This combination of research suggests that blue light has an important influence on our daily lives and can have negative impacts if it is used unwisely.

As discussed in this chapter, light, and lighting technologies have the potential to add health benefits to the non-visual effects of lighting. Therefore it is crucial to provide the right amount and spectrum of light at the right time.
As a partial conclusion to this chapter, it is essential to mention that bad lighting can seriously impact our health both physically and mentally. When designing with light, offices should consider the health effects since the employees carry out focused related tasks. However, in a home, it is not the same principle. Sometimes people do not know what light is beneficial for them; they mostly choose fixtures according to their appearances and something that fits their interior. Daily, we do things in our home that can disturb our circadian rhythm, such as using electronics at night and not paying attention to the blue light emitted from these screens. This chapter provides crucial information on what we need to consider when buying our light fixtures.

11. State of the art

After analyzing the literature review, study cases will be presented to summarize the general concept of atmosphere, CCT, illuminance, and type of light (natural or electrical), showing the importance of considering these aspects while designing for environments with work engagement. There is a contrast between the light at the office and the home in these cases.

Different cases from home and working environments will be presented to show the characteristics of the atmosphere and the type of light in different settings. It is important to mention that there is a combination of the use of electric and natural light in these cases. The cases are used as examples.

11.1 Light at home

Figure 31: Cases taken from different companies and lighting designers. See ref: (Louis Poulsen 2022), (Delta Light 2022), (Kreon 2022)

11.2 Light at the office

Figure 32: Cases taken from different companies and lighting designers. See ref: (Delta Light 2022), (Kreon 2022)

11.3 Light in home office

Most of the state of the art for home offices are examples of existing lighting design companies or manufacturers implementing their products in people's homes.
Lumens is a well-known company that designs unique luminaires for homes. They believe that home offices require different types of lighting and different layers of light, such as ambient lighting, task lighting, and accent lighting. For task lighting, they recommend a fixture that is both functional and versatile, a fixture that can change heights and angles is the best option.

A common issue with working online is that it can cause eye strain when looking at the computer for too long. Therefore it is highly recommended to get a fixture that can have its intensity changed and dimmed if necessary.

Figure 33: Cases taken from different companies and lighting designers. See ref: (Delta Light 2022), (Kreon 2022), (Ledvance 2022)

One task lamp might not be enough since different task lamps fulfil different needs. One lamp could give focused light, and a pendant lamp creates a diffuse and broader illumination. For this exact reason, a pendant lamp could be hung above a table in an open room with the possibility to be lowered so that it can give off a stronger downlight. The company also suggests paying importance to the correct location of the pendant light. If you prefer bright natural light, you should select a diffuse light that mimics the sunlight. When the pendant light is fitted with shade, it focuses the light down onto our task area.

The state of the art serves as an inspiration for the testing and design proposal. It shows existing solutions for office lighting, home lighting, and home office lighting. Most of the above-presented lighting designs are taken from companies and manufacturers who have been testing their designs and have a solid user experience. Lighting design companies are giving recommendations for home office lighting, which support the design proposal for this report. These cases give an understanding of the current lighting solutions for different environments and give the inspiration to study their effect and outcome. The differences in luminaires and lighting design show the importance and need for research on the directionality of the light, type of light, the color temperature, and the intensity.

12. Design

12.1 Idea generation

Concept

The interview with Mikkel Bille, the state of the art, and the literature review was followed by an idea generation that will have a design proposal as a final result. To create a design intention, it was needed to get inspiration from different sources. One of the main inspirations was our natural elements of light, such as the Sun and the Moon, that channel light to the earth and dictate our biological cycles.

Figure 34: The connection between the Sun and the Moon, (Montague, 2022)

The primary motivation of our concept was one of the answers given by Mikkel Bille about the “bubble” of light. He was asked about how the work and home atmosphere could coexist, and he answered that instead of blending these two atmospheres, it would be a good idea to box them off. A small part of the home turns into a working atmosphere, but it can switch back to a home atmosphere when it is needed. This bubble allows the user to immerse in their work activities without taking away the qualities of our home.

Figure 35 & 36: A bubble (Voss 2022), and a self-made image of a bubble of light

In this thought process, the idea was to refer to the Moon and Sun as the main inspiration for the shape of the light spheres. The Moon would represent the task lighting, a more concentrated and intense light zone in the focus area, while the Sun would represent the warm light surrounding us. This warm light is the constant ambient light that homes are known for in the Nordic countries.

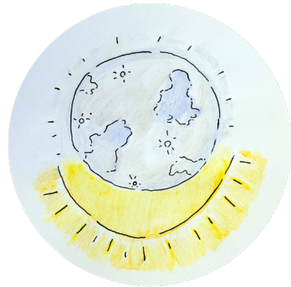


Figure 37: Sketch showing the initial idea

The connection with the Sun and Moon only refers to the shape and the color of the light. In reality, when perceiving the Sun, it has a much warmer temperature than the Moon. It is essential to clarify that these do not match with the true color temperatures, where the Sun is colder than the Moon. In this case, the concept refers to creating layers of light that help users differentiate some boundaries around the workspace and the home atmosphere. The color of the light has to do with the desired activity to perform and the intensity of it.

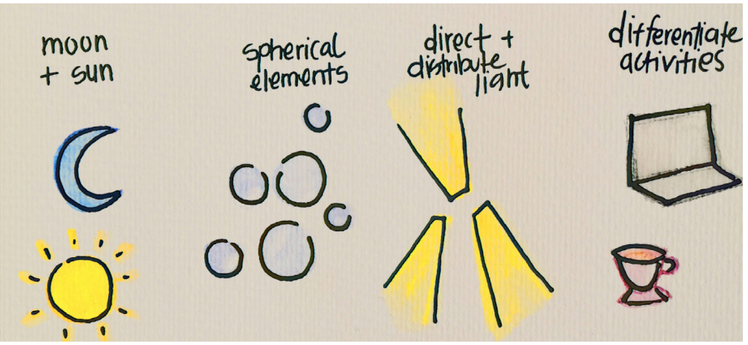


Figure 38: Sketches of the idea generation

The chosen color temperatures for the light spheres are linked to the perceived light from sunlight and moonlight and not their true color temperature. These color temperatures are discussed in the literature review of this thesis. Therefore, the illustration shows the concept simplified, where the task lighting is hanging from the ceiling, or it is recessed and emits its bubble effect onto the task area. The warm ambient light surrounds the task lighting. The ambient light is what we already have in our homes: it can be light underneath the kitchen cabinets, candlelight on a sofa table, or our preferred table lamp at home. The ambient light is a constant that always remains warm. The reason behind this is stated in the chapter with Mikkel Bille, where he explains that the warm light in the homes of Denmark is a cultural preference, and it is always a constant.

