Aalborg University Copenhagen

Semester: Spring 2016 – 6th semester Lighting Design

Title: Human centric lighting design in an art gallery

Project Period: 01.02.2016 – 26.05.2016

Semester Theme: Master Thesis

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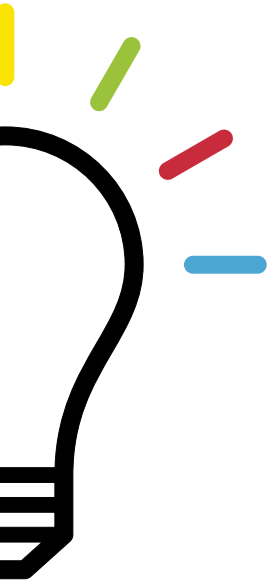
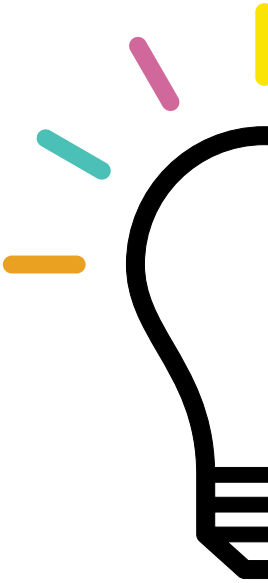
Abstract:

There is a general stagnation in the way that the art gallery lighting is designed.
The aim of this thesis is to establish a new direction in the art gallery lighting design by exploring the subject of human centric lighting (HCL). Primary goal of this study is to first analyse the importance of HCL, the relationship between human emotions and lighting and collecting the knowledge from the recent research on the topic.
I also argue about the difference between art gallery and a museum and its consequences for the lighting. Later on I collect the common practices of gallery lighting.
In the second part of the thesis I propose an experimental design and a test in which I examine the emotional reactions and preferences of the visitors of an art exhibition, where two, different kinds of light are provided. The study shows a preference for an inclusions of coloured, directional lighting in a given gallery space. I conclude by indicating a need for further investigation of the topic in relation to possible lighting techniques and product which could support the new approach to the gallery lighting.

Copies: 1
Pages: 72
Finished: 25.05.2016



HUMAN CENTRIC LIGHTING DESIGN IN AN ART GALLERY



Master Thesis

Mikolaj Lewandowski

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MA in Lighting Design
Aalborg Univeristy in Copenhagen

2016

ABOUT ME

My name is Mikolaj Marcin Lewandowski.

I was born in Wroclaw, Poland in 1989.

I hold a BA degree in Art and Technology from AAU.

I specialize in film and photography lighting.

I am a part of an art collective Unknown Twins.

ABSTRACT

There is a general stagnation in the way that the art gallery lighting is designed. The aim of this thesis is to establish a new direction in the art gallery lighting design by exploring the subject of human centric lighting (HCL). Primary goal of this study is to first analyze the importance of HCL, the relationship between human emotions and lighting and collecting the knowledge from the recent research on the topic. I also argue about the difference between art gallery and a museum and its consequences for the lighting. Later on I collect the common practices of gallery lighting. In the second part of the thesis I propose an experimental design and a test in which I examine the emotional reactions and preferences of the visitors of an art exhibition, where two, different kinds of light are provided. The study shows a preference for an inclusions of colored, directional lighting in a given gallery space. I conclude by indicating a need for further investigation of the topic in relation to possible lighting techniques and product which could support the new approach to the gallery lighting.

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INTRODUCTION

'The painting must reveal itself in different aspects if the moods of light are included in its viewing, in its seeing.'

Louis Isadore Kahn, 1901–1974

Light is one of the most important elements that shape our ability to perceive, understand and enjoy the surrounding world. Some researchers indicate that light, next to food is the most important environmental input which controls the human body (Martini: 1970). Although light's primary function is to help create a vision, it also has physiological and psychological effects on people. Through its brightness, color, intensity or temperature light shapes our likes and dislikes for the environment that surround it. This powerful connection between light and emotions that we perceive is the core motivation for the topic of this investigation. Further on I will place the subject in the context of another phenomenon which mere existence relies solemnly on human emotions - art.

The way we perceive artworks is usually in the context of a gallery or museum space in which they are exhibited. Together with space, light can play a crucial role in our understanding and appreciation of art.

Most of the works on the topic of art exhibition lighting (Steffy: 2003) put much emphasis on, what is called, hard issues of the light design such as distribution, intensity, light-induced damage or luminaire positioning – simply, well documented technical advice which concentrates mainly on the art itself. Much is also written about the visual perception of the visitors, yet one can seldom come across a topic of the art experience design or strategies for lighting as a tool to guide emotions. In his book ''Light for Art' Sake", Christopher Cuttle divides the lighting issues around the topic of art display into the following categories (Cuttle: 2007) :

- To make the artwork appear as it would have appeared to the artist at the time of its creation
- To ensure that no damage due to light exposure will occur
- To achieve the best possible appearance of the artwork
- To provide optimum conditions for viewing art
- To assist viewers to understand the displayed objects and their reason for being there

I include this example to draw attention to the factor which is missing in this, and many other works on the topic – simply the importance of emotional stimulation or well-being of the visitors as a part of their experience.

The 'blind' following of the technical advice leads to the endless amount of monotonous gallery spaces, lit with flat fluorescent light. I believe that the investigation and findings of this thesis will

be of much interest to the owners and curators of the smaller type of galleries, which because of the lack of professional light design strategy, suffer from lighting schemes which bring no stimulation to the visitors and result in a poor art experience.

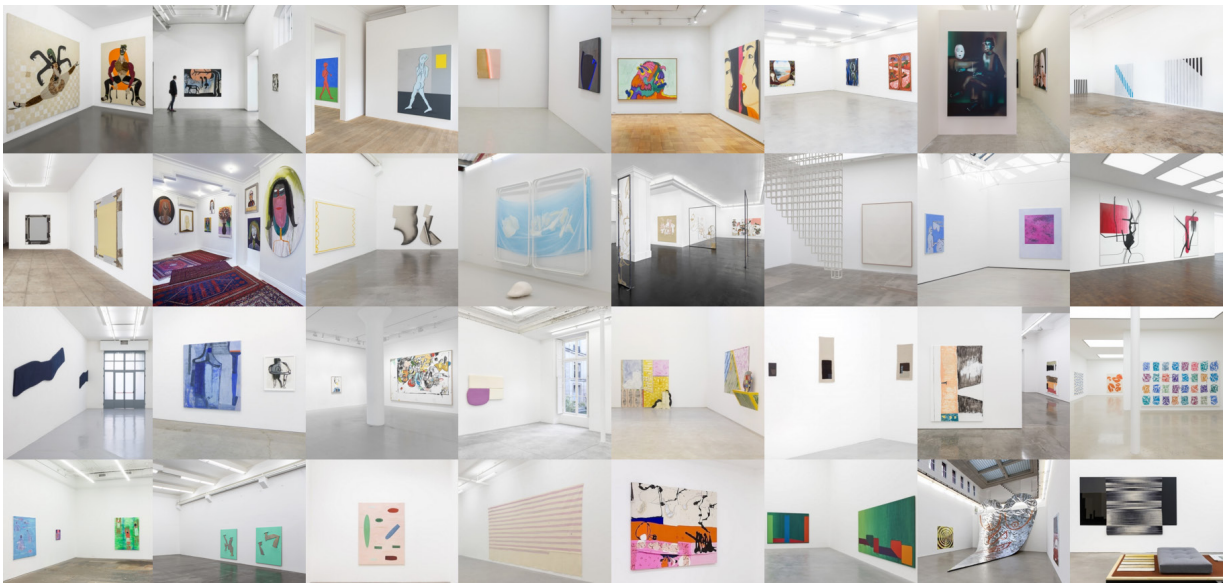


Illustration 1. From a distance, the whiteness of art galleries prevails.

In this paper I intend to propose an alternative way of looking at the art exhibition lighting, bringing into focus the receiver of the art, not only the received pieces. I believe that there must be a balance between correct lighting, which can render the colors and details of the artworks while maintaining their quality, and the lighting for people with a task to stimulate their mood and behavior. To support the proposed approach, I will investigate topics such as psychological effects of light, color theory, and visual perception.

On the parallel axis, the development of electrical lighting (and in particular) the invention of the LED technology created new possibilities for the light designers who want to engage the viewers in a more complex experience of the art. In that context, this paper will concentrate only on the artificial lighting strategies.

Hence the research question of this paper: ***How can alternative lighting of an art exhibition space, influence emotional state of the visitors?*** And subsequently - ***What is the perception of light's perceived attributes which accompanies these emotional reactions?***

To come closer to the understanding of the topic, I will apply an interdisciplinary approach, bringing in the knowledge from fields such as psychology, art history, architecture and experience design. Further on as the analysis method for this work, I incorporated the practice of cultural analysis proposed by Mieke Bal. As she explains - *the field is based on a keen awareness of the critic's situatedness in the present, the social and cultural present from which we look, and look back, at the objects that are always already of the past, objects that we take to define our current culture* (Bal: 1999) . Bal also proposed an idea of *a traveling concept* which applies directly to light as a factor which moves through different disciplines (Bal: 2002).

In the course of this paper, I will explain a difference between an art gallery and a museum and explain why it is important for the proposed lighting strategy. I will also introduce and compare different studies on the emotional impact of light and its potential for mood creation. As a result, I will perform a proof of concept and analyze its perceived qualities in a test.

HUMAN CENTRIC LIGHTING

'Light has thingness itself, so it is not something that reveals something about other things you are looking at, but it becomes a revelation itself.'

James Turrell, 1988

In this chapter, I will attempt a brief introduction to a relatively new concept of human centric lighting. I will offer an overview of human perception mechanism that allows for the visual and biological understanding of light by people. I will introduce James Russel's model for understanding the affective quality of places. I will also go through historically significant and most recent research which explains the relationship between human emotional preferences for light conditions, color, and visual stimulation.

Human in the center

The importance of human presence in the context of architecture has been cultivated since the early days of this domain. The famous principles proposed by Vitruvius describe good architecture as one which follows Firmatis (Durability), Utilitas (Utility) and Venustatis (Beauty). It is the third one that is of interest whent it comes to light (Vitruvius: 2001). According to Vitruvius beauty should delight people and raise their spirits. In many ways, this ancient principle describes the core foundation of what nowadays begins to be addressed as human centric lighting design - the focus of human's perception of space and light. Although these principles evolved among centuries and were shaped by many influential architects – they remain at the core of architectural practice.

As a part of the art of architecture, lighting design is a relatively young field. One of the key figures and father of modern lighting design William Lam created a list of criteria which were to help identify human needs in the context of any given space. They were divided into 'activity needs' – connected to performing visual activities and 'biological needs' – psychological aspects of what people may experience in a given space and which are related to a particular lighting situation (Lam: 1977).

Activity and biological needs:

1. Need for orientation (affected by expectations and prior experience)
2. Need for time orientation
3. Need for consistency

4. Need for contact with daylight
5. Need for view (and signs or other directional clues)
6. Need for focus
7. Need for definition and personalization of territory
8. Understanding of exterior space

In the early 2000s the advanced development of LED-based, dynamic lighting solutions allowed for a new beginning in the topic of understanding of human biological needs which could be addressed by light design. Together with a discovery of internal photosensitive Retinal Ganglion Cells who are responsible for light's influence over circadian rhythm and production of melatonin the LED technology began to gain significant influence in the lighting world ("Melanopsin-expressing, Intrinsically Photosensitive Retinal Ganglion Cells": 2015). This discovery created two opportunities for human centric lighting (HCL) – biologically and emotionally effective lighting.

In a recent interview, Stan Walerczyk introduced HCL as a solution which not only could provide good visual lighting quality, energy efficiency, and sustainability at a reasonable cost, but it could also improve circadian rhythms, short and long term alertness, sleep, mood, visual acuity, perception, and performance–productivity (Walerczyk: 2015). This investigation will concentrate on the perception and mood categories in an attempt to further explain their connection to light.

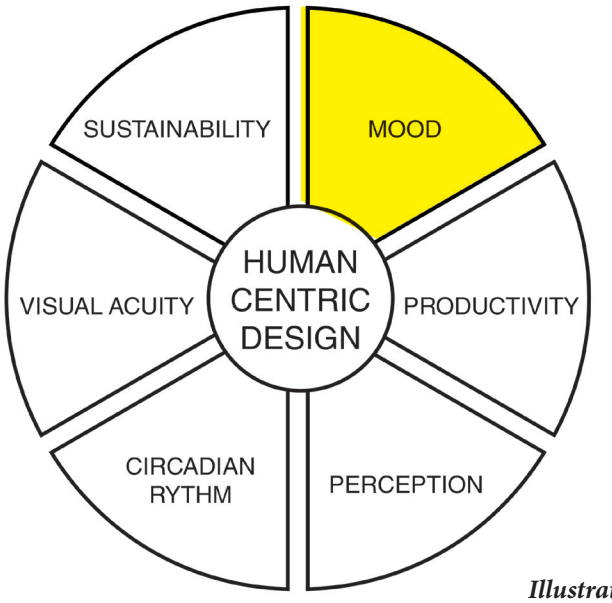


Illustration 2. The elements of HCL

In 2004, Virgil D. Gligor established a model which help to understand the range of influences which light has over us. He explains: *The luminous environment acts through a chain of mechanisms on human physiological and psychological factors, which further influence human performance and productivity. Variations of luminances and colors can strengthen attractiveness, trigger emotions, and affect our mood, the impact of lighting depending much on the individuals and their state of mind. A lighting installation that does not meet the user's expectations can be considered unacceptable even if it provides the conditions for adequate visual performance (Gligor: 2004).*

Feeling the light

Our vision and the way that we perceive the surrounding world is strictly dependent on the way that our brain interprets and stores the received information. In many ways, our eyes are merely an extension of our brain and the impulses that they provide influence the way that we feel, act or remember things (Kumaresch: 2014).

