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Empathic Lighting Design for Healthcare Environments

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Empathic Lighting Design for Healthcare Environments

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Abstract. Light has the powerful capacity to generate a certain quality and atmosphere within a room. However, lighting design specification is often only characterized via quantitative metrics. In healthcare institutions, such as care homes, hospitals and rehabilitation centres, the use of lighting design may support a positive atmosphere, and potentially also support the health and wellbeing of patients. When people are hospitalised, they are in a difficult and often stressful situation, in which they meet nurses, physicians and relatives within new, unfamiliar surroundings. These situations call for supportive architectural spaces with atmospheres that help people relax and feel safe. Nevertheless, these spaces often lack a lighting design that supports this intent. The objective of this study is to implement two different lighting scenarios and investigate how they affect patients in a psychiatric affective healthcare unit at Copenhagen Psychiatric Centre. Two different lighting scenarios were implemented and tested in a SW-facing group therapy room, during one winter period (November 2022–March 2023). In all, the study included 12 patients. Through questionnaires, the patients were asked how they perceived the luminous environments of two lighting scenarios, one in the existing healthcare lighting vs. a new lighting setup. The patients indicated their preferences and how the lighting design affected and supported heir therapeutic session. The two lighting scenarios are: a) Four high-positioned LED-luminaires (H=2,65 m) in the ceiling; and b) Two low-positioned LED-luminaires suspended above the meeting table (H=1,50 m). The results of the survey showed that patients overall preferred the low-positioned, non-uniform lighting, which scored a total of 60 points in the semantic analysis, compared to 35 points for the high-positioned, uniform lighting. In addition, from a sustainability viewpoint, energy consumption for the low-positioned lighting scenario was only 21 W, compared to 140 W for the high-positioned lighting scenario, providing an 85% reduction in total energy consumption.

1. Introduction

Light has the powerful capacity to generate a certain quality and atmosphere within a room. However, lighting design specifications for institutions, including healthcare spaces, often tend to focus on efficiency, cost-effectiveness and practicality. Traditionally, healthcare spaces have an impersonal atmosphere that tends to reflect functionality rather than empathy and caring [1]. One element designed to support efficiency is a standard lighting design scheme that prescribes a specific amount of lux in the space, often resulting in uniform lighting. However, when people are exposed to healthcare environments, they are often stressed, fragile, and in a vulnerable situation, in need of care and attention. In addition, when relatives visit their loved ones in healthcare institutions, the physical built

environment, including the lighting design, is important to the experience. A biography by the Danish author Lise Munk Thygesen describes a visit to a Danish hospital around 2008, where the author meets her ill mother: 'The walls were painted light blue at the bottom, while the rest was white. Black streaks from collisions with rolling hospital beds were drawn across the blue, and then the damned, usual neon light. It wasn't clean and it wasn't private' [2]. She describes quite distinctly how her experience of the environment did not support the difficult situation, nor did the lighting design add positively to visiting a close relative in a vulnerable situation. To highlight the point, she even curses to emphasize the inappropriate nature of the lighting scheme. The stark lighting Thygesen describes is sharp and revealing, in a situation in which the opposite character of light would have felt more supportive [2]. Such accounts of the atmosphere are recognisable in the Danish healthcare context, and unfortunately, are also expected to some extent when visiting a healthcare institution. The functional and efficient uniform institutional hospital lighting does not offer comfort, safety or relaxation [3]. Research shows adjustments to non-uniform lighting support more intimate and home-like atmospheres, can affect the feeling of a place, and can enable acclimation, such as encouraging lower voices and reducing stress in delivery rooms [4]. Similar relationships between the effects of different lighting distributions and behaviours have been observed in other public settings, such as schools [5], workspaces [6] and restaurants [7].