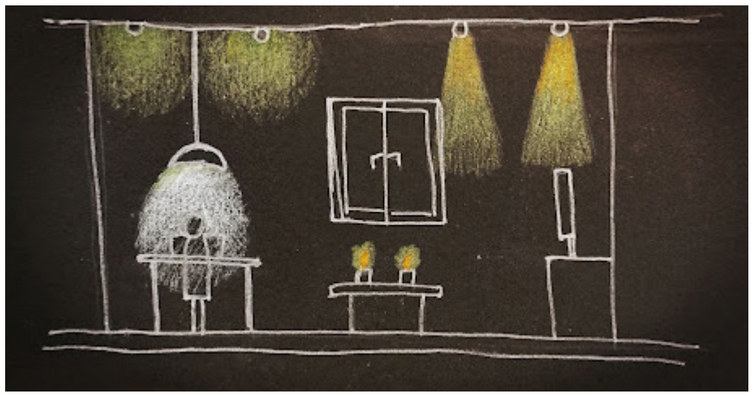


Figure 39: Sketches of the concept simplified

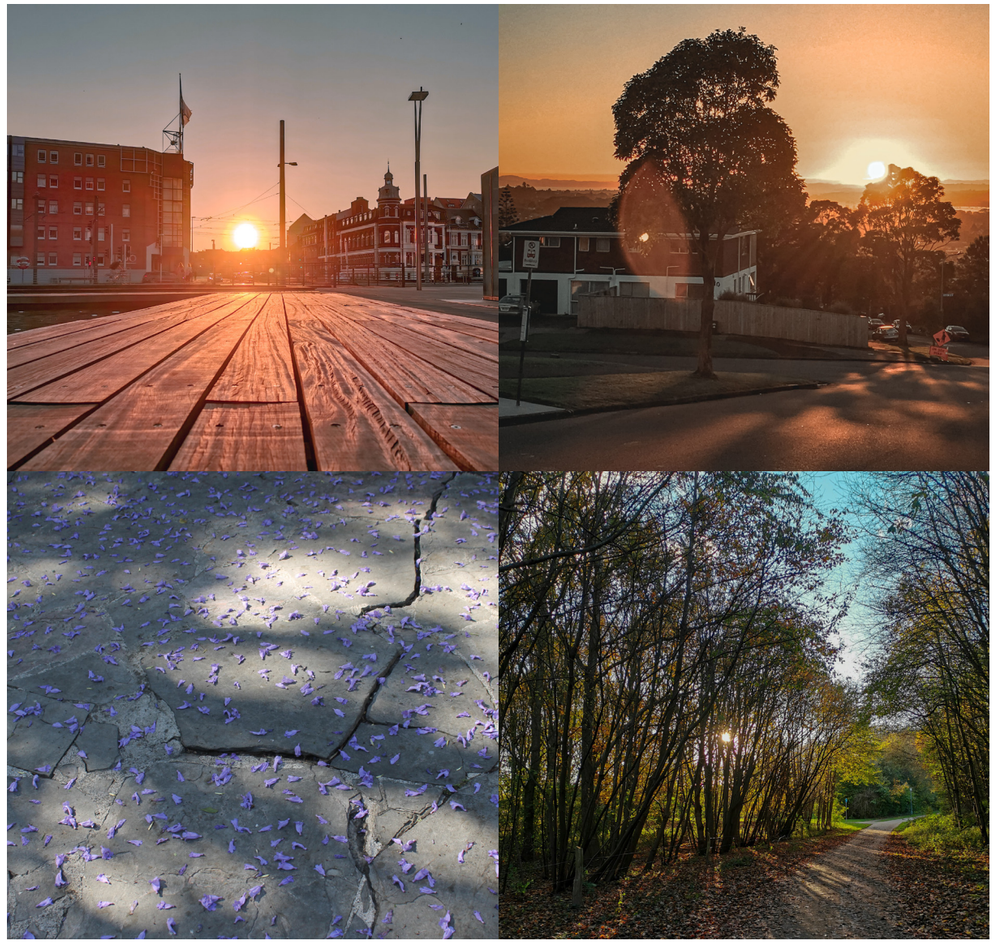


Figure 40: Self-made images of the perceived color of the sunlight

Sketches

After discovering the needs and elaborating on research on the topic, several sketches were created to illustrate and combine the design concept with the bubble and the layers of light. Following the analysis structure and the unmet needs, two scenarios were chosen: the working time and the break time.

The idea is to propose settings for two main activities around a regular workday: the working time and break time. These activities require a specific light setting to create the right atmosphere. As discussed in the research above, working time is a more focused activity that requires the person's full attention and concentration. However, during break time, the aim is to relax the mind and give a break to the body. The drawings exemplify the different settings that are proposed for the pilot testing

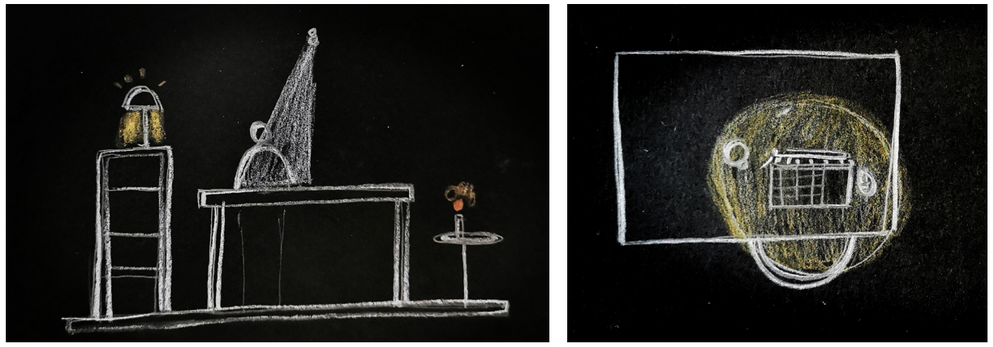


Figure 41 & 42: Sketches showing the "work setting" following the concept idea

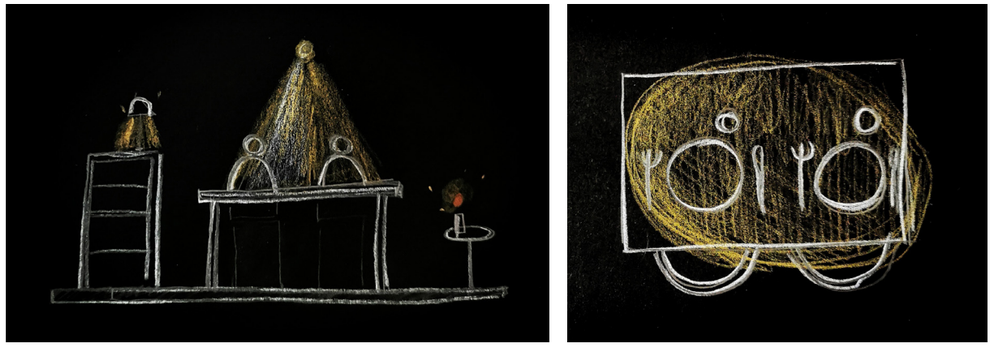


Figure 43 & 44: Sketches showing the "break setting" following the concept idea

Following the principles of direction and distribution, height, and illuminance, combined with the spherical shape, some sketches were made to show the initial idea of the light source prototype. It is important to mention that the fixture is not the main focus, but it defines the characteristics of light that will help to prove the concept of the "sphere of light".

Figure 45: The sketches show how the sphere of light can be interacting in the space and how the light can be perceived in a room.

Chosen space

Shared space was chosen for testing throughout the idea generation, such as a living room or dining room. During the interviews, most participants used their shared space for work, which generated more difficulties than the users who had their own office space. Therefore, there was a need to investigate further the possibilities of improving work engagement in such spaces.

Multifuncionality

The light source should be multifunctional because it can change settings according to different activities. It can switch from a work setting to a warm homely atmosphere or an atmosphere appropriate for a family dinner. Different activities require different light settings. Not only the light but also the color temperature, intensity, distribution, and directionality need to be considered when discussing a multifunctional light source. In this case, work-related tasks require a more focused light dedicated to being immersed in our work. On the other hand, a coffee break during our work or a dinner with our family might require another light setting, with a more distributed, warmer light that allows our faces to be well lit, therefore, look better during a gathering.

Our homes will always remain our homes; hence the office light will never take over the entire place. Providing more settings within one light source allows the user to be more flexible. Based on the answers of the interviews, the multifunctionality of the light can help the users to create and adjust their own needs to the environment they want to achieve with light, especially the needs found in this report that have to do with blurred boundaries and distractions.

12.2 Prototype

The purpose of using a prototype is to test the light source's intensity and directionality and try to recreate the effect of the bubble of light. More considerations should be further addressed to build a proper fixture. The aim here was to get an idea of how it would be possible to create this effect. Different fixtures, light bulbs, materials, and light sources were used to test the concept idea. Many of these fixtures and light sources are standard found in a home environment.

Figure 46: Self-made image with words for the prototype and the test

The prototype was made with different materials to recreate a shape that will imitate a "sphere" and show a proof of concept about the layered light interacting in the space. After experimenting with different materials, it was clear that making a cone of light is more manageable with less translucent materials, such as cardboard paper and newspaper. These help with the glare and create a more personal effect than other materials. A semi-translucent plastic was also used for testing. However, the light got through it and created an ambient light on unwanted surfaces.
Since the purpose was to create a concentrated area with light, the translucent paper was not an option anymore. The thin paper was also giving similar results. A plastic cone from an existing fixture was also used for the prototype; however, it also had indirect light illuminating the space around the task area.