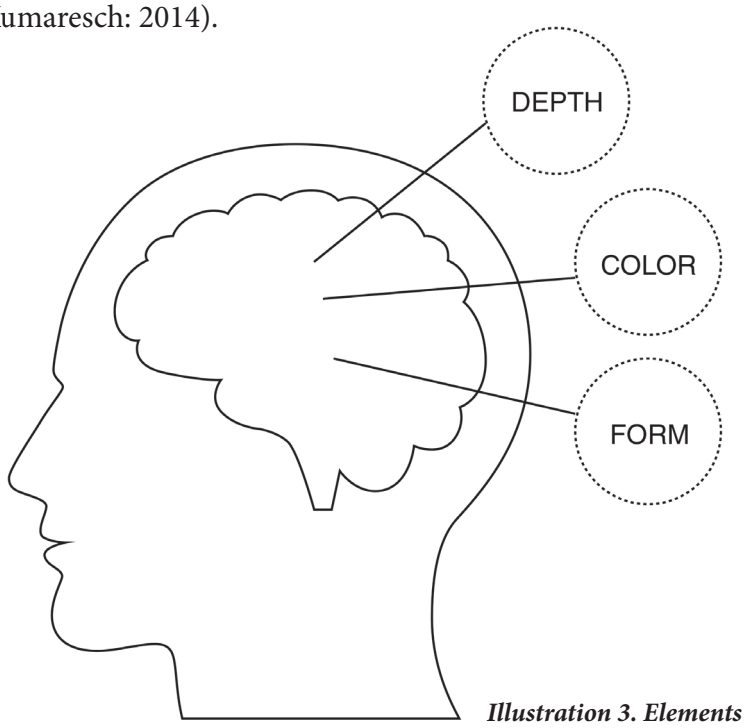


Illustration 3. Elements of the final image

Human brain analyses the information and splits it into different parts like i.a. Depth, color or form. On this base, it associates different emotions to what we see. If our vision is accompanied by the emotional output, it is very likely that an individual memory will be created and stored for

later use (Furnham: 2009). On the other hand, if there are no emotions connected to what we see the result will most certainly be only information. Light, of course, have a significant influence over the way our brain will process the input we receive – to illustrate this we can imagine two situations. In the first one, we see a monument a part of a skyline of the city. In the second we are looking at the same monument, yet beautifully lit and glittering at night. The first situation will most likely result in a small, informational input whereas the latter one will become a part of a memory connected to that encounter.

The light traveling from our eyes to the brain can take one of the two paths – visual and biological.

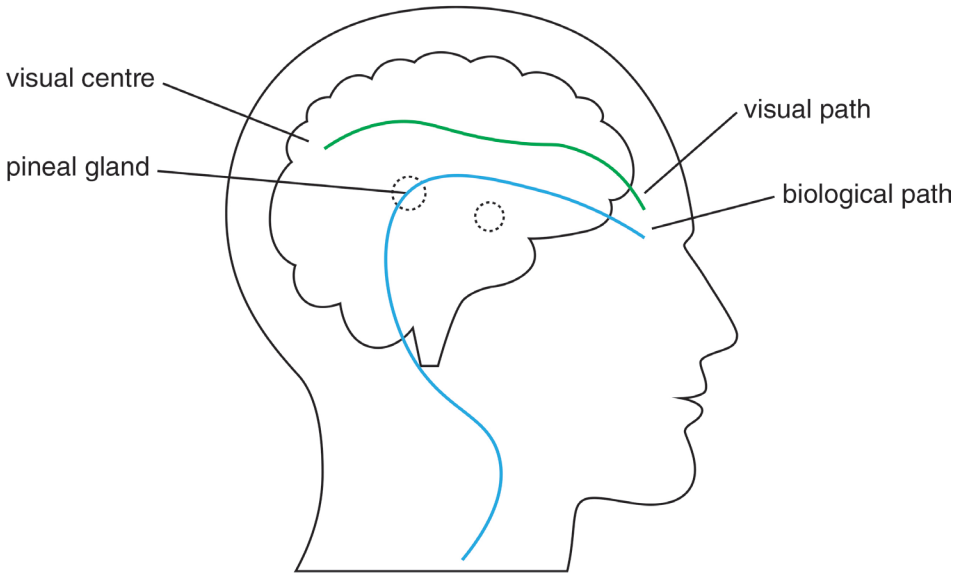
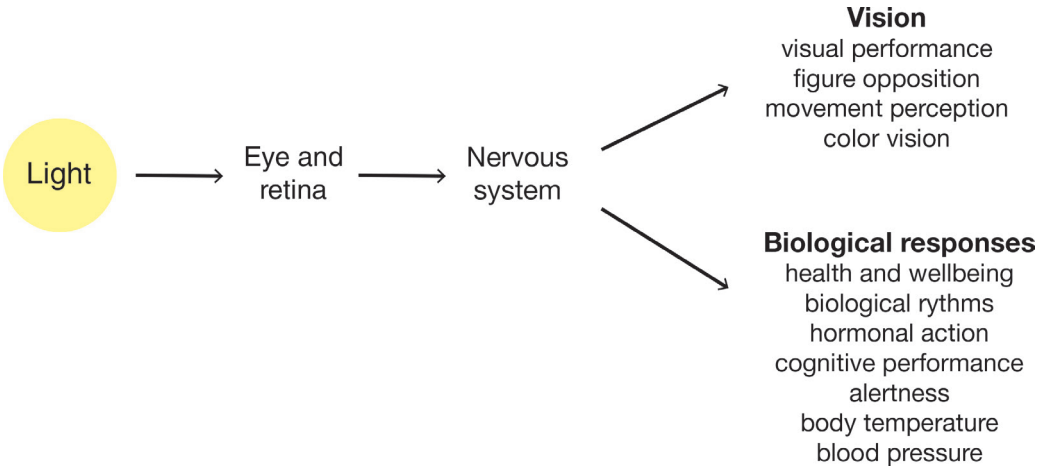


Illustration 4. The two paths

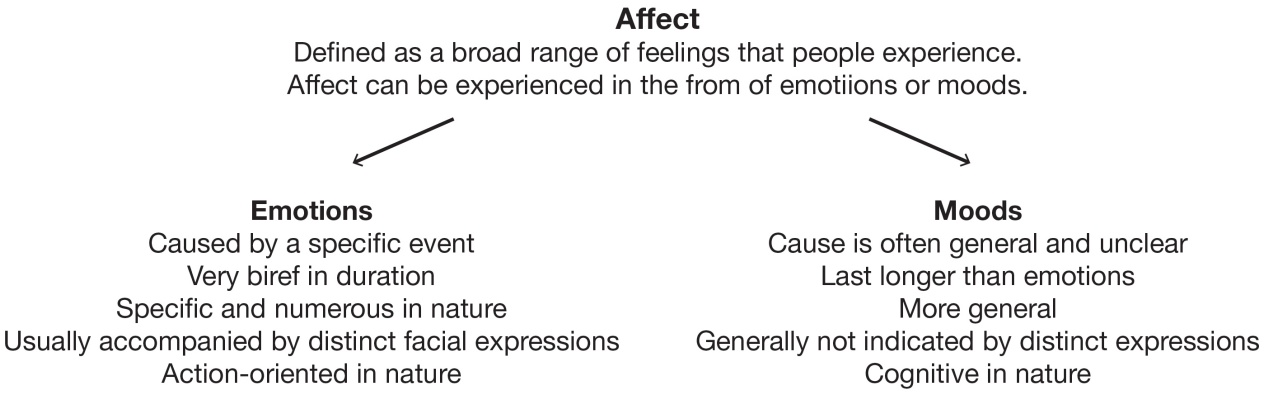
Although they are both connected to the human decision-making process, they influence our behavior on different levels. The visual path can also be described as a conscious one – it brings a big part of the visual knowledge about the surrounding world that we have immediate access to. The biological path is providing us what can be called a subconscious input – it results in activation and de-activation of hormone secretion (e.g. it is strictly connected to the pineal gland and its importance for the secretion of melatonin. And melatonin is strictly connected to human sleep cycle and the circadian rhythm). The pineal gland as a part of the biological path is also responsible for the emotional impact of light (Macchi;Bruce: 2004).



As illustrated by the diagram above, light has both visual and non-visual responses acting through the different retinal photoreceptors and tracts in the nervous system. The scientists in many centuries of research have described the elements and functions of the visual path. We also know more about the indirect consequences of light for our behavior - yet as of today, there is still a lot to be discovered about the biological influences of light.

Light as a feeling

Before we can go any further, the first step is to define the actual difference between affect, mood, and emotion. According to most conventional definitions, an affect is a semantic container covering an entire range of feelings which people might experience (Frijda: 1993). Our emotions are intense feelings usually caused by or directed at something or somebody. Moods, on the other hand, tend to be less intense and most often are not attributed to any contextual stimulus (Frijda: 1993).



What is interesting though the emotions can, although intense can disappear quite quickly – whereas mood is something that can last much longer.

In 1980, James A. Russell published a paper in which he proposed a model for classification of affective quality which people attribute to environments. He also introduced the light as one of the important factors, influencing the affect. The model consists of eight emotional states (variables): pleasant, exciting, arousing, distressing, unpleasant, gloomy, sleepy and relaxing (Russel: 1980). This scale can be most useful in understanding different ways in which light can have an effect on people's mood in a given space.

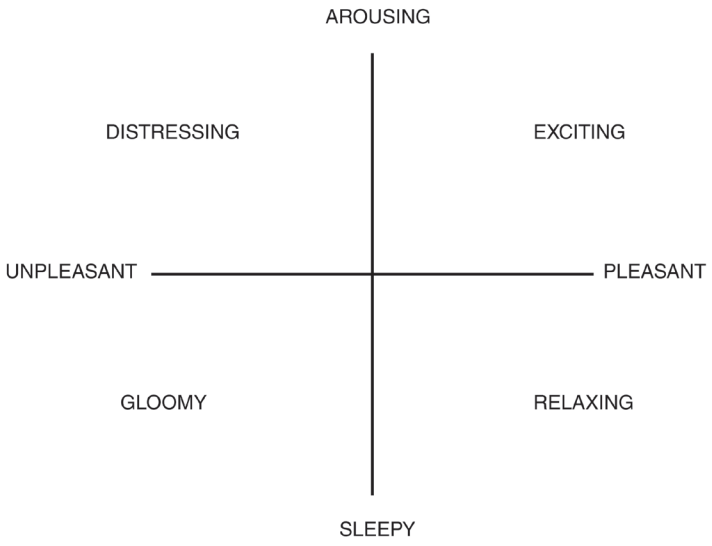


Illustration 5. Model of emotion classification

The feelings of pleasure, excitement and arousal and relax are usually described as positive or constructive (Russel: 1980). Based on this model, Russel followed with a proposal of what he called PAD model– pleasure, arousal, domination – primary behavioral responses to the environment (which follow the initial affective response) (Russel: 1980). According to the PAD model, our senses process the environment and characterize a different aspect of what the stimulus is (Davis: 2013). Quoting Russel: *sensory input combines with personality characteristics to produce primary emotional responses in three areas – the pleasure that a person finds in the environment, the amount of arousal or stimulation that the environment provides, and the extent of dominance or control that people feel they have while in the environment* (Russel: 1980).

Why are emotions so important?

A life without emotions is hard to imagine and of course, most of the social situations evoke many different feelings. They help us shape our life at various levels - intrapersonal, interpersonal, social and cultural (Baumeister et al.: 2007). This thesis explores the relation between the light and emotion in the context of art gallery exhibition and therefore there are some significant effects of emotional stimulation especially attractive to this relation (Shimamura: 2013).

Emotions help us remember situations

One of the core functions of our emotions is to assist our brain turn information and facts into memories (Wang et al. 2007). Emotions serve as a base of many attitudes, values and beliefs – without emotions, these would be only statements without meaning; they shape our thinking process (Matsumoto et al. 2008).

Emotions influence the body

The science of embodied cognition defines how the emotions that we perceive manifest in our body. Our body remembers many previous experiences (Matsumoto et al. 2008) and allows for individual emotional states when the situation repeats (e.g. we relax when entering a café because we remember similar events from the past) (Matsumoto et al. 2013).

Positive emotions increase our cognitive abilities

Researchers found a correlation between the positive emotional states and our ability to collect, store and process information (Seligman: 2000). When in a positive mood we are also able to incorporate more data (Estrada et al.: 1997).

Studies review

In the following paragraphs, I will present a review of studies in three crucial areas which will help to shape the background for this paper's hypothesis and the conducted experiment. I will be looking at the effects of light, colors, and harmony vs. the variety of human emotions.

The effects of light on emotions

As early as 1941 Arie Andries Kruithof performed a study dedicated to psychological preferences connected to color light's color temperature and its intensity. As primary light sources for the experiment, Kruithof used gas-discharge fluorescent lamps and daylight. The results were classified into categories of pleasant (natural) or unpleasant (unnatural). What followed the research is a diagram which shows a correlation which results in the highest preference for the light which is closest to daylight. The model has been very influential over the years yet it is also biased (a primitive type of lights with poor color rendering index, little sample). Nevertheless many later studies confirmed Kruithof's experimental findings in the relation between high/low light levels on positive/negative emotions (Vienot et al. 2009).

In 1974 researchers Kumari and Venkatramaiah (Cloughan et al. 1998) conducted a study, suggesting that higher levels of illumination have a strong effect on arousal.

Also, Mehrabian and Russell in that same year found that lighting is a highly important determinant of the environment- namely because brightly lit rooms are more arousing than dimly lit ones and that increased levels of lighting produce arousal and pleasure (Russell: 1974).

In 1996, Julie Baker and Michelle Cameron pointed out that people can usually define the basic level on which they find the light most pleasing. According to the study, this preference depends on the situation, surroundings, and activity (Baker;Cameron: 1996).

The relation between lighting and mood and affect have been investigated by many researchers. Robert Gifford's study resulted in finding a correlation between light levels and people's positive attitude towards communication (in low level the conversations would become more intimate whereas the bright light stimulated more general talk) (Gifford:1994).

In a study from 1995, Igor Knez found out that the amount of exposure to light resulted in a mood change of the participants. (He also indicated that the temperature of light had a different effect depending on the gender of the subject, yet these type of findings vary across different researches and are usually dismissed) (Knez: 1995). Rober Baron suggested that low level of light results in a more positive emotional state than high levels. (Baron: 1991).

In 1996 Peter Boyce conducted a research which showed that the more light in a space (in that

case supermarket) the more pleasant and comfortable it becomes (I mention this reference because it clearly shows the influence of the space on the perceived emotions – thus it is impossible to apply one general lighting rule to all.) (Boyce: 1981).

One of the most influential and hihgly referenced studies of brightness and softness of light and human perception of space, were conducted by John E. Flynn. His findings showed a.o. A great importance of soft light for evoking the feelings of relaxation and pleasantness. What he also discovered was a relation between relaxation and the non-uniform lighting (e.g. wall washing) – on the other hand, spaces which have a uniform, bright light tend to be perceived as bigger. (Flynn et al. 1979).

Later studies which aimed at confronting Flynn's findings were conducted by the University College London. With an increased the number of luminaires and improved quality of rendered light the study proved the relation between brightness and spaciousness and non-uniform light patterns as important factors for space's pleasant affect (Vetich: 2001).

The effect of colors on emotions

In 1987, Frank Mahnke wrote a study of color and light. He stated that every human being gives psychological reaction (pleasure, disapproval, antipathy or sympathy) when exposed to color or mixture of colors. (Mahnke: 1987). Mahnke wrote that that colored light as a form of energy affects not only our body functions but also emotions. 'Color affects cortical activation (brain waves); functions of the autonomic nervous system (which regulates the body's internal environment), and hormonal activity; and that color arouses positive emotional and aesthetic associations' (Mahnke: 1987).

This statement can be backed with the writings of Faber Birren. In his research which started in the early 1980's he looked at the human response to form and color and as a result he stated that while form evokes the intellectual processes, it is a color which is responsible for our emotional reactions (Birren: 1982).