2. Theoretical and methodological framework

Light is a multifaceted element involving many technical and professional skills, and covering a profusion of scientific knowledge branches. Light can be described in precise terms, primarily concerned with its quantitative aspects, traditionally through natural sciences. Perception of light is typically related to the humanistic sciences, spanning multiple topics from healthcare, ethnography, anthropology, and environmental psychology to philosophical theories. Research examining design of electrical lighting can be aligned with research exploring architecture, as both incorporate several branches of knowledge and work across scientific and professional practices, as well as end-users [8]. In order to emphasize the supportive role of lighting in the built environment, including how different characteristics and distribution can support specific functions and scenarios, this project introduces the notion of *empathic lighting design*. Lighting is part of everyday life, and entangled in our practices [9]. In the healthcare setting, it supports the different activities taking place, including interactions and conversations between professionals and their clients in vulnerable situations. In these settings, light is not simply a neutral environmental setting, but a dynamic factor that can impact the trajectory of a given situation [10]. Drawing on the field of empathic design, a context-sensitive design method that combines subjective and objective approaches and design competencies in field studies of everyday life experiences [11], we introduce empathic lighting design as the ability to understand a situation from different user perspectives, accounting for the emotional and cognitive experiences resulting from utilisation of the design. Empathic lighting design focuses on a stimulating visual environment and immersive atmosphere that goes beyond mere functionality.

2.1 Hypothesis

The hypothesis of this study is that current conventional 'institutional' lighting design scheme may be questionable, and in some situations even counter-productive, inappropriate, or insufficiently supportive and empathic for patient care [12]. The objective of this study is to investigate how lighting design can add to a more supportive atmosphere and improve experiences in healthcare environments [13]. This paper presents the preliminary investigations of how vulnerable people experience two different healthcare facility lighting scenarios, installed in a group-therapy room used by patients and their therapist at Copenhagen Psychiatric Centre. The investigations concern what kind of light patients prefer in a group therapy room, to address the following research questions: How can various lighting scenarios change the atmosphere of a space? How do the patients experience different lighting designs? How can this knowledge promote and improve more sustainable lighting design and planning at healthcare units in the future?

2.2 Method

This research is based on a case-study design, using a group therapy room as the case site. The project implements two different lighting scenarios, and subsequently investigates how respondents perceive these two different lighting environments. The group therapy room is located at a psychiatric hospital, where the respondents are patients who attend therapy sessions concerning the challenges in relation to their illness, typically after their discharge from the psychiatric hospital following severe depression. The intervention includes two different lighting scenarios, followed by two semantic questionnaires. The study was conducted during winter months (November 2021–March 2022). The two lighting scenarios respectively consist of high- and low-positioned lighting. The high-positioned light is also the original light setting of the room, and represents the conventional strategy of organising lighting design for a space to support as many different functions as possible. Meanwhile, the low-positioned light represents an alternative lighting scenario that targets the specific function of the space as a group therapy room. The main focal areas in the study are the *distribution of light*, an important aspect when addressing the atmosphere of a room, and the *empathic* potential of the lighting's impacts on the behaviours of the space's occupants [14].

2.2.1 Light measurements

On-site measurements of the two lighting design scenarios are performed through illuminance measurements (Hagner Digital Luxmeter, model EC1-X), photographic documentation, and luminance photographs (SmartBeam). The luminance photographs are generated via a mobile phone camera (Samsung Galaxy S22+) using the SmartBeam mobile application by Fusion Optix to convert the photographs into luminance maps. The SmartBeam illustrations are visually clear, but not reliable in terms of exact measurements [15]; therefore, they only indicate the luminance distribution. The measurements and data documentation for illuminance in both lighting scenarios are measured on-site at a horizontal plane 0.85 m above the floor in a grid of 0.50 m x 0.50 m.

2.2.2 Semantic questionnaire

The respondents are asked to answer a questionnaire related to each lighting design scenario. The questionnaire focuses on respondents' perceptions of the space and preferences regarding the lighting design scheme. The first half of the questionnaire comprises six statements related to the experience of the space in relation to the activity. The respondents rate the statements using a five-point Likert scale ranging from *strongly agree* to *strongly disagree* [16]. The second half of the questionnaire comprises a variety of negatively and positively loaded words, among which each respondent chooses the word(s) describing their experience of the lighting scenario. Data collection via the questionnaire supports respondents remaining anonymous, as no name, age or gender are asked for. At no time was the research team in direct contact with the respondents. Questionnaire distribution is handled by the nurse, who joins the respondents in person and organises the sessions including handout of the questionnaires. This research inquiry is viewed as a quality assessment of the physical environment of the centre, and the project is therefore not required to undergo approvals of The Danish Ethics Committee. As no personal data was included in the study and only the nurses knew the identity of the participants, GDPR regulations do not apply. Before designing the questionnaire, the researchers have held an informal meeting with a relevant nurse, to discuss the patients' typical mental conditions and the organisation of their therapy sessions.