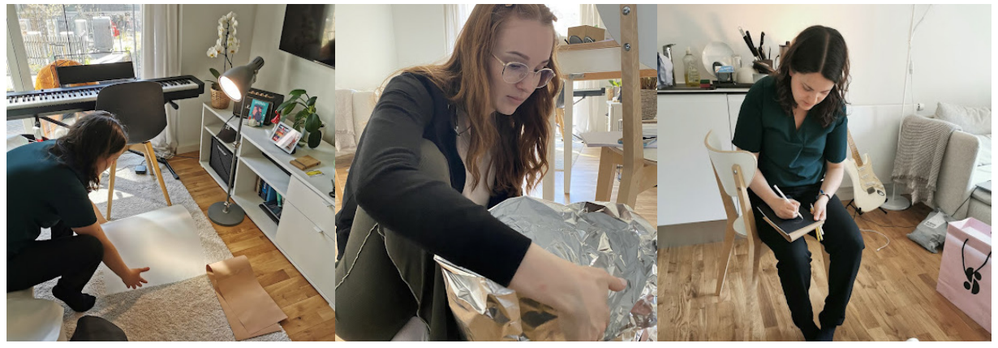


Figure 47: Experimentation with different materials such as translucent paper and foil

Figure 48: Cones made for the prototype with different materials and forms

Figure 49:Different light sources were used for the prototype: A LED A21 full color bulb, a LED A21 reflector type and Candle B12 E12. (Wiz connected, 2022)

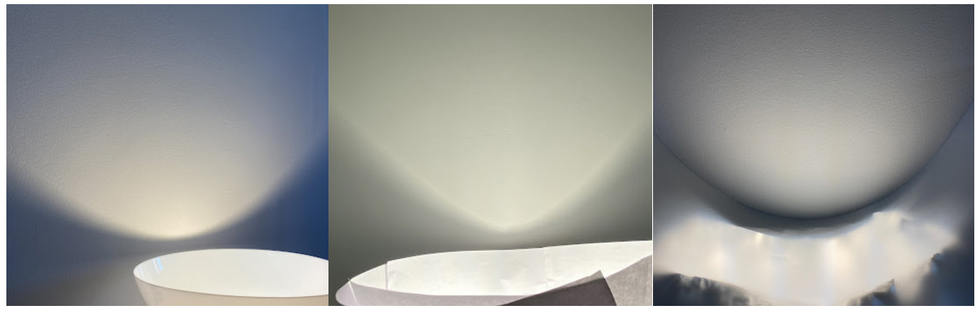


Figure 50: Angles and spheres created with different materials and shapes while trying out several intensities

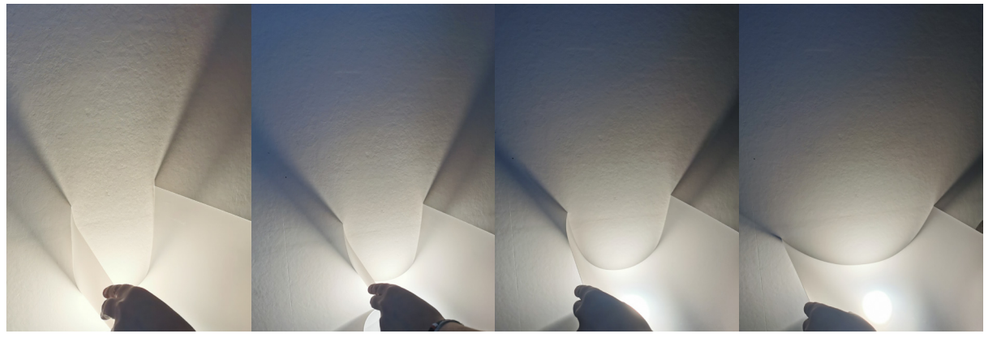


Figure 51: Exploring the directionality of the light to create a bubble

12.3 Pilot test

To end up with more accurate results, the settings for the testing were conducted in one of the interview participant's home working environments, in Copenhagen, Denmark. Future works on the topic could be conducted in a more personal setting and adapted to each case.
The space is a dining room and a living room inside a flat located in Vanløse.

A total of ten participants were invited to the space at different times:

- Participants 1 and 2 did the test on the 4th of May, 2022, between 1 pm and 2 pm. It was a cloudy day without sunlight.
- Participants number 3, 4, 5, and 6 did the test on the 5th of May, 2022, between 10 am, and 11 am. The weather was sunny, so the shades had to be used to block the sun from entering the room and to create a more gloomy day effect.
- Participants 7, 8, 9, and 10 did the test on the 6th of May, 2022, between 10 am and 12 am. The weather was cloudy and grey.

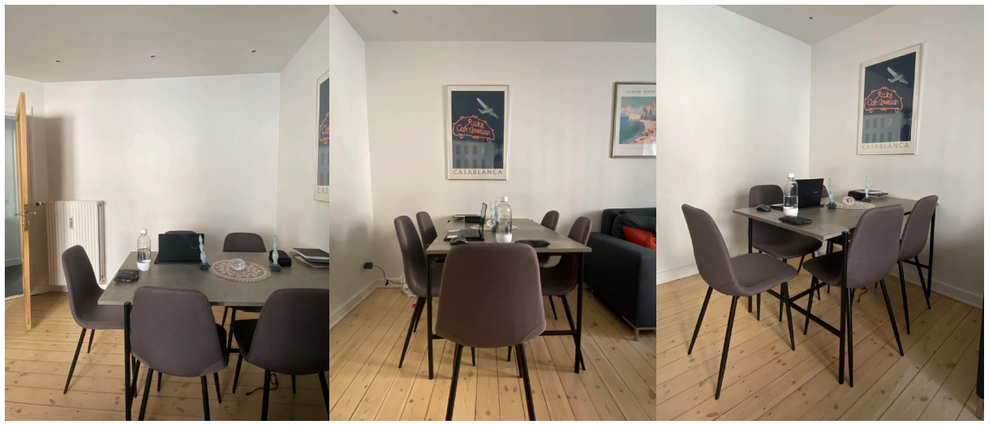


Figure 52:Sel-made images showing the home office setting for the pilot test

Setting

The home working setting is a rectangular dining table with dimensions of 0.80m x 1.20m and five chairs around it. In the space, there are 3 LED spotlights with warm colors. There is a window in the room 5.50 meters away from the table. The window faces the northeast, so it has most of the light in the morning and no direct sunlight in the afternoon, making the space dark.

The test had two main parts. The first part focused on the task lighting and the second on the break time. A home lighting control system called Wiz was used and controlled via an app designed for homes and can be programmed and used by anybody. This app is a basic tool that allows the user to choose the color temperature, and intensity and creates personalized scenarios depending on the activity.

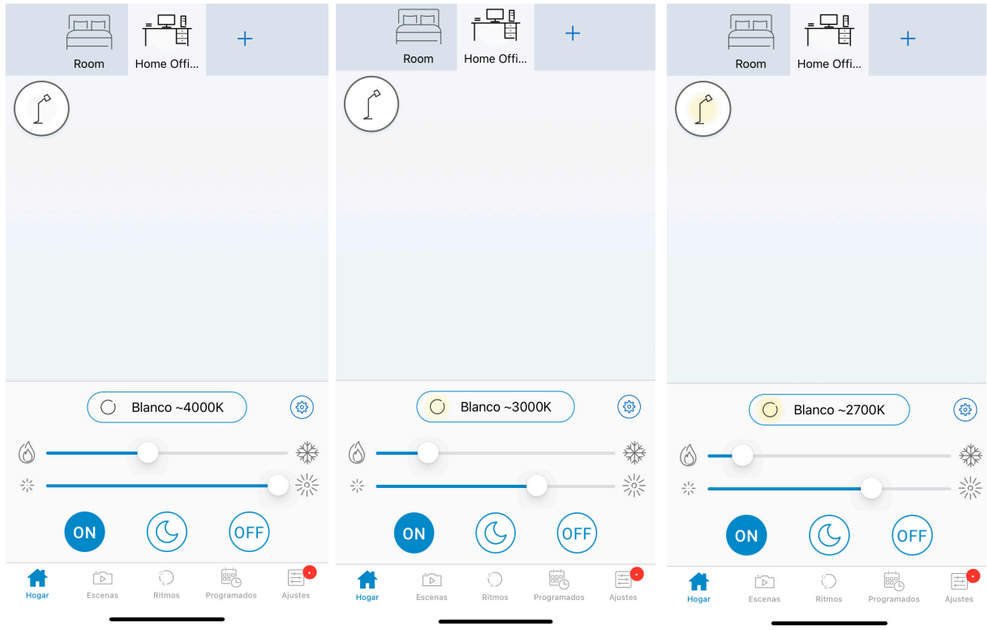


Figure 53: Different settings in one room: Wiz app

1. Task lighting

For the task lighting, participants were asked to sit down at a dinner table and use a computer to describe a regular day at their work under two different light settings. The first setting is a direct task lighting with a narrow beam and a color temperature of 4000K and the surrounding with a constant cozy light of 2700K. The intensity of the light was 60% for the task area.