Mahnke in his later work used the model of emotional classification created by Russel (described earlier in this paper) and looked for a correlation between the emotional states and colored light. He asked the participants of the study to indicate how they feel about light tinted in green, yel-

low, red and blue (Mahnke: 1996). The first significant finding was that the emotions described by people were equally distributed among the model. He described red as stimulating, yellow as tense but releasing, green as balanced and blue as calming (Mahnke: 1996).

In a study from 1981, Rikard Küller wrote about the associations between colors and emotions in the cross-cultural context - not only across nations or continents but also genders, age or educational background. The results seem to prove that there is a strong, innate reaction to colors (Küller: 1977). Faber Birren, who conducted a study which described the emotional reactions to light of infants, summarizes his finding by stating that their psychological reactions were innate and not learned (Birren: 1983).

The effect of variety and uniformity on emotions

In his late work from 1993, Faber Birren concentrated on the people's emotional preferences for the surroundings. In the artificial, built environment people expect all their senses to be mildly stimulated. What follows is a negative emotional reaction for spaces which lack complexity (Birren: 1993).

Those findings can be explained through the research of Rachel and Stephen Kaplan. They conducted a study which aim was to measure human preference for coherence and complexity of any new environment (Kaplan; Kaplan: 1989). When we enter a new space, we are automatically searching for a memory or experience to understand the surrounding. On one hand it is necessary for the viewer not to be overwhelmed by the new elements but on the other we all strive to explore and challenge new information and therefore appreciate certain complexity. These new features lead to higher involvement. About light design, the overall illumination of space should support the feeling of coherence. In addition to this directional lighting could be used in order to stimulate the sense of visual complexity (Cuttle: 2007).

Gary Gordon in his book writes about two essential characteristics of visual stimulation – what he describes as the high load is an environment which encourages participation and increases enjoyment. Low load helps results in comfortable, relaxed and focused feeling (Gordon: 2015).

Rikard Küller in his research from 1981 conducted an experiment where he tested the psychological effects of these two types of environments (high load/complex and low load/coherent). One of

the tested rooms was colorful and varied and the other gray and mellow (Küller: 1981). The result showed that the visually complex space had a significant effect on both the physiology and psychology of the participants. What is also worth noticing, people experiencing the low load room had higher stress levels. Küller concluded that under-stimulation could a.o. The result in irritation, restlessness, and bad concentration – what follows is his conclusion that human beings need a varied and changing environment to maintain their well-being (Küller:1981).

As an extension of the matter of complexity vs. uniformity comes the ideology of gestalt. It is often described as a relation between the elements and the whole of the scene. According to the early theoretician Kurt Koffka, gestalt can be divided into Proximity, Similarity, Closure, Symmetry, Common Fate, Continuity and Good balance and experience (Smith: 1988). (These elements are often used in the light design e.g. Erco lighting guidebook)(ERCO: 2015).

Summing up the studies review

There are certain interesting elements which can be withdrawn from the collection of studies presented above. Most importantly there is strong evidence that people use the distribution of light in given space to from judgments about its appearance. The most influential elements are brightness and variability.

We learned that people are very similar in their emotional reactions – across cultures, genders or age, people seem to attribute same emotions to same colors. Contrary to popular belief that the relation between colors and emotions can be a result of cultural background, recent studies prove that this relation and human reaction to it is innate.

The studies show that in any given space, human sense should be moderately stimulated at all times. The neutral environments where this stimulation is very low, seem to have a negative influence on people and result in restlessness, irritation or concentration loss. There is a need for good balance between variety and coherence in lighting. These indications are also found in the base of Gestalt practice in lighting design.

In any environment, there must be colors in changing degrees of lightness (light and dark), temperature (warm and cool), and intensity (strong and weak), and the complementary of the dominant color should be present to some extent (Mahnke, 1996).

THE ART EXPERIENCE

'Art is a human activity, consisting in this, that one man consciously, by means of certain external signs, hands on to others feelings he has lived through, and that other people are infected by these feeling and also experience them.'

Leo Tolstoy (1897-1910)

In this chapter, I explain (in the context of this thesis topic) what the difference between an art gallery and the museum is. I will also present theories which describe a particular emotional state which helps experience, analyze and remember the art. Later I will present the white box issue and attempt a critique of the conventional gallery setting.

A gallery and museum

To talk about the differences between a museum and a gallery is to talk about private and public. Paraphrasing the statement of International Council of Museums (ICOM) a museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment ("Museum definition":2007). The history of the museum started in the ancient Egypt and over the years was strictly connected to the preservation and cultivation of western cultural heritage.

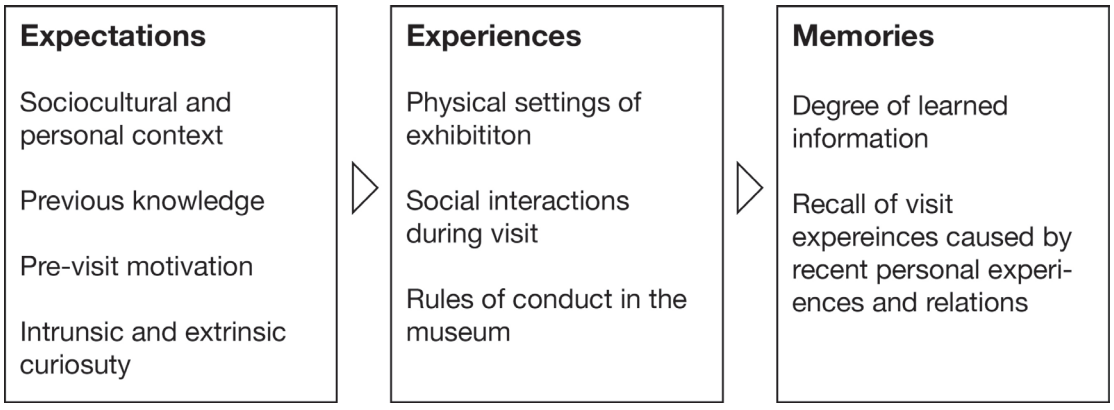
A gallery is usually a private initiative, dedicated to displaying, promotion and selling of art. Although there are as many profiles of galleries as there are types of art, most of them display contemporary art in a dynamic rotation. Although very often the name is used interchangeably (e.g. Art Bunker Gallery in Krakow – which is a museum) in this paper I will refer to a gallery as defined above.

The galleries that are of most relevance to this thesis investigation are the smaller, to mid-size – their owners' challenge is to present art in an interesting and engaging way, without having the privilege of the funding and timeframe of an institution such as museum and real chances to introduce most advanced lighting strategies. The physical, temporal and financial limitations usually result in a very monotonous light set up. The owners of the galleries and exhibition curators treat the given space more like a container for art than a dynamic display, which could follow the profile and emotional impact of each exhibition. On the other hand, this situation poses an advantage of independence. The decision-making process is much shorter than in the case of bigger galleries or museums, and there is more possibility for experimentation or non-conventional

approach to displaying, curating and lighting the exposition.

Visitors experience and aesthetic attitude

Art by its core definition can address our emotions, release associations or create new meaning. But what about the viewing experience? Matthew Pelowski proposed a model which he called a 'Five steps of aesthetic experience' (Pelowski: 2011). Part one – most relevant for this paper's topic - addresses the state before one encounters the work of art or exhibition – so called pre-expectation. The mere fact that someone has been in a gallery in the past creates a particular memory which is addressed any time the situation repeats. A certain expectation is unwillingly or subconsciously created. John Falk in 2009 quotes the findings of Smithsonian Institute: 'visitors arrive with their visit agendas and sense of time…[and they] tend to frequent the museums and exhibitions that they think will be congruent with their attitude, with whose point of view they expect to agree. . . [Exhibitions] can be powerful tools for confirming, reinforcing, and extending existing beliefs. . . . Individuals come to museums with different entrance narratives . . . And different perspectives and expectations toward the experience of visiting a museum'. (Falk: 2009) What follows is the chart proposed by Falk which describes the total path of visitors experience creation:



On the more phenomenological side - Pelowski in his paper praises approach of John Dewey. Dewey argued that 'it is the disruption of viewer interaction with art, and subsequently viewer

response to disruption which both provides a mechanism for substantial change in the experience of art, and a means of organizing this experience' (Dewey: 2012). This idea indicates a connection between a need for diversification in the light experience which I described in the last chapter and the importance of disruption or breaking out of the expectation of a gallery visitor.

Another theory investigating the emotional needs of art spectators is the aesthetic attitude. It has been investigated by philosophers, critics, and theoreticians for centuries. One of the latest and most exciting of them is Roger Scruton. In his book, he describes the aesthetic attitude – a mood which is preferred for experiencing art – to a positive attitude, one in which we open ourselves to new information and are willing to reach out and incorporate it (Scruton: 1982). Scruton defines the goal of the aesthetic attitude as pleasure, enjoyment or satisfaction (Scruton: 1982) – emotions which comes very close to the Russel's PAD model. Slobodan Marković also indicates arousal as the most important requirement for the aesthetic art experience (what is interesting the object of the experience can be both pleasant and unpleasant) (Markovic: 2006).

Types of visitors

In 2010, Bonnie Pitman concluded a 3-year research on visitors experience and proposed a division of visitor clusters. According to her research, there are four types of people who come to see the art (each of them representing 25% of the overall count) (Pitman: 2011).

Observers – the least comfortable in talking and analyzing their experience

Participants – enjoying the learning aspect and are comfortable with most types of art

Independents – like to view art on their own and have strong interpretations of what they see

Enthusiasts – very knowledgeable about art, are interested in artist techniques and materials

This division can give an overall understanding of not only what is the type of experience that the visitors could be looking for but also what information or expectation do they bring along to the exhibition. It is important to notice that each viewer can experience the art differently, and so the aesthetic attitude can differ, yet according to most theorists, it is the drive for pleasure (or arousal) and making discovering which is universal (Sandelands: 1989). On the list of possible form-givers

of the aesthetic experience Markovic indicates that it is most importantly the visitor of the gallery who needs to be willing and ready to open to the aesthetic experience (yet what is crucial, he also mentions light as one of the factors which can encourage this state) (Markovic: 2006).

The white box issue

There is a certain problem with the way in which the tradition of presenting artworks in a gallery has evolved. The shift towards the gallery display as we know it today is connected to the modernist art movement of the early XX century. The painting of Samuel F.B. Morse's *Exhibition Gallery at the Louvre* (1833) could be an excellent example of how the traditional art display looked not more than 200 years ago.

Samuel F.B. Morse's Exhibition Gallery at the Louvre (1833)

The paintings tightly occupy the walls of the gallery spreading from top to bottom. Traditionally the largest and newest artworks were *skied*, and the ones of lesser value *floored (O'Doherty: 1976)*. This was possible because also the notion of how the artwork (painting in this case) was

to be interpreted was different – according to O'Doherty each of the pictures was isolated from the neighboring one by a thick frame and therefore constituted an entity on its own. An image positioned on the wall was representing something that nowadays we could compare to a virtual reality headset – an opening to a deeper space.

On the contrary in the modern gallery, the artwork is rather isolated from the rest. On one hand this situation allows for more focus on the piece itself, on the other it stresses the importance of the space. Since there is more distance between the artworks, the walls become more visible. As the tradition of a gallery space become older, the context becomes part of the content.

O'Doherty defines the gallery situation as following: *A gallery is constructed along laws as rigorous as those for lighting a medieval church. The outside world must not come in, so windows are usually sealed off. Walls are painted white. The ceiling becomes the source of light. The wooden floor is polished so that you click along clinically, or carpeted so that you pad soundlessly, resting the feet while the eyes have at the wall. Unshadowed, white, clean, artificial- the space is devoted to the technology of esthetics* (O'Doherty: 1976). This situation poses a problem because as we learned before if the expectations of the experience have such a significant influence over the experience and the memory – the setting (gallery) that became standardized, does not help engage and excite the visitor – not only during but also in the pre-visit stage.

Actually according to O'Doherty in the white box of gallery space human body seems almost an intrusion – in such space it might appear that while eyes and minds are welcome, the body is not (O'Doherty: 1976).

THE ROLE OF LIGHT IN AN ART GALLERY

"All department stores will become museums,
and all museums will become department stores."

Andy Warhol (1928-1987)

In this chapter – in order to create an overall understanding and a reference - I will sum up the most common lighting design practices which are suggested by the luminaire manufacturers and professionals. I will be concentrating on the artificial lighting scenarios here, because of its flexibility in comparison to daylighting. The chapter will be concluded with a presentation and brief analysis of lighting design of three selected art galleries in Copenhagen.

Art lighting by definition

The most extensive description of what lighting for an art exhibition is comes from a book rooted in the tradition of experience design. In *The Exhibition Design* David Dernie explains that the presentation of art should always concern human comfort (Dernie: 2006). Alongside qualities such us temperature and humidity or air quality, light is crucial for the spectator's experience. Lighting affects the exhibition space and the way that the exhibition' is understood – it is also important for the correct display of colors and the visibility of images.

In the introduction to this paper, I have introduced what Christopher Cuttle calls philosophy for the presentation of art. It encompasses the lighting design practice for art exhibitions. I will use it to expand on the topic in a generalized way. (Cuttle: 2007)

1. **To make the artwork appear as it would have appeared to the artist at the time of its creation**

Each artist has a different approach to where, when and under which light condition are they working. One thing is sure, though – it is impossible for the galleries to create such varied and individual lighting. Therefore the choice of 'lesser evil' – uniform, bright light, same for all the art pieces.

2. **To ensure that no damage due to light exposure will occur**

Most of the experts agree – there is no safe level of light exposure. Most of the paintings and sculptures are responsive to the light and therefore in a long time it will cause damage. Of course, the situation in art galleries is a little bit less dramatic. They usually display art for a comparatively short period so the lighting conditions can be less strict.

3. **To achieve the best possible appearance of the artwork**

According to Cuttle, most of the lighting techniques and equipment which is used for art exhibition originates from merchandising practices. The goal is to catch visitors' attention and present the art pieces in a most attractive way – make colors brighter and more saturated and materials to sparkle and shine. This point can be read in connection with the critical quote by Andy Warhol, which is opening this chapter. Sadly it is becoming a trend in many contemporary galleries to pay little attention to light and display art in a manner similar to shops.

4. **To provide optimum conditions for viewing art**

There are many rules for optimum visibility, which mostly draw from our understanding of human vision. Elements which need to be taken into consideration are e.g. maximum color rendering, the balanced contrast between object and surrounding, an absence of glare and well established gradual adaptation to the brighter/darker environment – depending on the outside conditions. All these elements require the high flexibility of the light settings and make the use of electric lighting a necessity.

5. **To assist, viewers to understand the displayed objects and their reason for being there**

Exhibitions very often serve more purposes than just 'pleasuring the eye' (e.g. informative or educational). Therefore, special lighting techniques for illumination of e.g. information boards might be needed. Also, some installations or art pieces depend on viewer's understanding of the texture or special technique – then the light needs to be able to underline this specific detail

Visible characteristics of lighting

In general, the way we understand and describe light in a given space can be divided into two categories – measurable characteristics of light and visible characteristics of light. Since this paper focuses on the human centric approach to lighting, it is important to understand which are the

perceived effects of lighting in a gallery space, when should they be strengthened and how to measure them.