3. Case site

The case site is a group therapy room with dimensions of 4.60 m x 5.90 m, for a total of 27m². The space is on the building's 1st floor, and has an entrance door facing the corridor and a French balcony placed in the middle of the façade-wall that provides daylight, fresh air and a view towards a garden. The ceiling height is 3.0 m. The walls and ceiling are painted white (0.8 reflectance), and the floor is grey linoleum (0.3 reflectance). The two different lighting design scenarios are installed in this room; after installation, the respondents are exposed to one scenario at a time, but sequentially within the same session. The two lighting design scenarios are: A) high-positioned light fixtures, and B) low-positioned light fixtures.

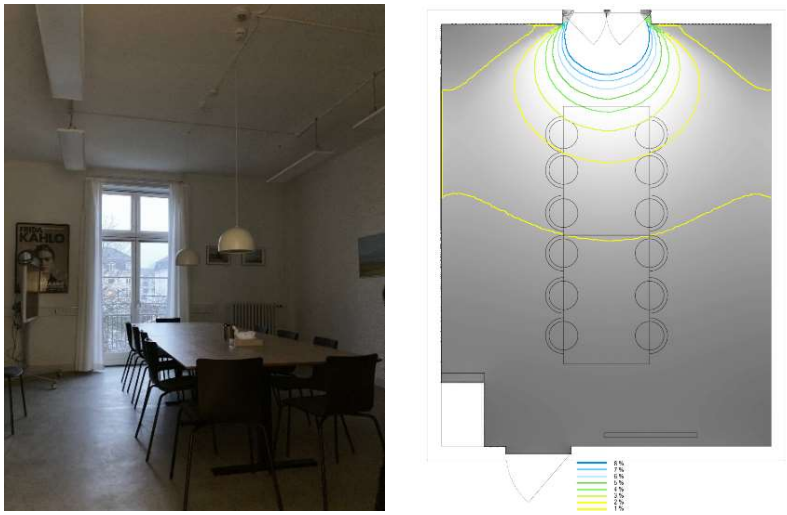

Fig 01 Left to right: Photo of the group therapy room in daylight situation with overcast sky, and plan drawing with DF.

	Specification of luminaire				*Specification of light source*		
scenario	Position of luminaire	Number of luminaires	Size and shape of luminaires	Distribution of light	Light source	CCT	Power consumption
HIGH	2,64m	4	1,20 m x 0,24 m	uniform	LED tube T8, 2 x 17,5 W x 4	3000 K	140 W
LOW	1,50m	2	Ø 0,30 m	non-uniform	LED lamp E27, 2 X 10,5 W	2700 K	21 W

Fig 02 Two scenarios: specification of luminaire and light source for the high- and low-positioned lights