The second setting is a direct task lighting with a color temperature of 3000K and the surroundings with the constant cozy light of 2700K. The intensity of the light was 60% for the task area.
During the second setting, the participants were asked to write a short description of their education. The participants spend approximately 5 minutes on each of the two tasks.

The surrounding light here has no percentage of intensity, and it will depend on the user and their home environment.

Figure 54: Participant in the testing set

The participants were working in this “bubble” of light in this setting. The bubble effect lies in the horizontal working area, which draws people’s attention to it and creates an immersed working atmosphere around it. As shown in the picture above, the participant has focused light on his task area and also a light on his face.

Figure 55: Participant in the testing set

After spending about ten minutes under the different settings, a survey was presented to the participants with questions related to the light settings, the visual appearance, and the perceived atmosphere. After the short survey, the second part of the testing, called “light for break time”, was prepared.

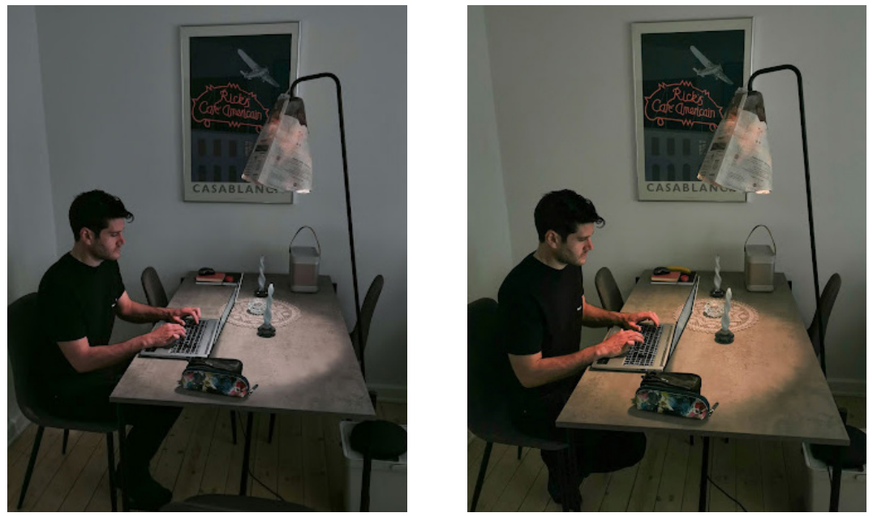


Figure 56: Testing 1 with the different color temperatures for task-focused work

1. Break time lighting

For the break time setting, participants were asked to sit down at a dinner table with other participants and have a casual conversation while enjoying a cup of tea. For this setting, the cone of the light source was changed to a wider angle, shaped like a dome. The fixture was positioned on a higher level, and it was covered with a layer of translucent material to avoid uncomfortable glare.

The first setting is a cozy downlight with a wider beam, with a color temperature of 2700K and an intensity of 50%, while the surroundings remained with the constant cozy light of 2700K. The second setting is the same lighting but with an intensity of 75% and the surroundings with the constant cozy light of 2700K. The participants spend approximately 5 minutes on each of the two tasks.

Figure 57: Settings for the break time setting with 50% and 75% intensities

After spending about ten minutes under the different settings, a survey was presented to the participants with questions related to the light settings, the visual appearance, and the perceived atmosphere.

12.4 Results from the pilot test and the survey

Testing 1:

This test was focused on the task area and the work time. The number of participants was ten people in total. The majority of 8 people chose setting 2 with the color temperature of 3000 K. According to the answers, the participants believed that setting 2 (3000K) felt closer to the home environment than setting 1 (4000K).
8 out of 10 participants believed that setting 2 felt natural and comfortable. Another common reason for choosing this was that people felt that the light was cozy and interesting. Lastly, they perceived setting 2 as neither dim nor bright.

One of the questions was an open question about why they chose the setting they did and how they felt under the chosen light. An open answer about the task setting was that it was interesting to see a circular shape around the task area, delimiting the space between work and home. Another open answer to this question was that it was comfortable to be under the light without seeing the light source. Another participant mentioned that setting 2 felt less formal or office-like than setting 1. The participant also mentioned he relates the cooler light to offices, hospitals, and stores and it is not something that would be suitable for a home.
One of the participants argued that she liked sitting under this fixture because it made her feel more involved in the task and separated her from everything around her.
The last answer concerning setting 2 mentioned that the warm light made them feel immersed in the exercise because it matched the existing atmosphere of the home.

2 out of 10 participants preferred setting 1 (4000K). Their reasoning behind it was that the color of the light was similar to their computer screen, which created less contrast between these two elements. Both of the participants perceived the light as comfortable and natural. Moreover, they perceived this setting as more formal than cozy. Lastly, they perceived this setting as neither dim nor bright.

After the participants filled out the online survey, they were asked if they would like to have the possibility of a controlled light setting where work lights would automatically switch to the cozy light setting, which would help create boundaries between activities. All of the participants answered that they would prefer to have a controlled light setting at home for this.

Testing 2:

The test was focused on the “break time” setting. The exact number of participants took part in the second testing (10 people). The majority of 9 people chose setting 2 with the intensity of 75% and color temperature of 2700K. The participants believed that this setting was comfortable and natural, and 6 out of 9 people said it was a cozy and bright setting.

As an open answer, people explained that with this light, they can see the people’s faces better and it remains the same color as the elements in the home atmosphere. A participant mentioned that he likes to see what is on the table and in front of him. One of the answers argued that this light matched the outside. She also mentioned that if it was a dinner setting, she would change it to more dimmed, like the restaurants in Copenhagen. Lastly, one participant mentioned that this light energizes her in her break time rather than the one with less intensity.

Only 1 out of 10 participants chose setting 1 with a lower intensity of 50% and color temperature of 2700K. This participant believed that the setting was comfortable and cozy, and it was perceived as more dim and natural. The one participant who chose setting 1 argued that the light looked more suitable for a coffee break, but the second setting would be a better option for lunch or dinner or gathering.

All of the answers can be found in the Appendix.

13. Discussion

The evaluation of the results in testing 1 showed a strong preference for warmer CCT for task lighting in home working environments. People preferred to work under this light because it was more cozy, natural, and comfortable.
Some of the common answers gave the idea that people are biased by elements that relate to the home environment, including the light itself. People felt comfortable working under this light where they did not see the light source itself.

Participants in the task also mentioned that the created setting helped them be immersed in the exercise and liked the circular shape around the task area. Another participant mentioned that the light made her feel separated from everything around her. Participants were biased by the warm light and mentioned that the CCT of 4000K was related to more formal environments and not to a home.

The participants that chose the setting of 4000K related the color temperature of the light to the one on their computer screen. This is because being under this type of light created more contrast between these two elements. Participants perceived this setting as formal rather than cozy.

By evaluating the break time setting, most people preferred to have an intensity of 75% and a color temperature of 2700K. Common answers on this test had to do with seeing faces while people are talking and seeing other elements in the space. People mentioned that a lower intensity at home would be suitable for a “dinner setting” rather than a “break setting” during the day. One participant mentioned that this dinner setting reminds her more of the restaurants of Copenhagen during night hours.

The results of this test might suggest that people can feel a difference in the light setting when different factors are involved: the height of a fixture, the materials, the type of the light source, the CCT, the directionality, and distribution as well as the positioning and the angle of the light creating different effects around the space. Pre-ferences of people also suggest that the bubble of light will also have to do with elements related to a home or an environment that is personal and familiar. Participants that preferred a cooler setting might relate it to a working environment rather than a cozy one.

The test was made to prove the concept of controlled layers of light in a home and the users’ preferences. There is an indication that participants felt a part of the sphere of light while being tested. Moreover, they would like to have the possibility to control the light at home to create boundaries between activities.
This test was carried out with participants of different nationalities and backgrounds, which could have altered or influenced their preferred settings choices.

