"Re-evaluating residential lighting design criteria"

A pragmatic design game approach to transdisciplinary concept and product development in residential lighting

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Abstract

The functionalist paradigm has given us good visual performance, and a great understanding of visual discomfort, while recent contributions in the field of natural sciences have given us a greater understanding of the health issues, especially regarding circadian lighting. Both perspectives are quantifiable and therefore can be used in design criteria, giving a measurable economic argument for implementing certain features in lighting design products. Is that all there is to creating good lighting in your residency?

These features can at its best leave the resident indifferent, but they do not take into account the subjective human's emotional, cultural and social relation to lighting. Even though these can be found in some sparse qualitative studies on residential lighting, the difficulty in measuring them can make it hard to get on the agenda of design criteria.

An evaluation of what values design criteria rests upon today, and its historical traces, makes it possible for this study to reevaluate, and through transdisciplinary inquiry with the involved communities of practice, propose new values and visions as basis for future residential lighting.

This thesis proposes that residential lighting design criteria should be co-shaped through pragmatic design games by the involved communities of practice. These games should be based on values of the known functional and health perspectives but also through inclusion of the resident as an active part of lighting, which shapes the atmosphere with the help of light, guided by emotion and their social and cultural perspectives.

This is an effort to reevaluate the underlying values of design criterias.

But it is just as much an effort in creating the process through which it can happen, and how design criteria can be co-shaped from these. A process where the involved communities of practice can see through their localized, embedded and invested knowledge and find pragmatic application of each other's specific knowledge, and thereby co-shape a better value base for residential lighting design and a visionary direction for residential lighting design criteria.

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Introduction:

Design criteria for residential lighting can be seen as a boundary object (Star & Griesemer, 1989, Carlile, 2002, 2004) between the involved communities of practice (Duguid et al., 2001), which is historically embedded and invested (Carlile, 2002) in the functionalist paradigme (Burrel & Morgan, 1979) and its objective quantitative scientific approach. Ingold (2001) and Volf (2011) claims that this embeddedness creates a neglection of the subjective qualitative understanding and values of the human being. Mikkel Bille's (2007,2015,2017) anthropological studies of residential lighting cultures exposes the neglected emotional, social and cultural embeddedness of lighting practices, while introducing Gernot Böhmes atmosphere perspective as a qualitative sensiticing device (Ibid,1993).

In "Mapping danish lighting trends" (2014) Lone Stidsen proposes a method to translate the qualitative knowledge of residential lighting atmospheres into the quantitative language of functionalism.
I see this as a devaluation of the atmospheric qualities of for example "hygge", expressing an emotion or ambiance based in values of dwelling, homeliness and socialising in a syntax based on values of acuity and effectiveness.
I propose that qualitative criteria stays qualitative, while quantitative measures stay quantitative, but a bigger acceptance and understanding is made possible by focusing on what boundaries of knowledge exist in between the different perspectives proposed by the literature, and which values each of them are build upon.
Therefore this particular study will assemble four communities of practice working in the field of residential lighting, in a transdisciplinary inquiry ((Meeth,1978; Hansen,2014), represent the different perspectives found in the litterature.
Through two different design games they will inform us and each other on their individual design values, and which new boundary objects for knowledge sharing in between these different profession can be used to build ground for cooperation and inspiration, rather than alienation. Through this pragmatic recognition and collaboration create new methods, values and criteria for good residential lighting.

Methodology

Method-wise the empirical study was performed as an integration of interviews and design games for both data collection and hypothesis testing. The particular method of design games was chosen as it is seen to improve communication and ideation in a joint venture of different communities of practice (Brandt and Messeter, 2004). While this method normally downplays conflicts, these were in contrary taken in as part of the process (Ehn, 2008) as one of the big problems around the assembled profiles and their individual communities of practice is their conflicting views on knowledge (Stidsen,2014; Volf,2011; Ingold, 2000). For

this Ehn (2008) and Hansen (2016) proposes a pragmatic approach, which was included with the aid of Carlile(2002,2004) and Star's (1989) theoretical frame on boundary objects.

The collected material

Main stakeholders in the field of residential lighting, a lighting architect, a product developer, an anthropologist and designer, was first interviewed, giving an understanding of their individual workfields and visions in the field. This was background for the creation of the first design game, which was a negotiation process game on "Visions for good residential lighting", finding the four main visions in between the 4 communities of practice to create good residential lighting.
The 4 communities of practice was again represented in the following game "Mocking up good residential lighting" where the 4 visions was used as constructive obstructions for a design ideation process .