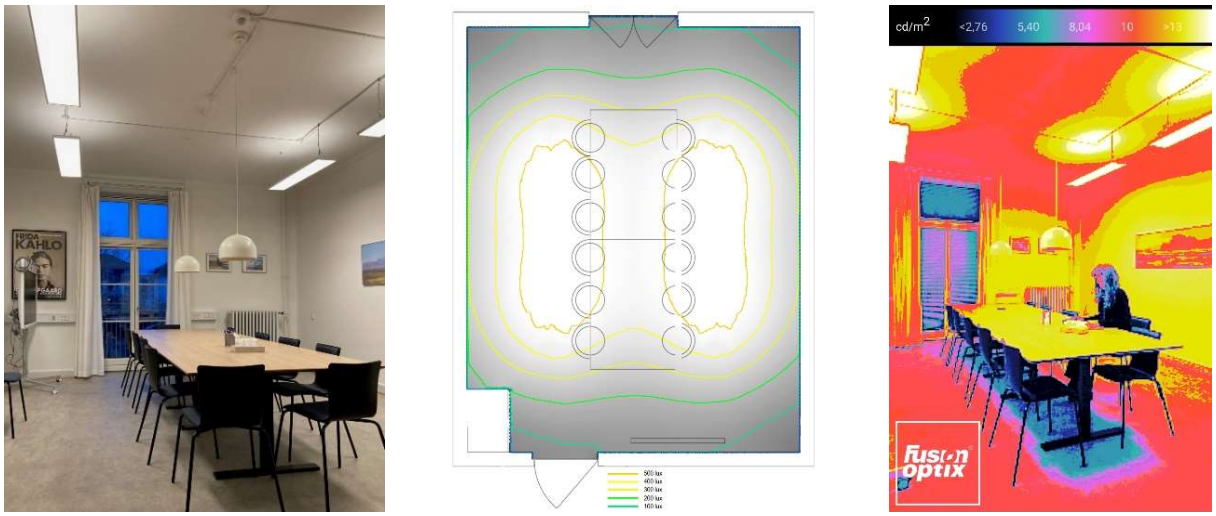

Fig 03 Left to right: Photo of high-positioned light, plan with iso lux curves and luminance photo.

3.1 High-positioned lighting

Four luminaires are positioned in suspension 0.35 m below the ceiling. The luminaires each measure 1.20 m x 0.24 m x 0.025 m. The lamps are positioned symmetrically in the room 1.40 m from the end walls and 1.04 m from the adjacent walls. The luminaires emit light both up towards the ceiling and down towards the table. The luminaires have a matte translucent screen. The light source is LED 140 W, 3000K. The light distribution is uniform, measured on site on a horizontal plane 0.85 m above the floor. The light has its strongest intensity at approximately 500–510 lux, below the two lamps hanging

in elongation to one another. From the centre of the space, the intensity of the light diminishes towards the walls, where the light level is approximately 150 lux (Fig 03). The experience of the light distribution in the space is that it is uniform, without any highlights. Even the more intense areas directly underneath the luminaires are not experienced as much brighter.

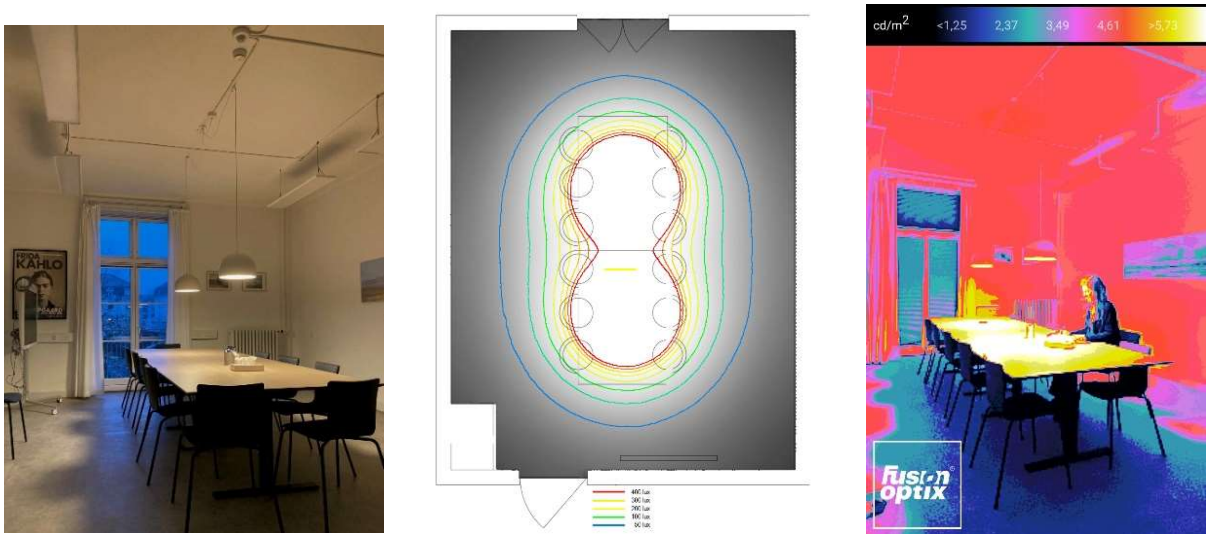

Fig 04 Left to right: Photo of low-positioned light, plan with iso lux curves and luminance photo.