There is a list of publications by Erco, Zumtobel or Licht.de, (ERCO: 2015), (ZUMTOBEL:2015) ('Good Lighting for Museums': 2013), which enlist many of the lighting concepts that will be discussed in this chapter. The most comprehensive matrix summarizing these ideas was proposed by Chrispoher Cuttle in his book Lighting by Design . He divides the topics into five parts (Cuttle: 2008). I will introduce each of them with a short description and a definition of physical values that can be used to understand the concepts further.

A. **Ambient illumination**

Manifestation:

The first impression of space upon entering. Space can be lit brightly, dimly or in between. This impression can be influenced by visitor's previous state before entering the space. The perception of the illumination of the space is accompanied by the overall color temperature – warmth or coolness. The use of white walls in most of the galleries can be explained by the reflectiveness which they provide and also the minimal contrast between the light source and surrounding (e.g. in a black space each light source will stand out more, but the walls will not reflect the light back to the room).

Associated metrics:

Ambient illumination ($E_{rs(i)}$) – is the amount of light that all the room surfaces receive by the inter-reflected flux.

Mean room surface exitance (M_{rs}) – it is some lumens per square meter emerging from a surface (after it has been bounced back to the room).

Correlated color temperature (*CCT*) – a value measured in Kelvins, the higher temperatures the number, the colder the light (e.g. conventionally 3300K is tungsten, and 5500 is fluorescent).

B. **Visual discrimination**

Manifestation:

The illumination in the space is crucial to allow people to see clearly and improve their visual per-

formance (e.g. distinguish details from a distance). It also helps to identify colors of the object or surfaces. The better the light, the more accurately will it render the colors. Of course two people might see the same object differently – starting from what they are looking at, how good is their eyesight, or what is the age difference between them.

Associated metrics:

Task or object Illuminance (E_t) – there is are specific recommendations when it comes to the minimum illuminance according to different tasks. E.g. according to IESNA, it is 30 lux for public spaces and 300 for office scenarios (IESNA: 2000).

Color rendering index (*CRI*) – in a test a light source is scored out of 100 of how well does it render a set of standardized colors. For art presentation, it is recommended to use light (regardless of the CCT) which has CRI > 80.

C. **Illumination hierarchy**

Manifestation:

The process called phototropism describes why most of the animals (also humans) are drawn to the brightest part of their visual field. It is very beneficial for the light design because it allows to plan the experience and draw the attention to a particular art piece or spot and away from ones of secondary importance. This practice should be applied carefully as under high contrast illumination the properties of an object such as color or glossiness can appear different than in reality.

Associated metrics:

Illuminance ratios (E_{s1}/E_{s2}) – depending on the differences in illumination of two or more objects they are perceived differently. J.A. Lynes in 1987 described these perceived differences as (from the lightest to most harsh) Noticeable, Distinct, Strong, Emphatic.

D. **Flow of light**

Manifestation:

When an object is placed in a room, it will always interact with the light. There are three ways (and their derivatives) in which the light will manifest itself on an object: shadow pattern (visible shadows), highlight pattern (evident highlights) and shading pattern (mild shadows on diffused

surfaces). It is important to note here that although the surfaces can be either reflective or diffusive – the light can be sharp or soft. These are the combination of the two that produce the perceived effects.

Associated metrics:

Scalar illumination (E/Esr) – is a ratio of illuminations on the surface of an object. It rates from 4.0 (dramatic) to 0 (shadow free).

E. **Luminous elements**

Manifestation:

Since light always needs its source and sometimes it is impossible to hide these sources – the luminaires might become a part of the space presented to the visitors.

Very often space can benefit from a particular placement of the luminaires which can introduce a certain liveliness to it. It is important always to think about glare. Glare is usually described regarding a ratio of illumination of the object and its background. There can be different types of glare. Disability glare occurs when the visibility of details is reduced by luminous elements present in the field of view. Discomfort glare is caused by a presence of bright luminaires in the field of vision while performing prolonged, continuous tasks.

Associated metrics:

Unified Glare Rating (*UGR*) – it is a way to measure glare in any given environment. It takes into account the luminance of all the visible sources divided by the background illumination.

Light situation assessment (3 art galleries)

The visible characteristic of light are necessary to understanding and can help in a quick assessment of any light situation in a given space. I will now present and describe the light situation in three selected art galleries in Copenhagen. This (combined with information collected in previous chapters) will serve as a base for this paper's hypothesis and proof of concept.

1. **Galleri Nicolai Wallner** - *Ny Carlsberg Vej 68, 1760 København V*

It opened in 1993 and over the years has become one of the most prominent galleries in Copenhagen. The gallery occupies and old car garage. The exhibition space is around 800 m2, which makes is the biggest privately owned art gallery in the city. At the moment, the exhibition features four artists who present mixed media art, yet mostly paintings.

Lighting

Of the five rooms which constitute the gallery exhibition space, only one has access to daylight – yet it is used as a foyer only. All the walls are white, and the floor and the floor is light gray cement. There is a railing suspended from the ceiling in each of the rooms. Each of the railings includes from 20 to 35 T-5 fluorescent light bulbs. There is high ambient illumination. There is no directional or discriminating light and no visual hierarchy. The average color temperature is white (so above 5500K). Since all the luminaires are positioned below the ceiling, there is no glare. The artworks are lit very equally.

Illustration 7. Light type and interior of the Galleri Nicolai Wallner

2. **V1 Gallery** - *Flæsketorvet 69 - 71, 1711 København V*

Gallery V1 is located in an old meatpacking area. It was established in 2002. It represents and selects a group of international established and emerging artists, and its mission is to introduce the art of all media to new audiences. It is one of the most recognized galleries in Denmark.

Lighting

The gallery space is quite small – it consists of two rooms on the ground level and a small basement. The main exhibition room has a row of windows on the perimeter which contributes to the lighting conditions. The walls are white, and the floor is dark gray concrete. There is a high level

of ambient illumination and no directional or mood lighting. The spaces are lit from a recessed ceiling railing in groups of 2 or 3. There are only T-8 fluorescent lightbulbs used. Both above the ground and in the basement the light is very white – 5500K. In the basement, there is a very low distance between the lights and the artworks. Hence, there might be occasional glaring. There is a transition zone between the main exhibition rooms and the basement – it is very dimly lit with incandescent lightbulb which creates a huge contrast with the other rooms. Even though there are different types of art at the exhibition at the moment, the light is not tailored to that variety.

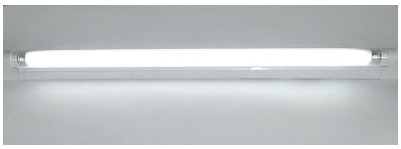
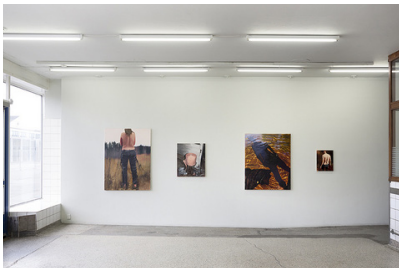



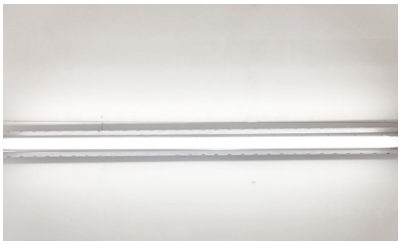

Illustration 8. Light type and interior of V1 Gallery

3. **Gallery AVLSKARL** - *Bredgade 28, 1260 Copenhagen K*

AVLSKARL has been established in 2008 and represents a new wave of smaller, ambitious galleries. It presents mostly painters and photographers. The gallery is located on one of the most expensive streets in Copenhagen – Bredgade. Since it is surrounded by many other galleries, there is a fast rotation of exhibits in ALVSKARL.

Lighting

There is only one room in the gallery. It is quite long. Both the walls and the floor are white. There is enough a high level of ambient illuminance, yet there are also spotlights which help with highlighting details or adding particular visual hierarchy to the exhibition. Two rows of T-12 LED light bulbs are position along the central axis of the room. There is quite a lot of daylight coming from a balcony at the end of the gallery and the entrance windows. The CCT is at ca. 5500K.



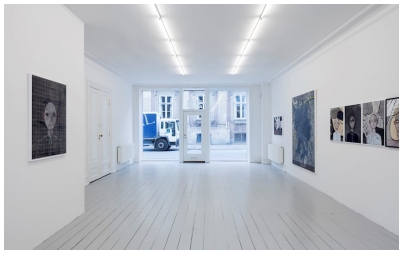


Illustration 9. Light type and interior of AVLSKARL Gallery

TOWARDS TEST DESIGN AND HYPOTHESES

'It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong.'

Richard P. Feynman (1918-1988)

In this chapter, I will sum up the theoretical findings from Chapters 2 to 4. In light of these discoveries, I will present an idealized, art gallery lighting design approach. It will be a base for the two hypotheses which led to establishing a proof of concept and conducting a test.

Sub-conclusion

I began chapter 2 by introducing the ways in which we as human beings perceive and transcode the light. I also presented the concept of human centric design which is crucial for an understanding of how the new lighting technologies (such as dynamic LED solutions) can be implemented to stimulate people in efficient and innovative ways. A part of that chapter further explains the two light paths – biological and visual and how they affect our body. In the rest of the chapter I present and compare different studies which show and explain the bond between light and our emotions. In the beginning, I determined a definition of the terms feelings, mood, and emotions. Later on, I introduced James Russel's model of emotion classification which will serve as a part of the following proposed test. In the remainder of the chapter, I looked into three crucial elements which help to understand the human connection with light in spaces: emotional responses to light, emotional responses to light's color and human preference for variety and uniformity.

People respond emotionally to the perceived levels of illumination. Studies show that higher levels of light result in arousal and pleasure yet these emotions depend on the situation and activity. Soft, non-directional light as was indicated as one evoking the feelings of relaxation and pleasantness.

In general, people respond emotionally to colors in the same way no matter the culture or age (there are many semantic differences though). In relation to light, it has been found that red is mostly stimulating, yellow tense but releasing, green is balanced and blue is calming.

The studies of uniformity and complexity show that contrary to the rational belief in neutral environments where the stimulation is below average; people might experience negative emotions and restlessness or irritation (rather than neutral). Traditionally the art galleries lighting design applies the uniform (or what is else called low load) visual approach.

In chapter 3 I concentrated on the second element of this thesis – the art gallery environment and the way that it is constructed and perceived. I presented a definition of a gallery and explained my motivation for working with this environment in my thesis' topic – as I believe there is a lack of professional lighting strategies in most of the art galleries, and there is a need for re-evaluation of the current methods and introduction of new ones. Later on in the chapter, I explained the importance of aesthetic attitude and that to stimulate it the emotions of pleasure, arousal or satisfaction need to be stimulated. I also present four most common types of visitors and their expectations. In the second part of the chapter I introduce the white box discourse started by Brian O'Doherty – the problem with overwhelming whiteness and numbness of gallery spaces which became a certain standard in course of the XX century.

In chapter 4 I collected and presented the aspects of lighting in gallery space as defined by lighting design theoreticians. The goal is to create an intuitive understanding of the layers on which light needs to be understood and treated. I start with the most theoretical approach proposed by Christopher Cuttle (philosophy for the presentation of art), and later on, I described in more details the visible characteristic of light with an intention of providing a more advanced dictionary of ways in which light manifests itself in a space such as a gallery.

As the end of the theoretical part of the thesis and chapter 4 I included a light analysis of 3 selected art galleries in Copenhagen. It was based on the knowledge that I collected and presented before. This comparison is, in a more grounded form, a manifestation of problems described indicated in the earlier chapter (e.g. white box issue).

Approaching new gallery lighting design

With the knowledge presented in the previous chapter of this paper, I tried to advocate that the human centric lighting design which evokes emotions and provides people with sufficient light levels but also determines their experience, can be considered a new, brave direction. Such lighting design should take into account people's preference for light which is varied in its distribution, creates a good flow and provides colors which could stimulate the emotional reactions.

Hypotheses

In context of the knowledge gathered in the theoretical part of this paper and towards a practical test, I proposed the following:

Hypothesis 1.

Visitors to the gallery will prefer the non-uniform, varied color lighting conditions to the uniform, flat lighting.

Hypothesis 2.

The inclusion of non-uniform, colored lighting will evoke the positive emotions (pleasant, exciting, relaxing, arousing).

A PROOF OF CONCEPT

"See now the power of truth; the same experiment which at first glance seemed to show one thing, when more carefully examined, assures us of the contrary."

Galileo Galilei (1564-1642)

In this chapter, I will describe the art exhibition which served as a context for the test I performed to validate the hypotheses. I will present the test method, questionnaire, the test set-up, and limitations. I will conclude the chapter by presenting the data resulting from the test, analyze them and attempt a critique of the testing method.

Test context

Exhibition

The in the art exhibition STOLEN ART FOR SALE the art collective Unknown Twins investigated the topic of stealing both in socio-political and cultural context. The artworks were presented to the public between 21.04 and 02.05.2016 in the gallery space of VerdensKulturCentret (VKC) in Nørrebro, Copenhagen. There was both vernissage and finissage for the opening and closing of the art show.

Nine artworks have been presented – amongst them video art installations, photography, graphic prints, paintings and performance art.

Location

VerdensKulturCentret is an institution funded by Københavns Kommune. VKC every month organizes a variety of cultural events. It also supports many different artistic and cultural initiatives. It is also an incubator for NGO's and art related communities.'

The exhibition Stolen Art for Sale was presented to the public on the bottom floor of the VKC building in a space which on everyday basis functions as an art gallery, event space and a café.

Gallery space

The space is relatively big. It consists of a small foyer room which is 24 x 2 x 2.8 meters and the main room measuring 24.5 x 8.20 x 2.8 meters. In the main room, there are two elevated stages at each of the ends. The smaller one being 30 cm high and the bigger one 50 cm above the ground. There is a lot of daylight entering the space, as the entire west-facing is covered with tall windows. (Yet for the purpose of the test the windows were covered and only the electric light was used).

There are 18 pendants, sphere shaped luminaries, made of paper. In each of them, there is a 1000 lumen, dimmable, warm-white LED lightbulb with the beam angle of 140 degrees.