It is important to mention that the task area is the computer’s screen, which is self-illuminating. In this case, it is not necessary to fulfill the requirements of the 300 lux, since it applies to a horizontal task area. The focus is on the perceived atmosphere, the characteristics of the light, and how it makes the users feel in the space.

The initial idea was to create a “bubble” or sphere of light that could be visible from any part of the room to remind people in the space that this was a concentrated setting for work engagement. This could help the user from being distracted. Nonetheless, the results of the pilot test showed something different. It was not easy to see the “bubble” on a vertical plane, but it was a visible element in the task area, delimiting and shaping the activities around it. In order to make this “bubble” more visible on vertical planes, a suggestion would be to have a wall near or behind this layer of light that could scatter the light back, thus forming a visible sphere on the vertical plane.

14. Conclusion

This thesis aimed to create a lighting design concept that could address the problems stated in the interviews, such as blurred boundaries and distractions in home working environments. This concept was based on creating a bubble of light in a home working environment that could help the user support work engagement and, at the same time, preserve a home atmosphere. After finding the problems in the interviews, a research question was presented: “How can light support work engagement in a home office and at the same time preserve a homely atmosphere?” This led to the hypothesis: “A sphere of light can serve as a tool to create an atmosphere that allows us to be engaged with work, having a better time awareness without taking away the home’s qualities.”

To answer the hypothesis, an idea generation and a test with two different light settings were made. The design of the settings is based on improving the home working environments and, therefore, creating a better experience for the users with light. The purpose of the design is not to break the identity of a home but to create a “bubble” where people can focus on a different activity, but still be a part of their cozy home environment. Combined with this, the solution for the research question will be met by using “bubbles” made of layers of light both for the work engagement and for a relaxing break time. These visible layers will have different qualities based on light characteristics like intensity, color temperature, distribution, and direction to indicate the boundaries between activities and atmospheres. A pilot test was carried out at a home office space to test this concept idea based on layers of light. In this test, participants experienced the light setting with a multifunctional light source changing from activity to activity. We conclude the following:

- Qualitative interviews can provide a deeper understanding of how light affects the perceived atmosphere in a home working environment.
- Participants prefer a warmer CCT of 3000K in a home working environment for task lighting. This finding should be adapted to different home working environments.
- Based on the pilot test, participants preferred to have control of the intensity of the light.
- Participants found the concentrated and intense light directed to their task area more suitable for working. In terms of distribution, a narrow beam, like the one recreated in the setting, is suitable for a home working environment to highlight the task area. As for directionality, the direct light is appropriate for a task area without forgetting the indirect ambient light in a home environment.

As for the break time setting, it was gathered that there is a preference for a warm color temperature of 2700K and intensity of 75%. The reasoning behind this is that this light allows users to be able to see people’s faces around them and the food on the table.

After doing the pilot test and seeing the participants’ reactions, the concept of layers of light demonstrates that it can be on the horizontal or vertical plane depending on the way people perceive it. Despite the low number of participants, it can be concluded that this “bubble” of light is preferred for a focused task where you can be immersed. It also has to do with how the desk is positioned in the room.

15. Further considerations

Future works should adequately address topics like face recognition and being well lit during video calls. This thesis focuses only on blurred boundaries and distractions given by the first answers from the interviews. These topics were brought up during the testing part when 2 of the participants mentioned their preference for the warm light around their faces for taking video calls. In the test, the light source was not vi-sible from the chair, and the light created a smooth transition around the task area and the participants. The positioning of the light source gave positive comments about the importance of seeing faces or the computer without having a visible light source. Therefore different light sources, shapes, and materials should be explored to recreate the feeling of being in a bubble.

For future works, it would be suggested to explore a combination of direct and indirect light, which serves as a “bubble” of light. Talking with participants and colleagues, an interesting case was brought to the topic: a person was using two lights for a work setting. One of the lights was placed on a horizontal plane, drawing attention to the table, and the other light source was illuminating the white wall in front of the desk. This could suggest that the sphere of light can exist in different planes and might be interpreted differently from vertical and horizontal surfaces. In this case, his “bubble of light” was the indirect light on the wall reminding him that it was his “work engagement” time. This case should be addressed as a specific room for working and not as the “shared space” tested in this thesis. (See appendix 5 for images)

Another essential aspect to consider is that no two homes look the same, so it is important to keep in mind that these settings and fixtures have to be adjusted in each home according to the user’s preferences. The tests should be carried out in different homes and with more participants for further exploration of the topic.

Two different cones of light with two different materials were used for the prototype. However, the prototype aims to have a fixture that can change from a narrow angle to a wide angle, making the bubble or sphere smaller or bigger according to different activities. Further exploration of fixtures, shapes, materials, cones, direction, and distribution should be addressed to come up with an efficient solution for a home environment.

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- Figure 50-57: Self made images

17. Appendix

Appendix 1
Online survey 1 - page 11

1. How did you feel about working from home during the pandemic?

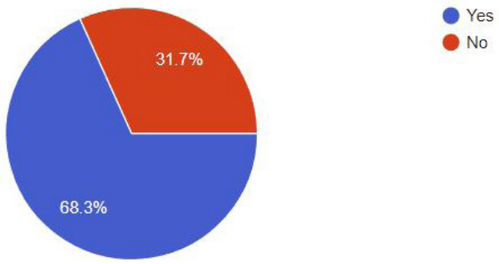
Copy

63 responses

2. Are you still working from home?

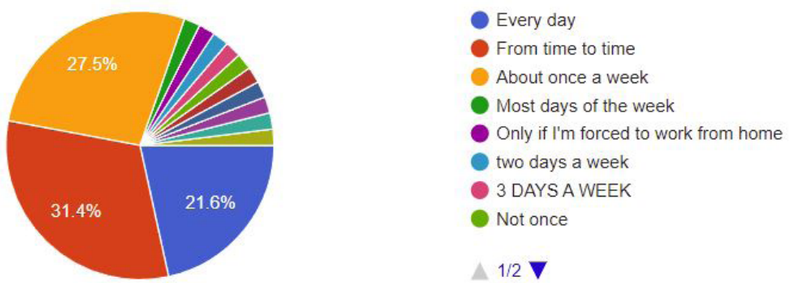
Copy

63 responses



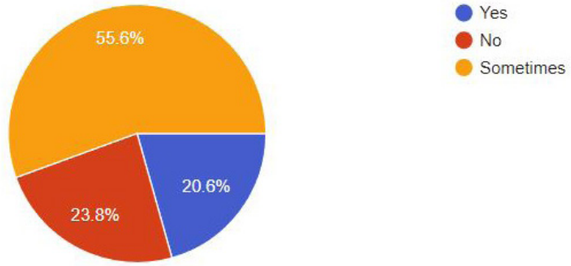
3. How often do you work from home? (Do not answer if your previous answer was no)

51 responses



4. Was it easy to stay focused on your work at home?

63 responses



5. What were the challenges or distractions you experienced while working from home?

63 responses

- You may get distracted by the urge to take a break and do something more fun, when no one is supervising you.
- Staying focused cause there is always other stuff to while being home
- Creating a working zone was important to me. After I moved to a smaller place, I lost my "office" space, which made it more difficult to get in the working mindset.
- Tv, bed, sofa, ps4.
- House chores that I could do.
- distractions, lack of space
- Lack of motivation and procrastination
- Mostly not very strict on myself and can get distracted easily

6. Would you rather work from home or the office and WHY?

63 responses

- I would rather have it mixed both have advantages in different stages of work
- A mix. Office is a neutral environment where you can meet colleagues and discuss projects, but also your home is a safe environment that can be positive for creativity.
- I am studying my batchelors so I'll use the university synonymously with the office. I perfer the office as the conditions for working are better there. I also feel like I enter a different mindset which I find better for when I am working.
- From office. I can't work from home: I'm alone and nothing motivates me to work.

A mix. Office: establishing daily routines, removing work atmosphere from home. Home: No disturbances.