3.2 Low-positioned lighting

Two pendants are suspended above the tables and 1.50 m above the floor. The two meeting tables, with dimensions of 1.20 m x 1.80 m, are placed in the centre of the room. The luminaires are centred 0.75 m above each table. The luminaire is painted white, has the shape of a semicircle, has a matte opaque screen, and measures 0.30 m in diameter. The light source is LED 21 W, 2700 K. The luminaires only emit light downwards. Therefore, their emittance of light is focused on the table surface, leaving the rest of the room darker. This causes a non-uniform light distribution in the room. Measured on site on a horizontal plane 0.85 m above the floor, the hotspots of the luminaires are 550–600 lux beneath the luminaires, fading to 150–200 lux at the edges of the tables. The rest of the room is dimly lit at approximately 20 -30 lux. This non-uniform lighting is clearly experienced when sitting in the room, as shown in the luminance photo (Fig 04).

3.3 The time schedule

The respondents are exposed to one scenario at a time during a single session split into two parts. During the first part of the session, the respondents are exposed to the high-positioned light for two hours. Then, a break is scheduled; after the break, the room lighting is changed to the low-positioned lighting, and respondents are exposed to the second scenario for two hours.

The experiment was conducted during winter, from November 2022–March 2023. To improve the reliability of the results, it was important that the main light source was electrical light, meaning daylight needed to be minimised within the experiment. During the test period (November–December 2023), it was dark and weather conditions were optimal, with overcast skies. The lighting scenario portions of the experiment took place on the 1st and 2nd of February 2023, during the afternoon. These dates were chosen based on the schedules for the participants' group therapy sessions, to allow the research experiments to occur within their usual schedule. A third experiment conducted later was not included in this paper, as the space had too large a contribution of sunlight, giving the daylight too much attention. On both days of the experiment, six respondents attended each group session, and each of them answered the questionnaire related to the two different lighting design scenarios; in all, 12 responses have been collected for each lighting design scheme, for a total of 24 responses to the experiment.

4. Results

The results of the questionnaires show significant differences among patients' perception of the two different lighting designs. In the semantic analysis, the low-positioned lighting is rated as the most pleasant, with respondents rating it 12 out of 18 points, while they rated the high-positioned lighting only six points (Fig 05). Responses indicate the low-positioned lighting works best for activities focused on and around the table, with a rating of 13 points out of 18, compared to the high-positioned lighting with only five (Fig 06). The same applies to how well the lighting supports therapy sessions; the low-positioned lighting receives 14 points out of 21, and the high-positioned lighting only seven (Fig 07). In addition, regarding supporting conversation around the table, respondents rate the low-positioned lighting as better with 12 out of 14 points, and high-positioned lighting with two (Fig 08). Finally, respondents rate the low-positioned lighting better regarding providing desirable levels of light on other participants, with 13 points out of 18, while they only award three to the high-positioned lighting (Fig 09). Only for blackboard education does the high-positioned lighting perform better, with 10 points out of 18, while the low-positioned lighting receives four (Fig 10). In general, the low-positioned lighting performs better (total score of 60 points) in comparison to the high-positioned light (total score of 35 points) (Fig 11).

When selecting words to characterize the different lighting scenarios, the respondents describe the high-positioned light with a diversity of words from the list provided in the questionnaire. Most of the words are highlighted, including both positive and negative evaluations. The statements regarding the high-positioned light can be interpreted as vaguer; overall, the respondents can be divided into two groups, one who dislikes the high-positioned light, and the other who likes it. The lighting design scheme with the high-positioned luminaires is hence a subject of more debate than the other scenario, and yields an unclear impression of the respondents' preferences. Nonetheless, one descriptive word stands out, chosen by most respondents: 'institutional'. This makes a clear statement that respondents interpret the high-positioned, evenly distributed light as creating an institutional atmosphere. Respondents also describe the low-positioned light using a range of different characteristics, but in contrast to the high-positioned light, the characteristics are all related to words typically interpreted as positive feelings, such as 'safe', 'relaxing', 'suitable', 'nice', 'beautiful', 'comfortable', 'homey' and 'cosy'.

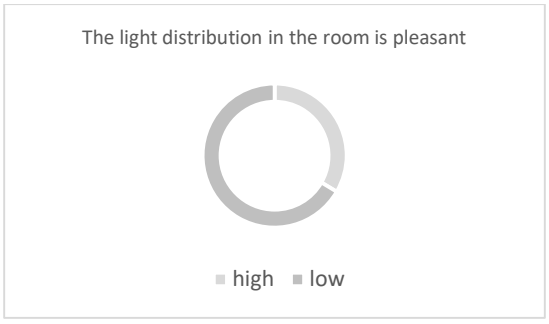

Fig 05 Respondents' preferences.