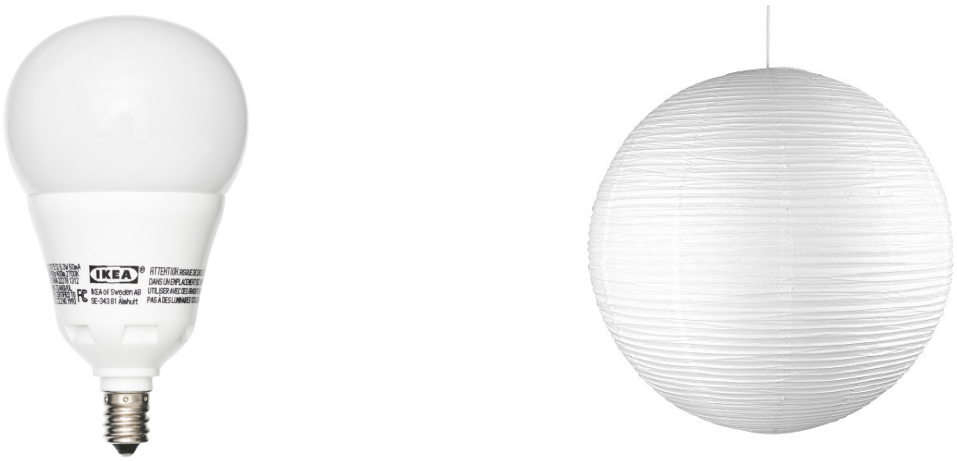


Illustration 10. 1000lm LED bulb and a paper pendant luminaire

There is a dimmer installed in the space. There are also four halogen spotlights used to illuminate the west wall further during the evenings or winter. With the dimmable lights, there is a possibility to create an ambient illumination ranging up to and the average of 350lx.

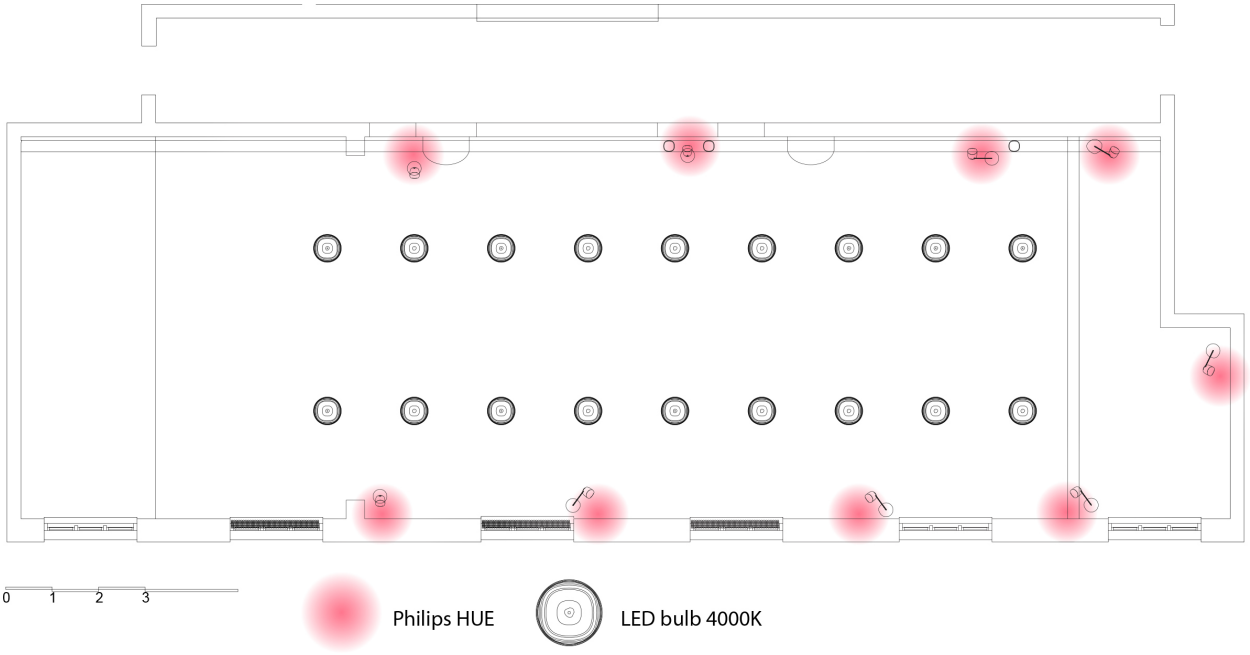


Illustration 11. Top view of the gallery space including the lights used in test1 and test 2

Test set up

For the test 1, the current lighting conditions in the space have been maintained, with an average of 160lx in the space. In test 2 the conditions of test 1 have been preserved, yet additional luminaires have been introduced. 9 identical floor luminaires have been paired with Philips HUE smart light bulbs which were controlled via iPhone. Each of the bulbs giving the maximum of 220 lumens at full brightness of chosen color and a 140 degree beam angle.

Illustration 12. Philips HUE bulb and floor luminaire

Each of the luminaires has been positioned next to one of the artworks in the space. The color of the HUE light was turned into red (the choice was random, yet it was important to choose a color which will be different from the ambient illumination).

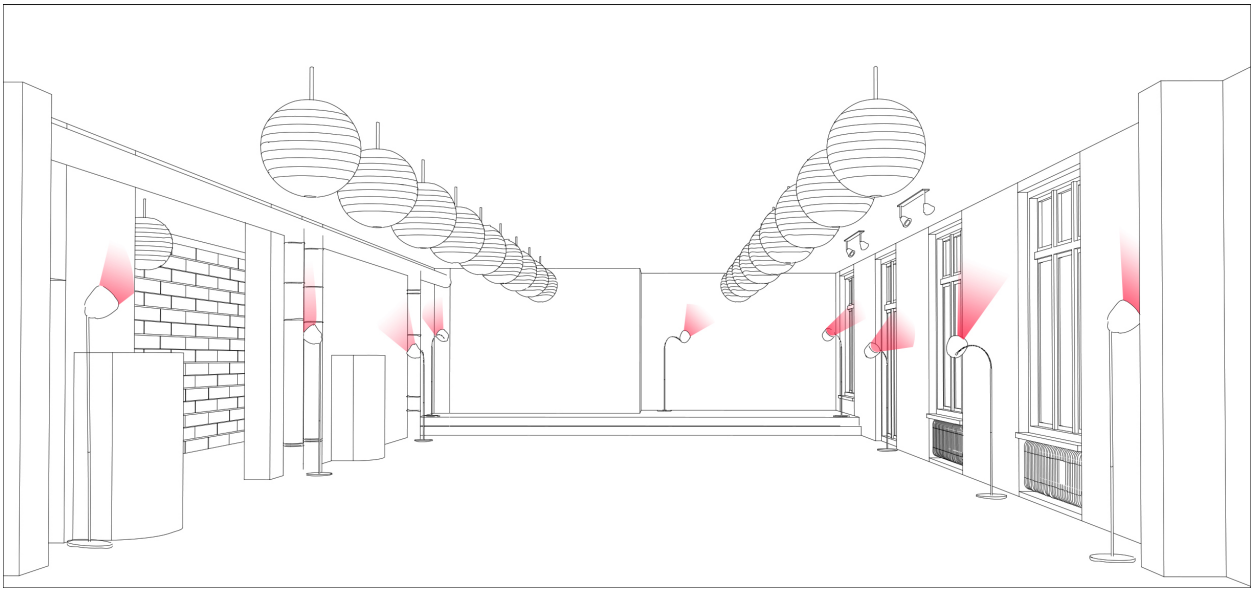


Illustration 13. Front view of the gallery space , including both lights used in test 1 and 2

The test has been divided into test 1 and test 2.

Illustration 14. Test 1: Only ambient lighting used.

Illustration 15. Test 2: Both types of light are used.

The only *variable parameter* was the inclusion of colored, smart lighting in test 2.
The data for the test was gathered during three days for each of the tests, between 17:00 and 20:00.
The visitors of the gallery were asked first to get to know the space and the artworks and afterward answer the following set of questions:

Age: (list of 5 choices)

Gender: (two choices)

1. Please indicate how much do you agree with each statement from 1 (strongly disagree) to 5 (strongly agree).

A. Space is adequately illuminated

B. There needs to be more light in the space

C. There needs to be less light in the space

D. Light is well distributed in the space

E. There are places that cannot be seen but should be made visible with lighting

F. The light helps me understand the situation in the room

G. Lighting creates a good contrast effect

H. The colors of light are efficiently used

I. I like the appearance of how this space looks

2. Please mark words that best describe your emotional response to the light:

pleasant, excited, aroused, distressed, unpleasant, gloomy, sleepy, relaxed

Question 1 was adopted and modified from the original questionnaire proposed by Ahmet Ünver - they are constructed to identify respondents' perceived preferences for the lighting situation (Ünver: 2006). The questions (in order of appearance) relate to the following perceived qualities of light: A.B.C. Brightness D. Distribution of light E. Legibility F. Guidance G. Contrast H. Color I. Preference

Question 2 was based on Russel's emotional reaction model.

Participants

The participants of the questionnaire were selected from the visitors of the art exhibition. Because of the variety of cultural background, gender, and age, the sample was randomized. The connection between the participants might be defined by the interest for art. Both tests gathered answers from 41 visitors in both tests.

Limitations and advantages

Limitations

Exhibition space of VKC plays different roles - from and art exhibition gallery to a café and a lecture room. Therefore, there was no complete control over the lighting set up in the space.

The existing light installation has not been designed by a professional - it is a very basic set up, which does not deliver uniform illumination conditions.

The luminaries used by the author served the purpose of the initial test for the proposed topic (evoking emotions) yet are not suited for general use in a gallery context.

Advantages

Since the purpose of this thesis is to introduce a new lighting approach for smaller and mid-size gallery owners, the tested space reflected most of the light-related issues which the mentioned galleries have to face on an everyday basis which made it quite relevant for the test.

Results

To display the results of both tests, I present them in a bar chart form together with all the metric data. All the results are included in the appendix section. In the next sub-chapter, I compare the results and attempt to draw conclusions from the indications. Questions 1-2 constitute the additional variables and do not have any impact on the validation of the hypothesis. In both question

3 and 4, the color of the light is the independent variable. Responses to question 3 correlate with the answer to hypothesis 1 and in question 4 to hypothesis 2.

Analysis

In the research, I collected two types of data – the answers based on Likert scale, given to a series of 9 questions describing the perceived attributes of the light in the gallery space and a multiple choice question aiming to define the current emotional status of the visitor in connection to the lighting.

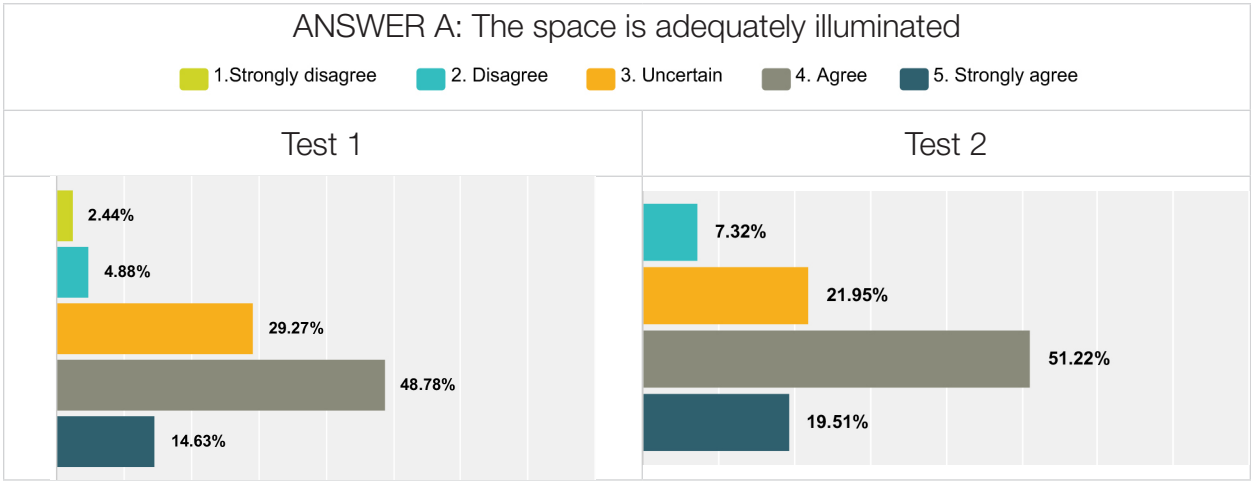
The questions about gender and age will serve as an extra data, indicating a possible a further understanding of the collected data.

The independent variable – inclusion of colored light – will be analyzed by comparing each of the answers from test 1 and test 2.

Both tests include answers from 41 people. They spread of participants in both test oscillates at 55% females and 45% males. In both test the average age of participants was between 19 and 35.

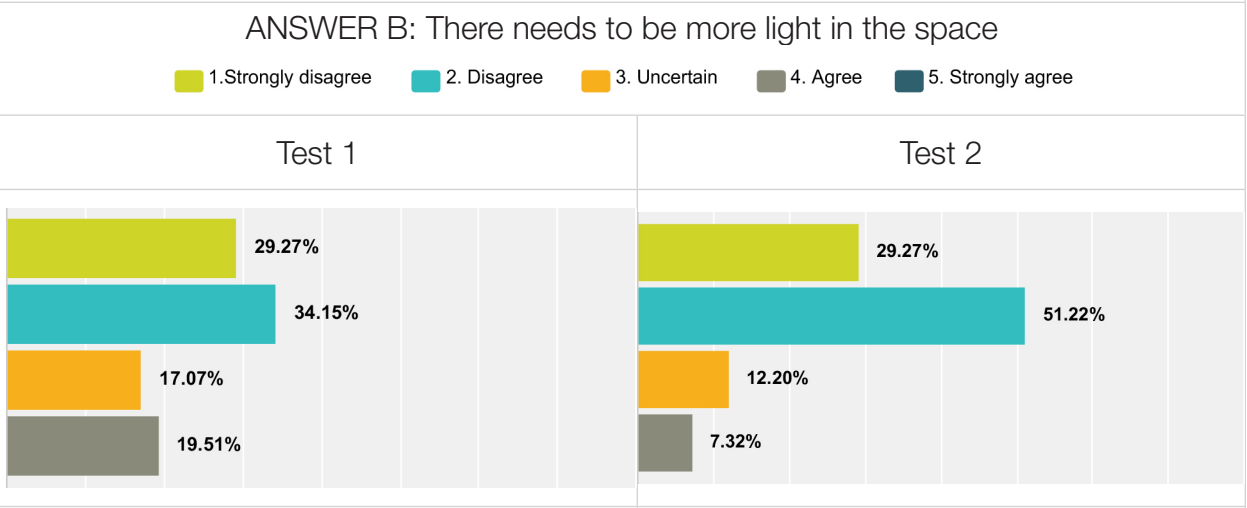
Hypothesis 1 (Question 3)

Visitors of the gallery will prefer the non-uniform, varied color lighting conditions to the uniform, flat lighting.