Both- but mainly home. 2 times a week is enough to get to the office. My work does not require to be present in the office

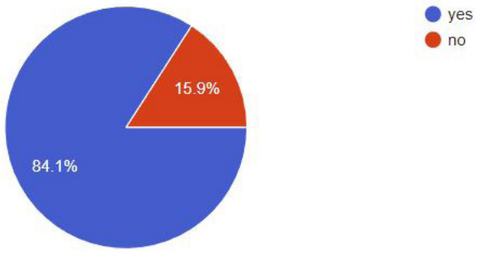
Home - time efficient, cheaper, more convenient

Office - better work environment, less distractions

7. Did you notice the light?

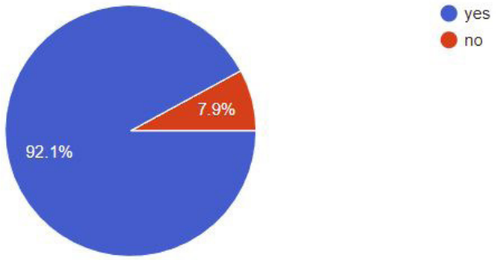
Copy

63 responses



8. Are the lighting conditions important to you?

63 responses



9. What light do/did you use for your home office?

63 responses

The light may have been a little too dim, as I felt like I wanted to turn down the screenlight to balance it out.

I tried to have as much daylight as possible but because of the very dark hours we have during the winter I also needed to ad a light by my desk and lights in the ceiling lighting up the entire room

A desk lamp, like an architecture lamp, primarily. Sometimes candles, or other decorative lighting.

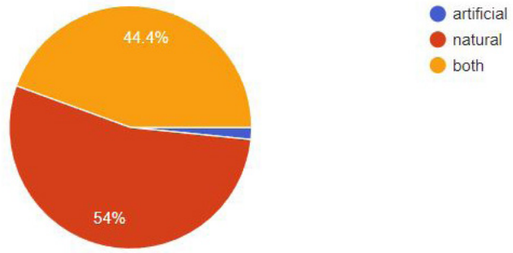
Using indirect light before, but added an extra direct light fixture when i started working at home

Su light during the day and when the sun sets I turn the light on. The light in my flat is mainly ceiling led spotlights with warm-ish light. The lighting is good

10. Do you prefer artificial or natural light?

Copy

63 responses



11. Why?

63 responses

Natual light is the best tho I do not have curtains so it can be hard to see my screen sometimes. With artificial light I can create my preferable atmosphere

Natural light is always nice, but it can be annoying working with a computer screen/monitor. Also in the winter months in Denmark natural light is not sufficient in early hours or late hours. Artificial light on the other hand needs to be soft and warm. Otherwise it can create a cold workspace (in my opinion). So a mix.

it does not make my eyes feel tired

daylight is nice to give energy and a nice "study atmosphere" but if I need to read something in a book, I need more light than the daylight can offer. Also the daylight limits the time where I can study, and since I prefer to study during evenings and nights, there is no natural light left, and I need the artificial light.

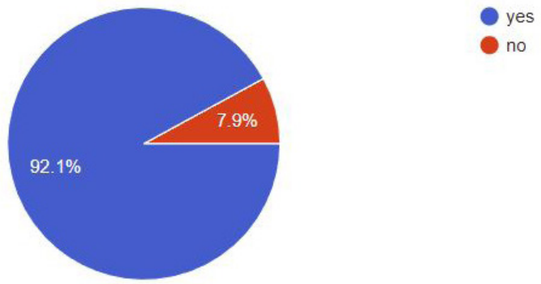
Customization of the amount of light, especially when all my lights are dimmable too

it feels happier with natural light for some reason. artificial light is more cosy and can also work.

Its natural

12. Do you think that light is supporting your working environment?

63 responses



13. Why?

56 responses

I couldn't see anything without light, I need light. And I want light to help creating a nice environment

The previous question is to vague. I would say most people don't even get it when you say "support". Most people dont really care as long as they can see it's fine. That is lighting designer talk eh eh

It can create a motivating mood

It is just much easier to focus if you dont get distracted by low or bad lighting conditions

If I dont have enough light, i will get tired too quickly and sometimes get headache. Light gives me energy, and motivation for my work. But ofc it's not the only thing that influence my working environment, but I think it's a big part of it, together with a table big enough and a good chair.

Every type of light awakens my body and motivates me for work

i think it affects the way i work. hyper focused or casual concentrated is how i think i would describe them

Natural light is positive

Appendix 2
Interview with Mikkel Bille - Transcript
Roskilde University, 24/03/2022
MB: Mikkel Bille

Eszter: As we said we know that you are the expert of this homey atmosphere and you observed a lot of people's homes. We were wondering if you have been noticing any differences within this home atmosphere since the pandemic and if anything has changed? Have you been analyzing people's homes?

MB: We have been into people´s homes but not in terms of understanding how they work as such, we did a project where we try to understand how people experience a city, during the pandemic and we started interviewing from the very first days, but in terms of the home. I think one of, let me start in a place that was before the pandemic, I did a lot of home studies and a book of homely atmospheres so one of the key points, one of those where people are working from home were the very idea of home while you work there. Was it a different notion of home, than the home after work. So it is just when you say how could you combine work in a cosy environment it was interesting to see that quite many people that I talked to, it is the idea of creating a space momentarily which is a workspace which is not necessary to be cosy you have other objects that you can use, but now its work and they kind of finish work and they do different things to make it cosy so you can say it is physically in a home, but in the moment where they work, they kind of simulate a work environment as far as possible.
But also a lot of people are allowed to get this table that rises, but it doesn't have the homey feeling, are also there when you have the home, and it's a kind of institutionalized thing. So one of the interesting things I found is how people make work at home that is not a workspace but it tries to get this kind of work atmosphere but with your own objects that can also be transformed into a home atmosphere later on. So the point is transforming the home momentarily, especially with the pandemic. We have data of people at home but it is not what I´ve been concentrating on but more of what they did in the city.

Anyway, the key point was simply to say that the home becomes something different when all of the sudden you have your books and you have put a more comfortable chair to the dining table or you have to work, lay in the bed. So you might be sitting in the kitchen even though you may have an office space where you normally would work. The question is whether that will happen in the future as well as compared to the idea that people get separate or specific workplaces in the home. What did happen was that the kids needed to be online, parents needed to be online, and some of the things had continued so people would work at home but maybe not on the same day as their partner does. So whereas the home is more fluid, what would become a temporary office such as the bed or bedroom or whatever now becomes more like: you cannot sit and work in bed, depending on the work you have. An accountant will work differently at home than a person like me that also has to read so I would go to the sofa and read for two hours, where I would sit there right. I think it's important for you to also distinguish between what kind of work functions people have.

Bego: In this book, you wrote "homely atmosphere" you were talking about how everything forms the atmosphere, the activities that you do every day at home, what are other people doing at home as well, do you think that these two environments can coexist? the working type with the home type? Or do you think that more people just adapt to what they have? Because this is something that we have been observing as well, people manage to work at home.

MB: Yes, it might not be for the best of our backs.
I think one of the things is exactly as you say but I think it's important to say that it really depends on what kind of work you have, and you say there is adaptability to it. When you say I'll just take the dining table and I'll work from there and maybe it is not the exact height as it is in here but it will work alright, at least until it doesn't. And there is the issue, and it suddenly becomes a working environment where I need to have a better chair and so on, but adapting is also a matter of privately adapting. So rather than getting the chair that the company is offering which may be a chair like this, you can see that people that can afford it will buy the designers chair which can do the same things but is just a little bit nicer so it's not always office chair, is also potentially a fifth chair for a birthday party without being kind of here comes my work.

So adaptability I would say yes to a large degree, but also I cannot remember of any of the people we interviewed actually went full-on getting a table (especially for work)

Eszter: I'm actually wondering, how do you manage to work from home? or do you work from home? And which one do you prefer: home or office?

MB: I prefer to work in the library if by work we don't mean me standing up teaching but if I'm writing an article it would be from my library mainly or I would say then I would do it at home because then I could be more flexible and wash clothes for example. I think now after corona having been home that much kind of destroyed the calmness of it and also because my wife now works from home as well so whereas previously it would actually be a free space being alone now it's just kind of a shared space. So, I think that it's also important to see that the very notion of how we relate to our home has changed also during the process of this. Actually had a student project once which was on people who go to prison but instead of going to prison, they get these foot chains that can be monitored and they can only stay at home unless they have the need to go shopping. It's another way of being in a prison where you're not exposed to other criminals. Going to prison can make you even more of a criminal because you are involved in these networks. Someone did a project on that and it was on how the home changes the emotional sense.