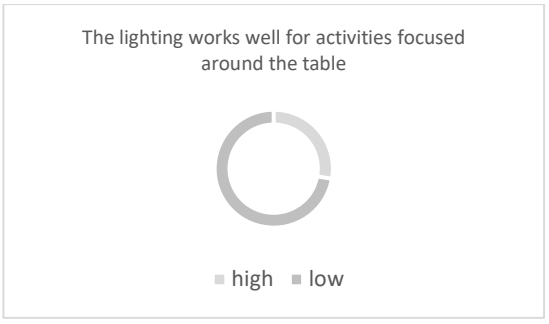

Fig 06 Respondents' preferences.

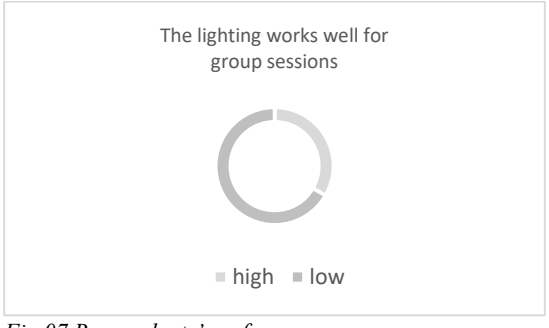

Fig 07 Respondents' preferences.

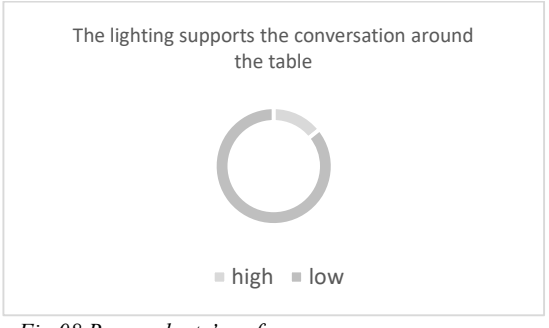

Fig 08 Respondents' preferences.

Fig 09 Respondents' preferences.

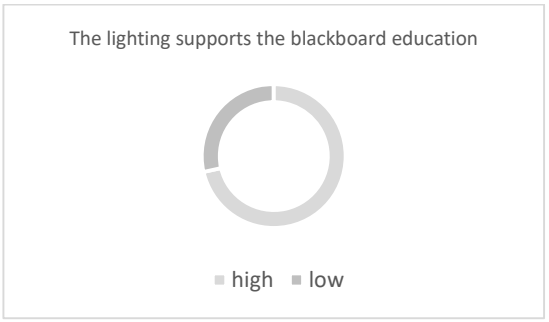

Fig 10 Respondents' preferences.

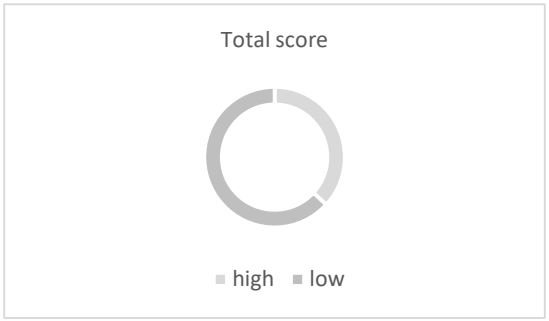

Fig 11 Respondents' preferences between the high- and low-positioned light in total.

The most significant difference between the two lighting scenarios involves the distribution of light, which is shown to have a pronounced impact on the visual environment. In general, light distribution is primarily related to the design of fixtures, and therefore often related to the designer's choice of lamps. Other aspects of lighting are related to the light source, such as light spectrum, colour rendering and the correlated colour temperature. Surveys focusing on aspects of the light source are more common than those examining light distribution. The current research focuses on light distribution, but recognizes the importance of the other aspects related to light source.

5. Discussion

The two different lighting scenarios in this study are fundamentally different in their expression. In addition, the respondents' ratings of the two schemes are markedly different; overall, patients prefer the low-positioned light, which provides a non-uniform light distribution. A potential follow-up question arises: Why has such a lighting design scheme not been widely adopted in practice for healthcare institutions, especially in environments where this type of lighting could support vulnerable users?