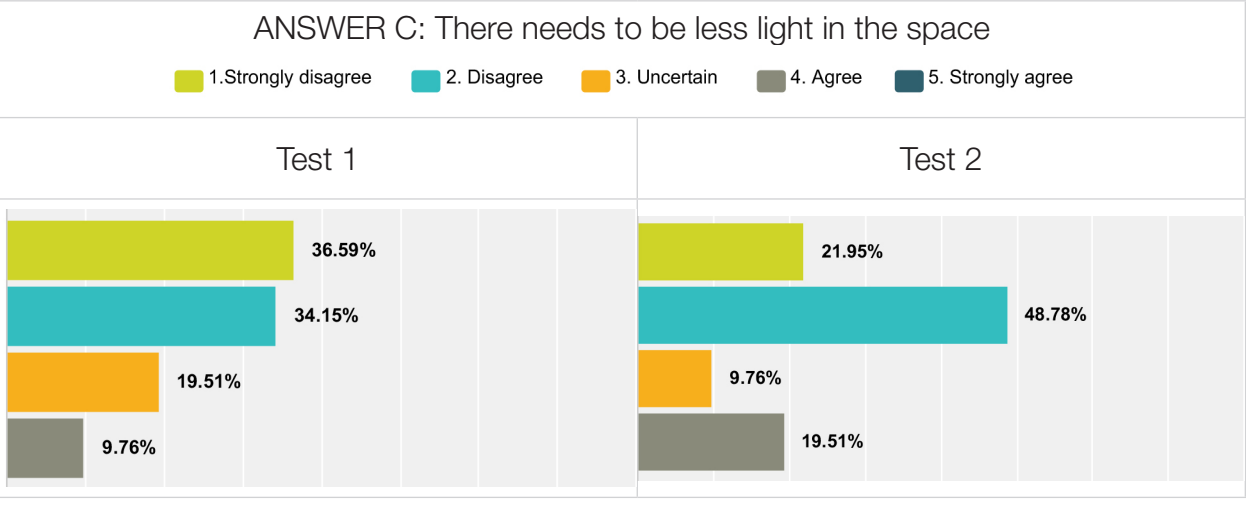
Mean value: 3.68 Standard deviation: 0.87	Mean value: 3.83 Standard deviation: 0.82

Measured factor: **Brightness**
Analysis: (This question is connected to the two following ones. And therefore I will treat the answers to questions B and C as an extension of question A). In both tests the mean value is close to Agree which indicates that there was an adequate amount of light provided for the likings of the visitors. Yet as we take a look at the percentage of answers almost 20% of the respondents of test 2 were more than satisfied with the conditions (in comparison to less than 15% in test 1).



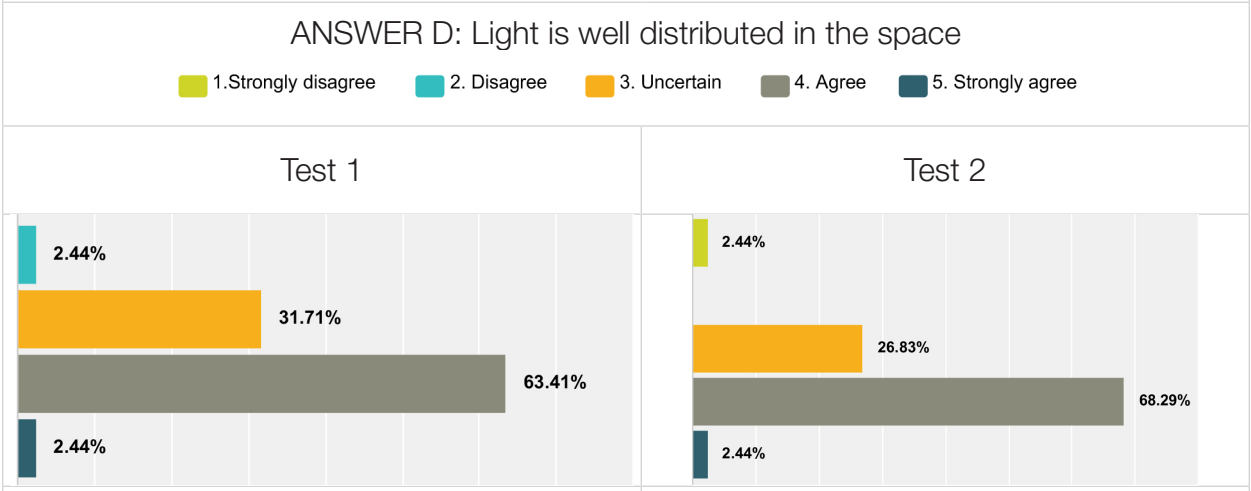
Mean value: 2.27 Standard deviation: 1.08	Mean value: 1.98 Standard deviation: 0.84

Measured factor: **Brightness**
Analysis: When asked about the need for more light, the respondents answered and average of 2 in both tests – which corresponds to Disagree on the Likert scale. What is interesting though in Test 2 a total of 80% of the visitors rejected or strongly rejected the need for more illumination. No men agreed with the statement.



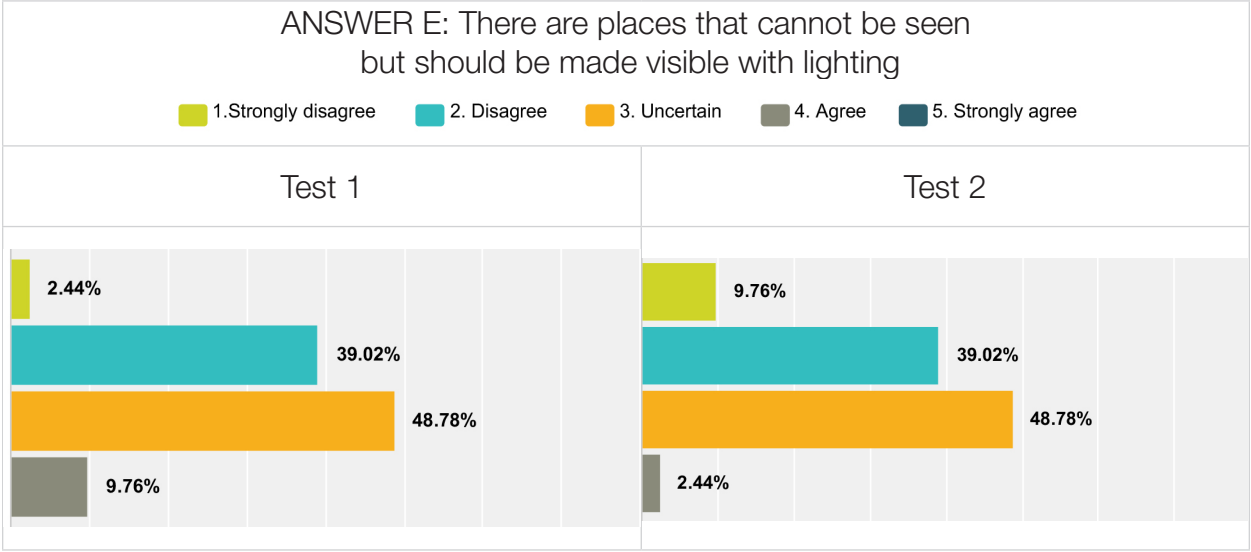
Mean value: 2.02 Standard deviation: 0.97	Mean value: 2.27 Standard deviation: 1.01

Measured factor: **Brightness**
Analysis: Summing up the topic of brightness, together with a strong rejection towards lighter conditions, there was an indication for a need of less light in the case of Test 2. In the second test almost 20% of the respondents agreed that there might be an excess of illumination. This could result from the inclusion of the colored lighting, which although did not provide much extra light, created a different perception of the space.



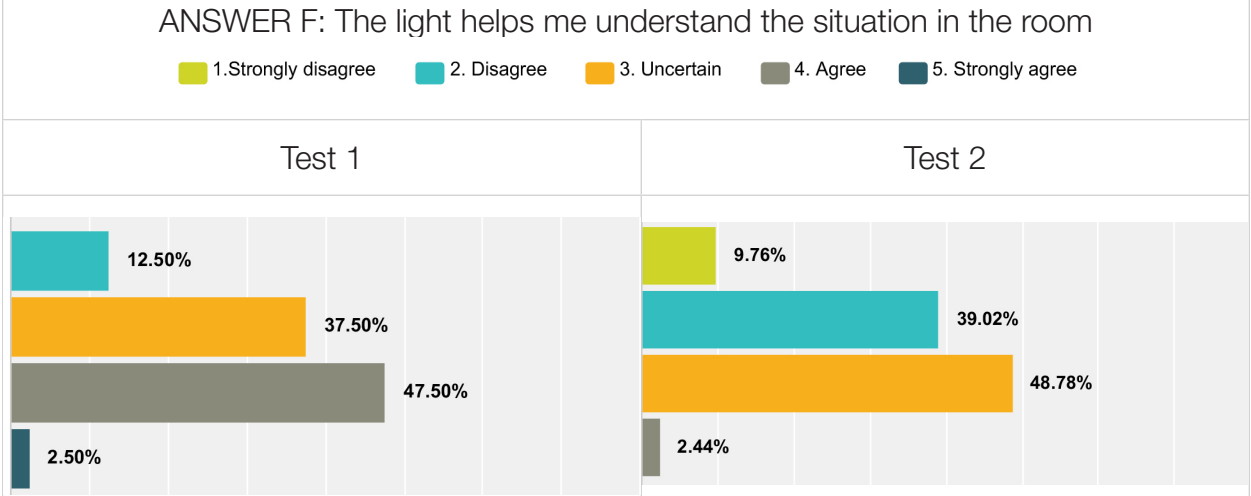
Mean value: 3.66 Standard deviation: 0.57	Mean value: 3.68 Standard deviation: 0.64

Measured factor: **Distribution of light**
Analysis: When we look at the values from both tests, they are almost identical with an average answer of 3.6 leaning towards Agree. Also no men disagreed with this statement. This answer indicates that the inclusion of colored light neither impaired nor positively influenced the perception of distribution.



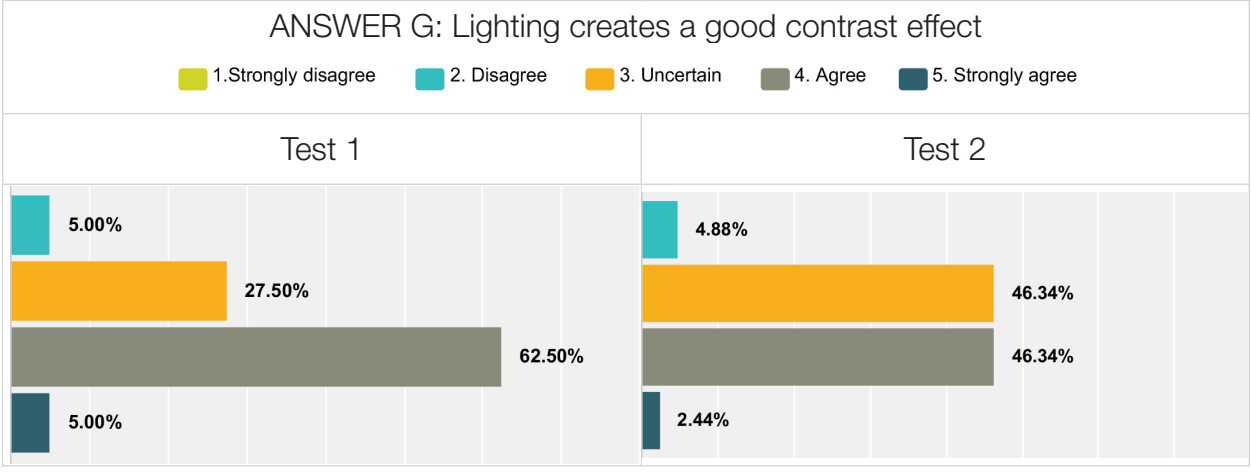
Mean value: 2.66 Standard deviation: 0.68	Mean value: 2.44 Standard deviation: 0.70

Measured factor: **Legibility**
Analysis: Both in test 1 and test 2 the respondents' answers averaged towards 2.5 which could indicate the disagreement or uncertainty. When we look closer on particular results from each test – there is almost 10% of visitors of test 1 who felt that some of the parts of the room were obscured. On the other hand 10% of visitors of test 2 strongly disagreed with the statement. This might suggest that the inclusion of colored light helps in directing gaze towards part of the room which need attention. Also no women in test 2 agreed with the statement.



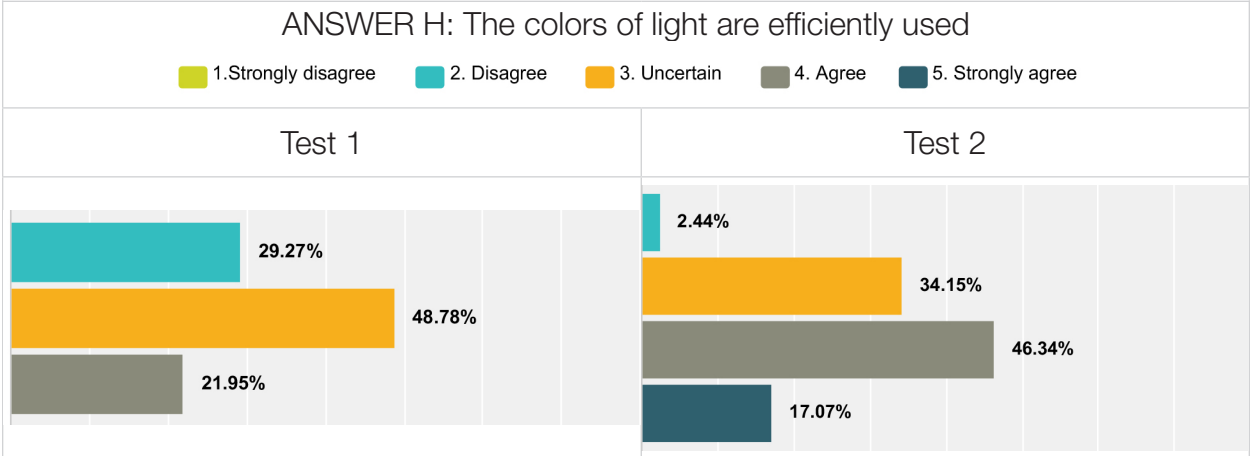
Mean value: 3.40 Standard deviation: 0.73	Mean value: 3.95 Standard deviation: 0.62

Measured factor: **Guidance**
Analysis: The mean values indicate that in test 1 the visitors were leaning towards the answer uncertain whereas in test 2 they mostly agreed (no men disagreed with the statement). Also when we look at the percentage of the answers agree and strongly agree in test 2 compared to test 1 – 82.92% vs 50% - there is a strong indication that the colored, directional light helped the respondents in understanding the situation in the room and provided for good guidance.