The home changes because all of a sudden it was a prison rather than a place where you can go and relax and be yourself. It became a place where they had to always be ready to answer the phone if the government calls. It's actually the relationship between a person and the home that has changed because of the foot chain. It would be the same with our situation since we've been so much at home lately because of the pandemic, it's not that it's a bad place but it has changed your relationship to the home as a kind of sanctuary place to relax.

Bego: I remember an architect, he's a Mexican architect and he's saying that his home is like everything for him, it is like his refuge where he can be safe and to feel in peace with you and then I was reading an article where they wrote that this might not be valid anymore because you're all the time there working.

MB: It never was like that. I mean, the home is also where the partner beats the other partner. The home is also where children are being raised and where they are shouting and so on. There's the romantic notion of what the home is and that's all well and good if you are single. But it's a bigger place as well, it's also where the neighbors are making noise. So, I think one way of looking at it, it's to realize that it's not a fairytale home, the actual home where people live is also a place of violence and chaos. I'm not saying that it should influence the design but it's just to think about it. It is nice and good with candlelight and nice designer lamps but that doesn't mean that it is cosy because people may also be shouting. Since you've been home so much you could also argue that actually because you've been home so much you've seen the world at different times than you normally would. You can see for example what happens on a Tuesday at 11 am. Before the pandemic, you would be sitting in your office or bank, and now all of a sudden you can sit down at home and see these things. In a sense, it also creates the idea that now we have larger possibilities of doing home office, which also allows us to experience the home in new atmospheres.

Eszter: We are trying to find a way to create this room within a room where you can do your work but still be in your cosy home atmosphere. It is quite challenging to find the right balance between home and work.

MB: Many psychologists say that you don't have to go get dressed for work in your home but it's actually a good idea to make that kind of division between your home kind of feeling and your work. I think instead of "blending the two atmospheres" it might be a good idea to box them off and say this is where the home stops and now it becomes something else. But the problem is if you have office-like furniture, it never becomes the home again. So, the question is how do you make a design that supports homeliness except when you work.
I just think there's a huge difference between work light and then sitting and reading vogue on the sofa. It's still reading but the point here is not to have the most productive light so you can concentrate but the point is that you can relax and therefore you need candlelight.

I wrote in my book as well, that this notion of being human is a question of being a human body whereas no, being human is also being a person with having a social life and cultural norms about coziness.
Good lighting is not just on the body it's also to kind of facilitates that social or atmospheric life.

Bego: We interviewed a couple of people, and we saw major differences in how people manage their work with their lights. I think this is also a bit cultural as well, it has to do with the way you perceive the atmosphere, so that's why we're getting so many different answers. And it's hard to come to a conclusion in a way.

MB: I think one of the mistakes is to say it's totally subjective because you will get many different answers but it's not completely random either. There is a personality trade where you would say there are people who are aware of their self-presentation and you have others who are more health-oriented. I think you could still come up with 7-10 categories.

You could have the category of people who are really structured, who would need their kind of workspace in order to work well. Another category could be people who like to be comfortable on a sofa. Those are just different types of people.

The very idea is that we may know something but we may not act according to that knowledge back home. It is important to keep in mind that during a study, people might act differently and choose a certain color temperature and intensity that in reality inside of their home will not use, for example, because of finances or simply because those lamps wouldn't match their interior. I always use candlelight at home even though I know that it is particle pollution. To me, it creates a relaxing space. I know quite a lot about light but that doesn't mean that when I actually sit at home, I do what makes sense to me. I accept the other studies and I know what they are but it doesn't necessarily fit into everyday life. People are different, just not endlessly different.

In a home, there are different spheres, where at one point it acts as something, and at another point, it is something else. Even though it is the same infrastructure and the same objects, people manage to create different atmospheres and transform the space from a private to a work-related atmosphere.

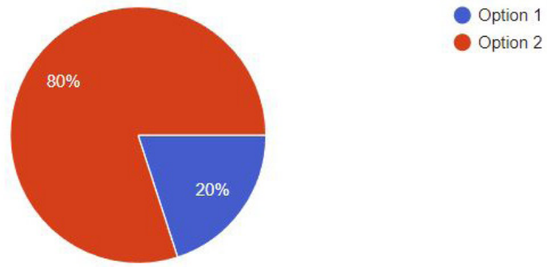
Bego: I have one more question: what other word would you use instead of coziness?

MB: I would not, but if I have to say, I would say intimacy or comfort perhaps. But comfort in English has two different meanings: one is whether it's comfortable so physiological but also comfort in the sense of a comforting hug. Could also be personal, but that can be many things.

Appendix 3
Online survey 2 - page 92

1. Which light setting would you prefer to have in your home office?

10 responses



2. Why did you choose this setting?

10 responses

Because I like the warm color that has like my home, also I noticed the small circle around my working area where I could see all the things that I have to work with like a computer, mouse and post it to write notes.

to me the white color looks similar to my screen on the laptop so there is less contrast between them which I like a lot, it also remind me a bit of my office because we have the same light

It was a warmer light, and to me it therefore produced a more comfortable working environment than option 1.

I felt calmer under this light and I felt like I can collect my thoughts better. It reminds me of the cozy home light which always relaxes me.

because the white light is a little bit intense, i feel the second light a little bit of glare

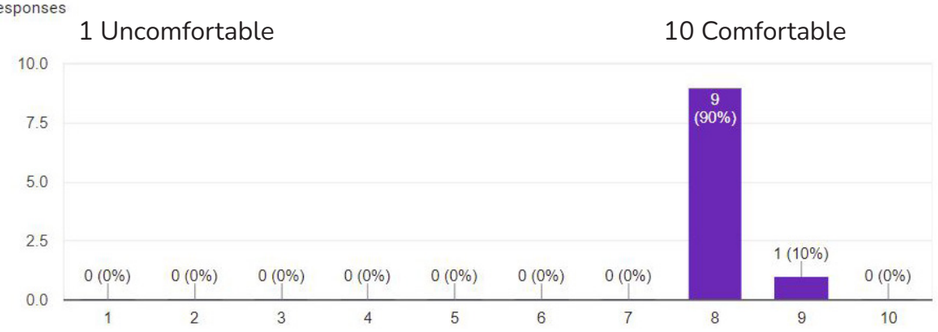
I like this seting because the light was warm and different from my screen. I feel like the cold setting is more formal

because it helps me to concentrate on my task and it makes me less tired

3. The selected light setting is:

Copy

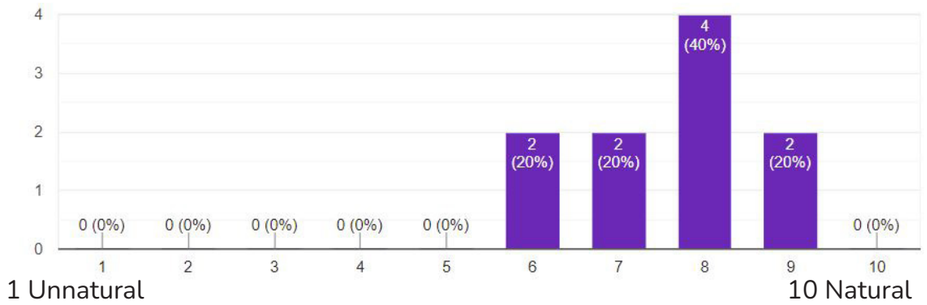
10 responses



4. The selected light setting is:

Copy

10 responses



5. The selected light setting is:

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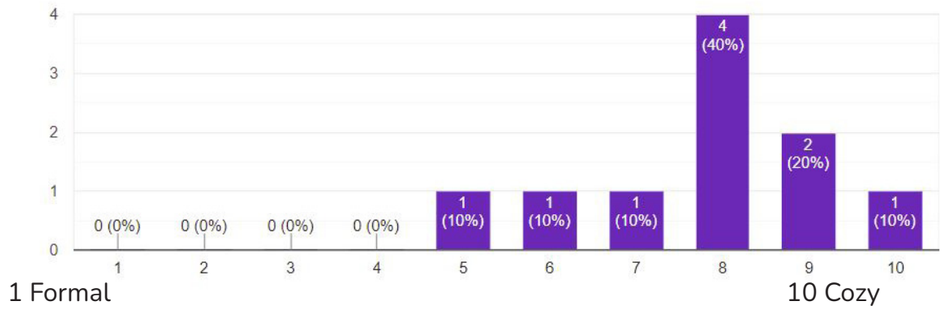
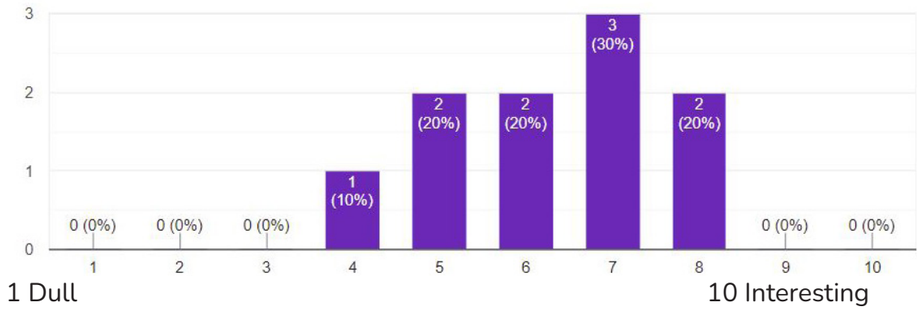
10 responses