Lighting design schemes for institutions, for example healthcare facilities such as hospitals and care homes, have traditionally been planned to be functional and efficient. Due to the need for a space to facilitate different functions, or to be easily reorganizable for additional people or other purposes, lighting design schemes are often created as highly universal: Typically, flexible use of space results in lighting design strategies that promote uniform light distribution. A lighting design scheme without any hierarchy and with approximately 300 lux on a vertical surface 0.85m above the floor [17], provides flexibility and the possibility of positioning desks, meeting tables, and workstations anywhere within the space. The same lighting design scheme is typically replicated within most institutional spaces, as the most effective solution concerning flexible use, cost, and maintaining the light. Focusing on practical solutions tends to emphasise light quantity rather than quality. This approach is widespread within design of electrical lighting schemes for institutions, and has probably given rise to the general understanding of how an 'institutional' environment looks. The current study, however, questions this approach to planning the general lighting for healthcare units, and recommends taking the specific activities in healthcare units more into account – not least due to the needs of a space's occupants, as they typically will be vulnerable individuals, hospitalized or enrolled in a course of treatment during

which they are in need of caring attention. The empathic approach can be a means to achieving aspects of social sustainability, including safety and security, sense of place, social interaction, social equity and social participation [18].

In a Scandinavian context, the uniformly lit environment is precisely the opposite of how we traditionally perceive and understand a comfortable, safe, cosy and 'homey' lighting environment [19]. The institutional lighting scheme is uniform, universal and without hierarchy, and the light is not directly linked to the function of the space. In contrast, a 'homey' lighting design scheme is made for specific purposes, with the light fixtures positioned in specific areas at specific heights [20]. Consequently, this generates another distinctive feature of homey lighting: a light hierarchy indicating where the different functions are positioned. These 'isles of light' guide the occupants of the space by pointing out the various functions. Such distinct variations in light can, though, create high levels of contrast, which can lead to visibility problems. Nevertheless, the varied light levels are often intuitively adjusted by the user and are therefore perceived as comfortable, creating a cosy atmosphere in which people typically feel safe and at home. Furthermore, light hierarchies affect the visual environment through the qualities of light: colour rendering, directionality of light and the form-enhancing shadow pattern that makes people and objects stand out more clearly [21, 22]. These findings from prior research are further supported by the results presented above, which show a clear favourite among the respondents, as the majority prefer the low-positioned, non-uniform light for this specific healthcare setting.

While the uniform lighting of many healthcare environments supports functionality and efficiency, non-uniform and intimacy-tailored lighting supports the semi-privacy and intimacy needed for facilitating therapeutic group conversations. Such non-uniform lighting contributes to a focused and shared space where the most important aspects, not only faces and expressions, but also gestural body language, are visible. Not only does the isles of light establish the table as a shared area of common focus, but also the boundary of the non-uniform lit space creates opportunities to participate more or less in the conversation by moving into or out of the isles of light.

6. Context and limitations

This study has only examined Scandinavian settings, and we acknowledge that culture might be a reason for the preferences participants express. The same survey in another cultural setting might lead to different results due to inherent social preferences [23, 24, 25]. Likewise, climate, including the prevalence of low solar altitude, might influence on respondents' preferences, as the relation to daylight can be reflected in electrical lighting design [26]. In addition, electrical lighting includes the light source, and the specifications of the light sources have varied in the two scenarios; consequently, our survey results may include bias, and in future studies the specifications of the light sources must be more uniform.

Furthermore, the low-positioned light follows a non-uniform light distribution. The distribution of light is one of the variables of light, perhaps an overlooked variable that merits further attention [27]. Often the intention is to meet requirements where the light must be as even as possible, whereas this study points towards the preference of a non-uniform light distribution.

Moreover, the survey method could also be discussed as a limitation: we likely would have gained improved understanding of the participants' experience regarding the lighting situation through interviews and participatory observations. However, due to the therapeutic trajectory and the patients' individual recovery processes, the more qualitative approaches were omitted after dialogue with the responsible healthcare professionals. Furthermore, questions related to emotions were also avoided, so as to not spark unwanted reactions among the patient participants. Value-laden spatial characteristics, such as 'safe', 'relaxing', 'suitable', 'nice', 'beautiful', 'comfortable', 'homey' and 'cosy', focus on the environment and social relations, more than on impacts to the individual.