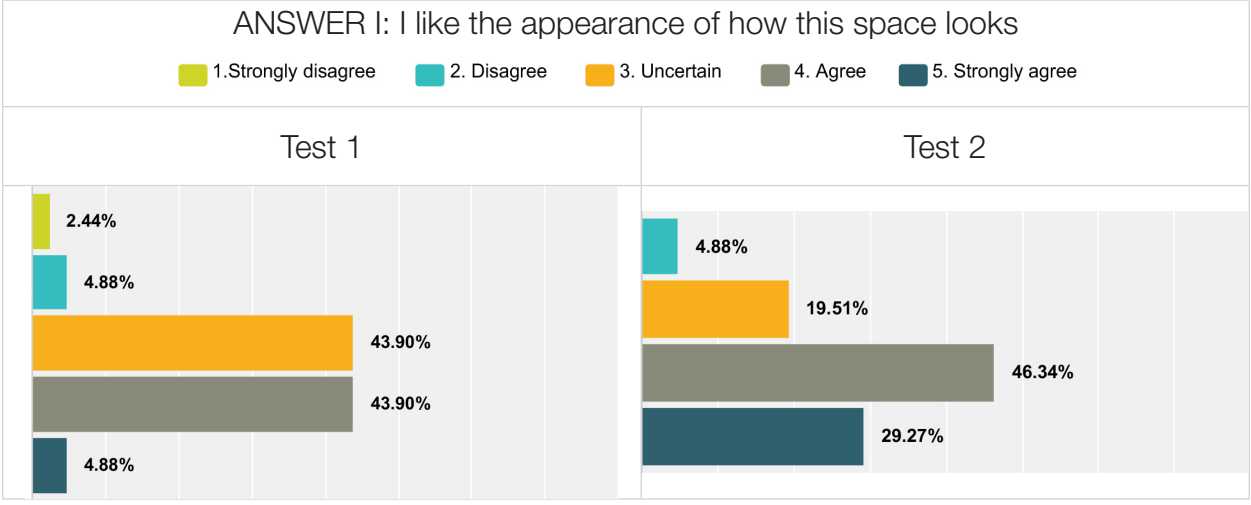
Mean value: 3.68 Standard deviation: 0.65	Mean value: 3.46 Standard deviation: 0.63

Measured factor: **Contrast**
Analysis: In both tests there was high amount of respondents agreeing with the statement. Yet in test 2 there was as many people agreeing as those who were uncertain. This might indicate that the introduction of colored light reduces the overall contrast. Yet an explanation could also be that there was a majority of people aged 35 and higher who pointed out the uncertainty. As research shows us, there is a correlation between aging and a loss of contrast in vision (Owsley: 1981).



Mean value: 2.93 Standard deviation: 0.71	Mean value: 3.78 Standard deviation: 0.75

Measured factor: **Color**
Analysis: There is a significant difference between an answer to this question across both tests. In test 1 the mean value indicates major uncertainty about the use of color of light. Yet in test 2 most of the respondents agree with the statement. There is also a strong lead in the percentage of answers – 63.41% of visitors agree or strongly agree with the statement in test 2. There is a strong indication that the efficient inclusion of colored, directional lighting is noticed and appreciated by the respondents.

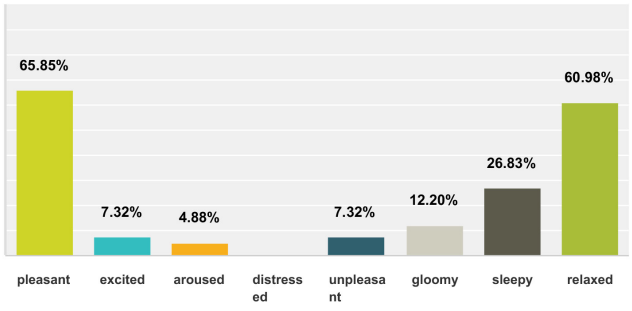
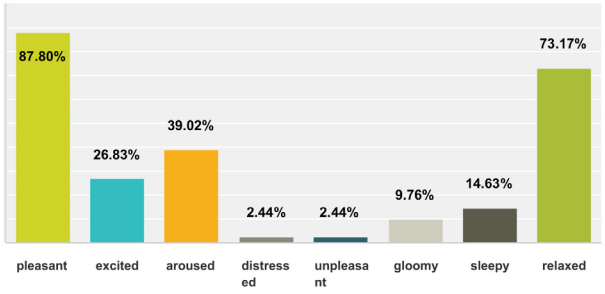


Mean value: 3.44 Standard deviation: 0.77	Mean value: 4.00 Standard deviation: 0.83
Measured factor: **Preference** Analysis: The comparison between the mean value of test 1 and test 2 show a clear indication towards respondents' preference of the colored light scenario. Although 2 female respondents did not agree with the general preference, the total of 75.61% of visitors agreed or strongly agreed with the statement. Compared with 48.78% of positive responses in test 1, collected data strongly indicates that the inclusion of colored light is preferred by the gallery visitors.	

Hypothesis 2 (Question 4)

The inclusion of non-uniform, colored lighting will evoke the positive emotions (pleasant, exciting, relaxing, arousing).

Mark the words that best describe your emotional response to the light

Test 1	Test 2
	

Measured factor: **Emotional state**

Analysis: The initial comparison of the results from test 1 and 2 show that the lighting in the gallery space evokes pleasant and relaxed emotional reaction in majority of the respondents. Yet there is a slight increase in the amounts – from 65.85 (pleasant) in the first test, to 87.8% in second. There is also an increase in case of relaxed – from 60.98 to 73.17. The codependence between these two, has already been pointed out by Russel (Russel:1980). Importantly, although there is a slight indication towards the feelings of excitement and arousal in test 1 (7.32% and 4.88%) there is a significant increase of responses pointing towards these feelings in test 2 (26.83% and 39.02%). This increase might be connected to the inclusion of colored, directional in test 2. In test 1 only women indicated arousal and excitement, whereas in test 2 there is an even split between male and female responses. Interestingly, there are less people pointing towards feeling gloomy, sleepy or unpleasant during test 2. On the other hand, one female indicated distress as one of the feelings in test 2.

Discussion

The conducted study was an attempt to establish and test an alternative approach to lighting art gallery space. In the course of the thesis, I tried to investigate how such lighting can influence emotional state of the visitors and subsequently what is the perception of light's perceived attributes that accompany these emotional reactions? My intention was to prove that light can be successfully used as a tool to change viewers' art experience. The new method might allow for a gradual change in the general, stereotypical view of what an art gallery looks like.

The goal of the test performed during the Stolen Art for sale exhibition was to try to prove two hypotheses. In Hypothesis 1 I presumed that visitors of the gallery would prefer the non-uniform, varied color lighting conditions to the uniform, flat lighting. This hypothesis was built in relation to findings presented in chapter 2 (especially in sub-chapter: The effect of light on emotions). The overall results of the test confirm the hypothesis 1. There was a significant difference between visitors preference for the lighting in test 1 (48.78% of positive responses) and test 2 (75.62%). Of course, this result can only be treated as an indication of a general preference. When we look at the results of other questions, the inclusion of colored, directional lighting into traditionally white space has a positive impact on the visitors. Most importantly – as seen in ANSWER I - the majority of respondents noticed and appreciated the additional light. Although ANSWER E does not indicate any preference for the colored light when it comes to legibility, the answers to question F allows for the assumption that the light in test 2 allowed for better and more efficient guidance in the space. Additional indication which comes from the analysis of ANSWERS A-C might be that the inclusion of colored light creates less need for the overall ambient illumination – it might be that people start to understand the space as more cozy or less official and therefore less light is needed (as proved by e.g. Gifford)(Gifford: 1994). As indicated in ANSWER G there was an equal amount of people agreeing on and not convinced that the lighting created an excellent contrast. (This finding in comparison with the answers from test 1 indicates that certain care needs to be applied when it comes to placement of the colored lights and their strength ratio, in comparison to the general lighting).

In Hypothesis 2, I stated that The inclusion of non-uniform, colored lighting will evoke the positive emotions (pleasant, exciting, relaxing, arousing) in the viewers.

This hypothesis was built around findings presented in chapter 2 (the psychology of light, light, and color), Russel's model of emotional reaction and the theory of aesthetic attitude in relation to positive emotions. The hypothesis was confirmed, or partially confirmed. The answers to test 1 and 2 prove that both types of tested lighting worked well with evoking pleasant and relaxed emotional states (which correlates with findings of e.g. Flynn or UCL group), yet there is a slight improvement in the case of test 2 (15% for relaxed and 22% for pleasant). This might indicate that colored light could be used to strengthen the already good effect of the overall soft light. Further analysis of the findings, shows that there is a significant increase (19% for excitement and 35% for arousal) of visitors who in test 2 marked feelings of excitement and arousal in connection to lighting. Because the directional light was of red color, this data also follows what Mahnke wrote about color red's connection to arousal and excitement. The results were particularly interesting in relation to the importance of these two emotions for the aesthetic experience (as described by e.g. Markovic) (Markovic: 2006). Finally, there were fewer people pointing towards feeling gloomy, sleepy or unpleasant during test 2 which also strengthens the initial supposition about colored, directional light evoking positive feelings.

Critique

Although both hypothesis 1 and 2 were proved by the results of the test, it is not possible to treat these findings as more than indications of a trend. This moderate trust in the results has to do with many limitations which I experienced in the course of the test.

There was a very small sample of people which responded to test's questions (41 people in each group). Therefore, it is impossible to talk about the universality of the findings. Some of the people who answered the questionnaires were also the workers of the café/gallery and therefore they might have been biased in their opinions.

Another aspect of the test which requires critique is the lighting. The original lighting conditions

in the space (18 pendant luminaires) were very site-specific and by no means 'neutral'. Therefore, it was difficult to draw a conclusion between e.g. the tested gallery and the 3 galleries analyzed at the end of chapter 4.

Also, the tested light colorful light, created with Philips Hue light might have been improved – since it was impossible to mount new, vertical, ceiling lights – I had to use standing luminaires. The shape and volume of the lamp might have been a factor influencing visitors' preferences. Within the scope of the tested light, there is another important element which has not been explored – namely the color of light.

I tested the set up only on with the use of red light, which might have been quite crucial for the findings (especially the second hypothesis of evoking positive emotions). On the other hand my intention was to limit the number of variables in order to make the results of the test simple to understand. A good idea would be to, after the initial tests, organise second and third rendition. In the second different colors of light could be tested (also as a non-monochromatic scenario). In the third the participants could determine the light colour by assigning color to one or many lamps.

Since I concentrated only on the use of artificial light in this thesis, I needed to alter the situation in the gallery to block daylight. I have done it by fully covering the windows. Since most of the test was happening during day hours (it was finished by 20:00 some time before sunset in Copenhagen) there might have been a discrepancy between the way that people felt outside and inside of the gallery – cause not only by the new lighting set-up but also by a 'forced' lack of daylight.

To understand the full amount of possible limitations I would have to conduct interviews with the visitors after they answered the questions – yet it was technically impossible to me at the time of the test.

GATHERING THE KNOWLEDGE

'To acquire knowledge, one must study; but to acquire wisdom, one must observe.'

Marilyn vos Savant (1946)

In this chapter, I will present the knowledge presented in this paper which can be used to analyze the light-related aspects of the gallery experience. I will also propose recommendations for the art gallery lighting design, based on the findings of this paper.

In the course of this paper, I have been advocating the importance of human responses to lighting in the context of an art gallery experience. I have also performed a test which strengthened my belief in an influence of colored, directional lighting on both people's positive mood and their overall liking of the space. My intention was to summarize the available, cross-cultural knowledge to create a material which can help e.g. a gallery curator or owner who wants to apply new, non-traditional methods in the exhibition space and understand which would be the benefits of such changes. This thesis is a suggestion towards a better understanding of new possibilities connected to lighting in a gallery context.

With the development and implementation of the newest LED technologies, we are all witnesses of a fast transition. It starts in our homes, extends to workplaces and ends on the streets of our cities. The world of LED will look different - more dynamic and vibrant. Therefore, it is only natural that this change will also find its way into the art gallery environment.

Below I present a table, divided into sections, corresponding to knowledge presented in each of the theoretical chapters of the paper. The table creates an easy to refer presentation of the findings.

Physiology	Emotions	Color	Structure	Perceived attributes
Our brain splits the information it receives into depth, color and form data. The light travelling from our eyes to our brain can take one of the two paths: visual and biological. The pineal gland is responsible for the emotional impact of light.	Light can evoke both positive and negative emotional reactions. Higher levels of illumination have a strong effect on arousal. Differences in the amount of light exposure can result in a mood change. Light levels influence people's communication needs. Soft light has a huge role in evoking feeling of pleasantness. The non-uniform lighting was found to have relaxing effects.	Every human being responds emotionally to colored light. There is a strong, innate reaction to colors which is independent from cultural context, gender or age. Red light is described as stimulating, yellow as tense but releasing, green as balanced and blue as calming.	People tend to respond negatively to spaces which lack visual complexity. People tend to look for a balance in between complexity and coherence. Under-stimulation can result in irritation and restlessness. The environments could be divided into two categories: high load (increasing enjoyment) and low load (controllable, relaxed).	Following elements of the characteristics of light can be stressed and manipulated in order to increase the influence of light over people: Ambient illumination Visual Discrimination Illumination hierarchy Flow of light Luminous elements

Illustration 16. Light in human context - important correlations

Based on the human-centric qualities of light, data presented in the above table, and the findings from the domain of exhibition studies, I propose the following recommendations for anyone willing to approach the gallery lighting design:

1. There is a pre-expectation of a visitor before coming
2. Visitors can be divided into four groups, having different pre-expectations: observers, participants, independents, and enthusiasts.
3. All of the pre-expectations can be confirmed or tackled.
4. The expectations will turn into experiences and later in memories.
5. The disruption of the viewer creates a new experience.
6. The aesthetic attitude helps viewers experience art.
7. The aesthetic attitude is connected to feelings of pleasure, enjoyment and satisfaction
8. Viewers experience can be altered with the use of varied lighting
9. The ambient illumination should provide enough light for the viewers to admire the artworks
10. Directional lighting can be used to ensure the best possible appearance of the artwork
11. A good illumination hierarchy will provide a varied and non-uniform lighting
12. Colors of light can be used to increase the uniqueness of the aesthetic experience
13. Colorful, directional lighting might increase visitors interest in the space and strengthen their art experience.

It is important to notice that there are many additional factors which can influence the visitors' art experience. The above recommendations are based on both the theoretical and practical results of the research and provide for the general understanding of the importance of treating light design as an emotion-shaping tool.

CONCLUSION

'Color is born of the interpenetration of light and dark.'

Sam Francis (1923-1994)

This paper serves as a gathering of interdisciplinary knowledge on the topics of human emotions and space perception in the context of light and gallery lighting design. In the course of this research, I hoped to highlight the need for more interest and investigation in the way that we as humans perceive light and how light influences our emotions, which when it comes to experiencing art, is the only right tool that we possess to understand it. I strongly believe that there is evidence showing the need for changes in the general approach to gallery lighting.

I tried to examine the indications of this need in a test. The test served as a proof for the two hypothesis which I stated. And although I acknowledge the limitations and biases connected to the test, the results, if not anything else, are an encouragement and an argument for further work on the topic. People response to a new, somehow surprising lighting situation was very positive, and I believe that it can be developed in the context of any gallery exhibition, no matter which topic or context the art might be connected to.

Of course, it is hard to assume that each and every art gallery is interested in spending more time and resources on developing new strategies, which can eventually benefit the viewers – we should not forget that most of these places are concentrated on basically selling the art. I hope that the new approach to gallery lighting might at least impose an interesting change in the common stereotype of an art gallery – a cold, white-walled entity. Since the amount of research in the area of human-centric light design is rapidly growing, I hope that new data, coming in the upcoming years will provide complex solutions aimed at a more flexible and individual approach to the art gallery lighting design.