6. The selected light setting is:

Copy

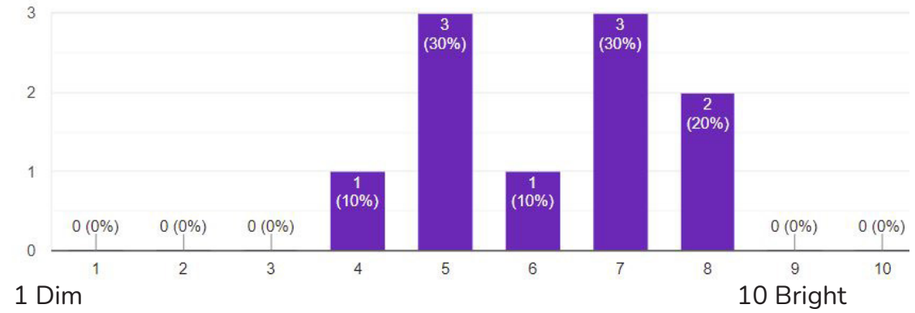
10 responses



7. The selected light setting is:

Copy

10 responses

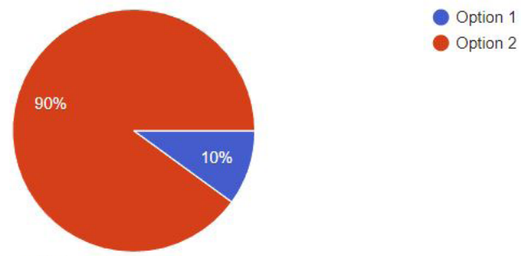


Appendix 4
Online survey 3 - page 93

1. Which light setting would you prefer to have in your home office for a break time (lunch, coffee break, dinner)?

Copy

10 responses



2. Why did you choose this setting?

10 responses

I felt like it could energize me in my break time rather than the one with less brightness

i liked that i was able to see everything and everyone around me

because is easy to see facial expressions and still the light is not to harsh.

I like to see what is around me and on the table infront of me

I like the intensity for the day because it kind of matches the outside, but for dinner maybe i would like to have it more dimmed, like the restaurants here in Copenhagen.

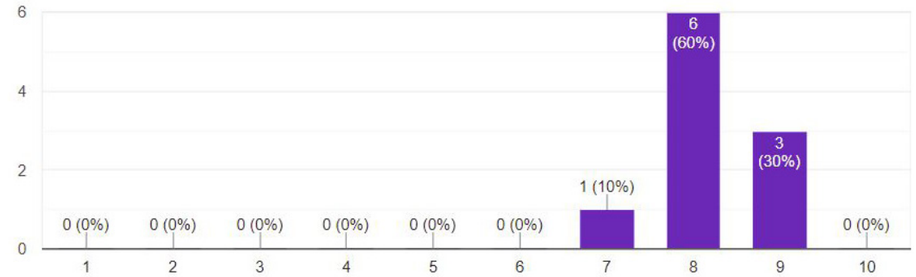
I like when the lamp was moved higher because that also made me feel that the exercise was changing, and so the light. Also that way the task area or whatever is it called, became bigger to create a talking / social space.

It was possible to see others' faces better, with fewer shadows. I also think that if the light is too dim I might get a headache. Maybe after dark, a dimmer light would feel appropriate, but during the daytime, this setting looks fine.

3. The selected light setting is:

Copy

10 responses

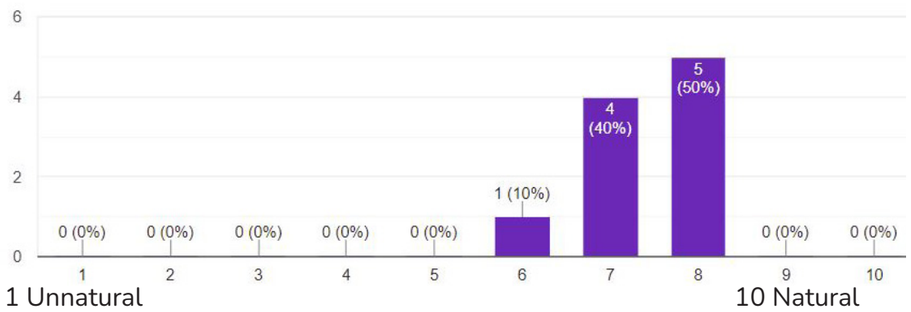


1 Uncomfortable 10 Comfortable

4. The selected light setting is:

Copy

10 responses



1 Unnatural 10 Natural

5. The selected light setting is:

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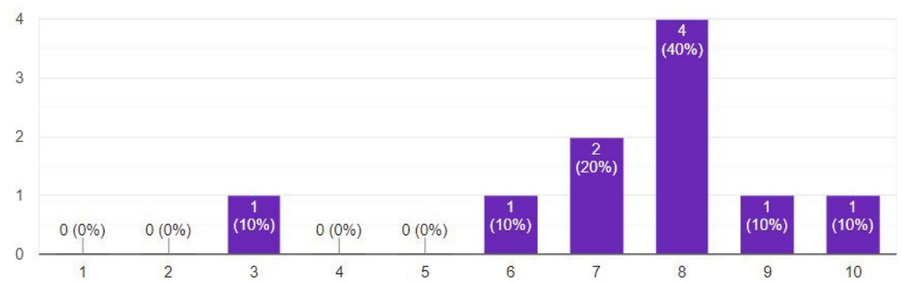
10 responses

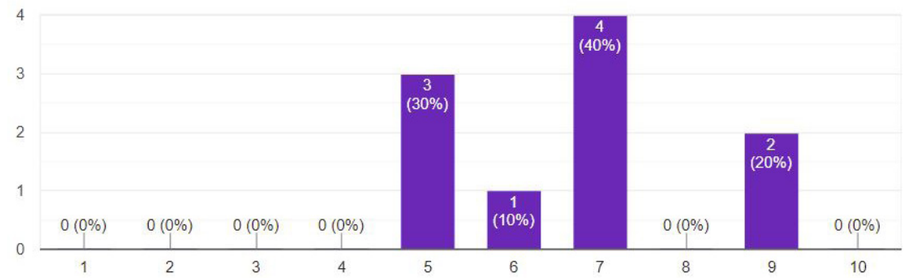


1 Formal 10 Cozy

6. The selected light setting is:

Copy

10 responses

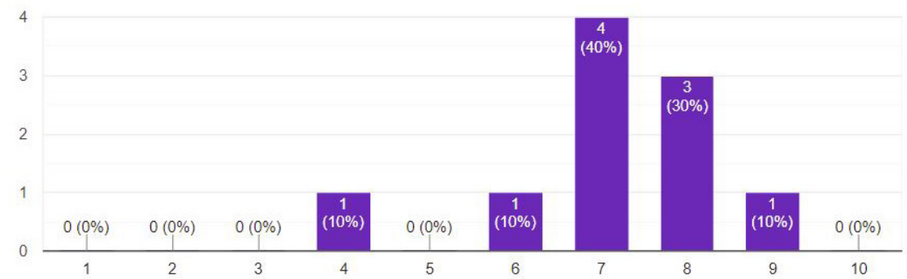


1 Dull 10 Interesting

7. The selected light setting is:

Copy

10 responses



1 Dim 10 Bright

Appendix 5
page 99