In a broader historical perspective, electrical light is a rather new invention: in particular, the development of the incandescent light bulb and its success in market penetration changed the interior lighting environment. In the Danish context, the architect and designer Poul Henningsen profoundly investigated what was, at the time, brand-new technology, and designed the famous PH luminaire. This was specifically designed in relationship to the emittance of light from an incandescent bulb.

Henningsen wrote intensively about his lighting design concepts, both pedagogically, so that lay-people could understand his points, and more scientifically to confront engineers with knowledge and thoughts on electrical light. In a series of articles published from 1926–1930, he introduces the new lighting technology to the public, and shares his thoughts on the qualities of light and which aspects merit awareness [28], including the position of the luminaire. One of the guidelines he offers is to position light low, both to avoid glare and to support the functionality of the light by directing it onto the subject that needs to be seen [29].

From a more universal perspective, the preference within this study for low-positioned light could also be related to the mythical narrative about how architecture emerges. The low positions of the lamps generate a light distribution type that may be related to the far older central position of the fireplace, which the ancient Roman architect Vitruvius describes in his discussion of the primitive hut and the rise of formal architecture [30]. Gottfried Semper describes a similar progression [31]. Both relate the central fireplace to the feeling of being safe and secure, and to feeling part of a social gathering. Both refer to low-positioned light as offering an atmosphere universally interpreted as positive.

7. Conclusion

This study shows that different light distributions can fundamentally change perceptions of a room. It documents how respondents clearly distinguish between high- and the low-positioned lighting within a specific therapeutic room at a healthcare institution. The respondents characterize and rate the atmosphere of two different lighting design scenarios as being significantly different. The high-positioned uniform light is mostly characterized in negative terms, specifically as ‘institutional’, by most respondents. In contrast, the low-positioned, non-uniform light is unanimously described in positive terms, including ‘cosy’, ‘homey’ and ‘comfortable’.

The project is a pilot project investigating how electrical lighting may affect vulnerable people, and how it eventually can support them. In this paper, the results of the user assessments are discussed in relation to the initial hypothesis that the lighting makes a difference. Professional assessment of the lighting settings provides opportunity for these findings to inform future strategies for supportive empathic lighting design in healthcare environments. Lighting a specific space can be conducted in relationship to meeting standards and supporting flexible spatial use. However, supporting the needs of vulnerable people who are hospitalised and in treatment constitutes additional objectives that require other lighting design strategies. Being in a space is more than simply being able to see the area; it also concerns perception of the space and the ability to feel comfortable and secure.

In the space this case study has examined, the respondents participate in sessions in which they are taught by nurses and physicians how to handle challenges related to their diseases. This also means the respondents are examples of vulnerable patients in difficult situations who are encountering a healthcare institution, thereby being exposed to a specific physical environment that includes a specific atmosphere created by the lighting design. Precisely this type of meeting, between vulnerable people and a specific lighting design, has been the core interest of this investigation.

The two lighting design scenarios represent two archetypal lighting schemes, although they also reflect the traditional approaches to lighting design for healthcare institutions and more private environments. A coherent preference for lighting design in a specific culture might reflect relationships to technical developments in the region, climate conditions, or religious traditions and ceremonies. As mentioned above, this experiment has only been executed in a Scandinavian context; cultural preferences might differ if repeated in another context. Furthermore, the survey is a pilot project which has included few respondents; to strengthen statistical reliability of the evidence, future research design should include higher numbers of respondents.

Overall, the distinct interpretations of the respondents, with their apparent preference for the low-positioned non-uniform light, suggests that re-evaluating the visual environment at healthcare institutions could be worthwhile, to focus on creating empathic light design schemes for improved support of vulnerable patients. Such action could be especially worthwhile as the results also document an 85% reduction in energy consumption when using the low-positioned, non-uniform lighting, compared to the high-positioned lighting. Future planning for healthcare lighting design may take these

results into account, to incorporate lower light levels and lower luminaire positioning to improve architectural planning of sustainable, supportive, and empathic lighting.

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