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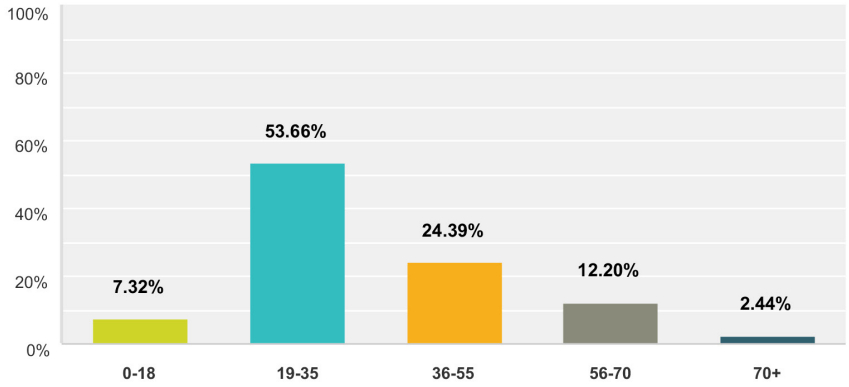
APPENDIX

Extended results of test 1

Q1 What is your age?

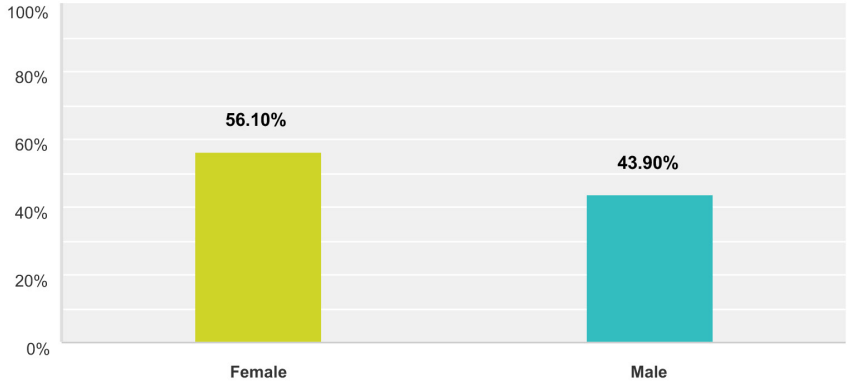
Answered: 41 Skipped: 0



Answer Choices	Responses	
0-18 (1)	7.32%	3
19-35 (2)	53.66%	22
36-55 (3)	24.39%	10
56-70 (4)	12.20%	5
70+ (5)	2.44%	1
Total		41

Q2 What is your gender?

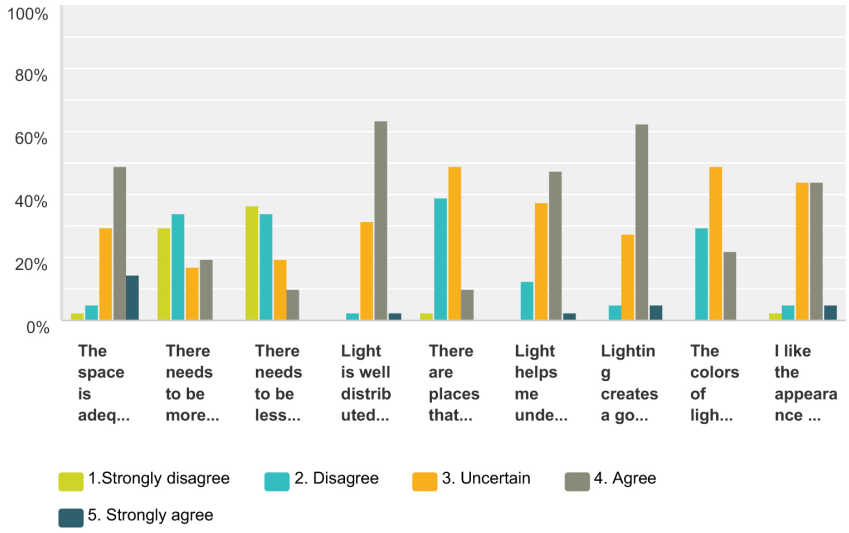
Answered: 41 Skipped: 0



Answer Choices	Responses	
Female (1)	56.10%	23
Male (2)	43.90%	18
Total		41

Q3 Please indicate how much do you agree with each statement from 1 (strongly disagree) to 5 (strongly agree).

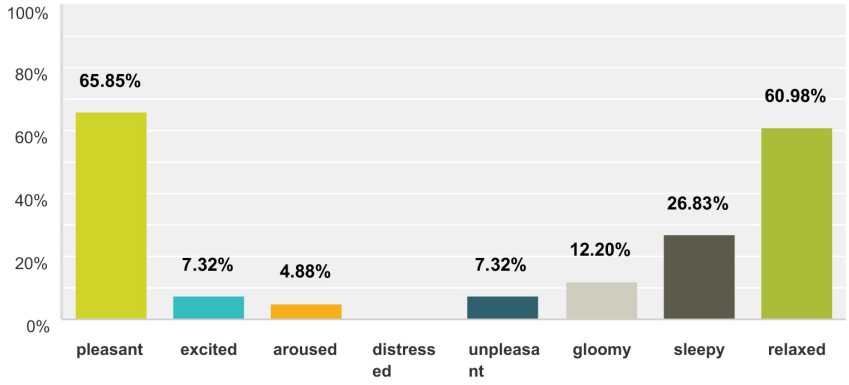
Answered: 41 Skipped: 0



	1.Strongly disagree (1)	2. Disagree (2)	3. Uncertain (3)	4. Agree (4)	5. Strongly agree (5)	Total	Weighted Average
The space is adequately illuminated	**2.44%** 1	**4.88%** 2	**29.27%** 12	**48.78%** 20	**14.63%** 6	41	3.68
There needs to be more light in the space	**29.27%** 12	**34.15%** 14	**17.07%** 7	**19.51%** 8	**0.00%** 0	41	2.27
There needs to be less light in the space	**36.59%** 15	**34.15%** 14	**19.51%** 8	**9.76%** 4	**0.00%** 0	41	2.02
Light is well distributed in the space	**0.00%** 0	**2.44%** 1	**31.71%** 13	**63.41%** 26	**2.44%** 1	41	3.66
There are places that cannot be seen but should be made visible with lighting	**2.44%** 1	**39.02%** 16	**48.78%** 20	**9.76%** 4	**0.00%** 0	41	2.66
Light helps me understand the situation in the room	**0.00%** 0	**12.50%** 5	**37.50%** 15	**47.50%** 19	**2.50%** 1	40	3.40
Lighting creates a good contrast effect	**0.00%** 0	**5.00%** 2	**27.50%** 11	**62.50%** 25	**5.00%** 2	40	3.67
The colors of light are efficiently used	**0.00%** 0	**29.27%** 12	**48.78%** 20	**21.95%** 9	**0.00%** 0	41	2.93
I like the appearance of how the space looks like	**2.44%** 1	**4.88%** 2	**43.90%** 18	**43.90%** 18	**4.88%** 2	41	3.44

Q4 Please mark words that best describe your emotional response to the light:

Answered: 41 Skipped: 0

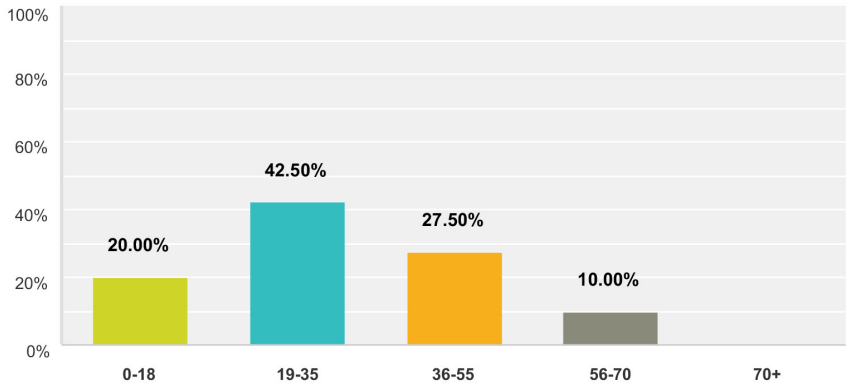


Answer Choices	Responses	
pleasant (1)	65.85%	27
excited (2)	7.32%	3
aroused (3)	4.88%	2
distressed (4)	0.00%	0
unpleasant (5)	7.32%	3
gloomy (6)	12.20%	5
sleepy (7)	26.83%	11
relaxed (8)	60.98%	25
Total Respondents: 41		

Extended results of test 1

Q1 What is your age?

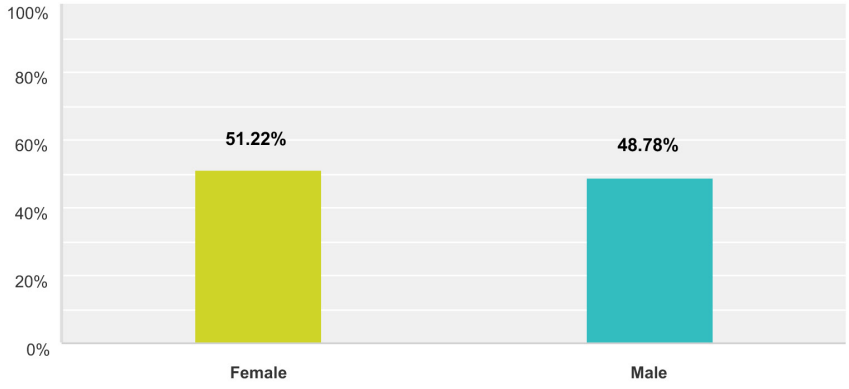
Answered: 40 Skipped: 1



Answer Choices	Responses	
0-18 (1)	20.00%	8
19-35 (2)	42.50%	17
36-55 (3)	27.50%	11
56-70 (4)	10.00%	4
70+ (5)	0.00%	0
Total		40

Q2 What is your gender?

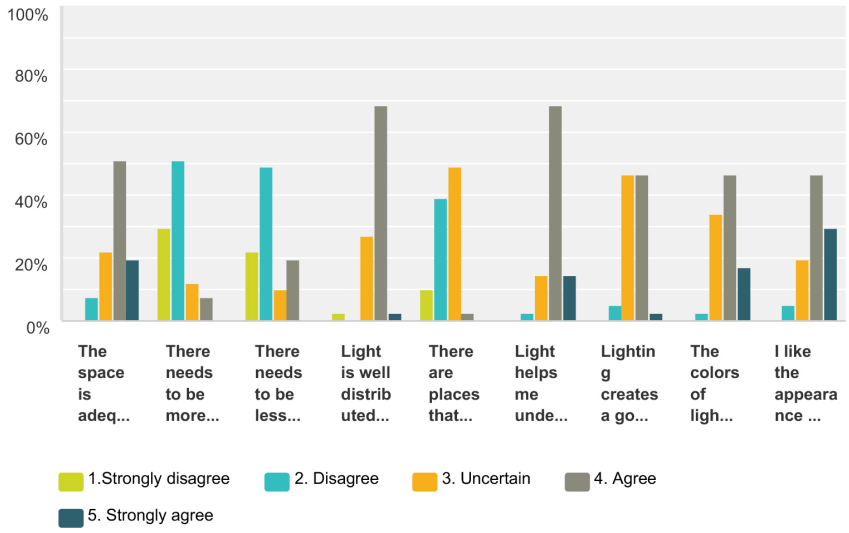
Answered: 41 Skipped: 0



Answer Choices	Responses	
Female (1)	51.22%	21
Male (2)	48.78%	20
Total		41

Q3 Please indicate how much do you agree with each statement from 1 (strongly disagree) to 5 (strongly agree).

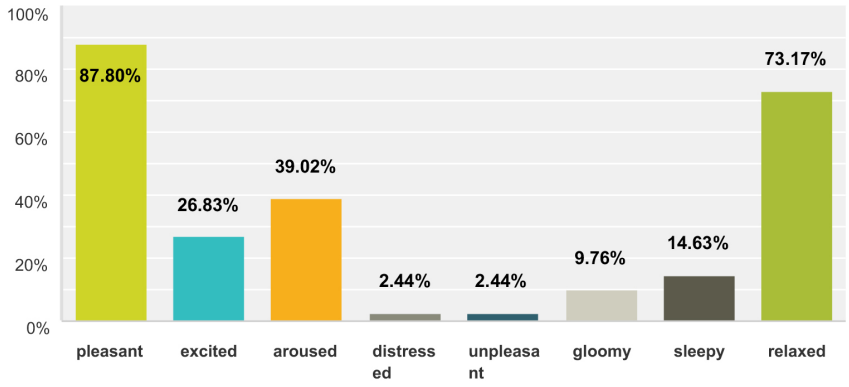
Answered: 41 Skipped: 0



	1.Strongly disagree (1)	2. Disagree (2)	3. Uncertain (3)	4. Agree (4)	5. Strongly agree (5)	Total	Weighted Average
The space is adequately illuminated	**0.00%** 0	**7.32%** 3	**21.95%** 9	**51.22%** 21	**19.51%** 8	41	3.83
There needs to be more light in the space	**29.27%** 12	**51.22%** 21	**12.20%** 5	**7.32%** 3	**0.00%** 0	41	1.98
There needs to be less light in the space	**21.95%** 9	**48.78%** 20	**9.76%** 4	**19.51%** 8	**0.00%** 0	41	2.27
Light is well distributed in the space	**2.44%** 1	**0.00%** 0	**26.83%** 11	**68.29%** 28	**2.44%** 1	41	3.68
There are places that cannot be seen but should be made visible with lighting	**9.76%** 4	**39.02%** 16	**48.78%** 20	**2.44%** 1	**0.00%** 0	41	2.44
Light helps me understand the situation in the room	**0.00%** 0	**2.44%** 1	**14.63%** 6	**68.29%** 28	**14.63%** 6	41	3.95
Lighting creates a good contrast effect	**0.00%** 0	**4.88%** 2	**46.34%** 19	**46.34%** 19	**2.44%** 1	41	3.46
The colors of light are efficiently used	**0.00%** 0	**2.44%** 1	**34.15%** 14	**46.34%** 19	**17.07%** 7	41	3.78
I like the appearance of how the space looks like	**0.00%** 0	**4.88%** 2	**19.51%** 8	**46.34%** 19	**29.27%** 12	41	4.00

Q4 Please mark words that best describe your emotional response to the light:

Answered: 41 Skipped: 0



Answer Choices	Responses	
pleasant (1)	87.80%	36
excited (2)	26.83%	11
aroused (3)	39.02%	16
distressed (4)	2.44%	1
unpleasant (5)	2.44%	1
gloomy (6)	9.76%	4
sleepy (7)	14.63%	6
relaxed (8)	73.17%	30
Total Respondents: 41		

Master Thesis

Mikolaj Lewandowski

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MA in Lighting Design
Aalborg Univeristy in Copenhagen

2016