Theory

Both to create the frame for the empirical research, the analysis thereof and the litterature, the theoretical backbone of boundary objects (Star, 1989) was used.
The particular theory utilised here proposed by Carlile (2002, 2004), gives a framework to understand how knowledge boundaries develop, how they differ in 3 different levels, while also proposing how these boundaries can be disintegrated. As mentioned the theory was used to create pragmatic alliances through design games, where shared knowledge creates the base for transforming the communities of practices specific knowledge.

Problem statement and research question

When designing residential lighting which criteria and values should guide the involved communities of practice?

Due to the broad nature of this question I will start by looking into residential lighting preferences in a historical, contemporary and future perspective, starting with the following question:

What is good residential lighting as of today, and what governs these preferences?

First this question will be asked to the literature, followed by a historical reflection, giving a perspective on how residential lighting preferences has been evolving. This gives us a perspective of where "good residential lighting" is coming from, how it has evolved and which factors has been impacting this, and therefore giving us the basis to ask the literature and

stakeholders of residential lighting for a future proposition of where good residential lighting is going or "**what is the future vision for good residential lighting?**".

It is one thing is to set a future direction, and another thing, to walk the talk. So furthermore an inquiry in how to travel from status quo to a given future vision is attempted.

Strategy

Due to the question`s dependence on a heterogene field of different stakeholders and knowledge domains, research into a wide range of knowledge is proposed, both using existing literature, interviews and design games as source. In the research phase expanding the problem field through literature research and interviewing different stakeholders. These interviews will then be basis for a negotiation design game, where 4 stakeholders meet and let their communities of practice determine 4 key visions for good residential lighting. In the following design game these visions will be used as constructive obstructions for the stakeholders to generate design criterias in a specific setting.

The approach is as follows:
Literature review
Interviewing experts from different professions working in the field of residential lighting.
Interviewing residential lighting users.
Using design games with experts as knowledge gathering and creating method:
- Analyse the interviews and let them inform the vision game
- Vision game, a design game with the intention to communicate and create visions across knowledge domains.
- Mocking up good residential lighting, a design game where stakeholders will be restricted by the aforementioned visions, as obstructions to ideate design criteria for a specific lighting setting.

These will be subject for analysis which will further inform the design criterias.
The body of literature, theory and empirical research will then be discussed, trying to enlighten the problem field and answer the research question(s).

Literature review:

The literature review, will inform the question of what is good residential lighting as of today, its historical traces, and its future trajectory, showing how the literature can help the design of such.

6 distinct perspectives which all shines a specific light on our use of lighting in our home, recognised in the literature, will be presented. These can all be seen as sensitizing devices, which can help seeing residential lighting from different perspectives, while also being used

as informants on design parameters. These will first be introduced in short, followed by subchapters presenting each category in depth. The six perspectives are

The Functionalist perspective. Is task oriented, as in which light is best for reading, which light is best for cutting onions. The subcategory of biomechanics, evaluates how light from a biomechanical perspective affects the body, both visual and non visual, and how the body affects the light we see. The functionalist perspective, can be evaluated with natural science and chart different thresholds and recommendations for best practice, which can be validated and measured by instruments, and qualitative tests. The functionalist perspective is dominant in the design of residential lighting.

The Marxist commodity perspective. Is an analytical perspective on how industrialisation and capitalism created the functionalist perspective ruled by necessity and its counterpart freedom, for example work and leisure, or clock time and free time (Ingold, 2000, p.p.329). A distinction between being objectified on work, opposed to "leisure" and individualistic focus on "needs", indulging in "desires" and selfhood.

The Dwelling perspective. Is the dichotomy to the above explained commodity perspective. Dwelling is what Ingold (Ibid, 2000) explains as the state of matter before the industrialisation and capitalisation. A perspective where work and life are not separate, and culture and social life is a part of the work. He argues that the dwelling perspective still exists, mainly in the "dwelling", and therefore can give us a new perspective on what we do at home, and how residential lighting is a part of that.

The Atmospheric perspective as senciticing device for residential lighting.
An introduction to the aesthetic theory of Gernot Böhme where aesthetics are described through the notion atmosphere. An atmosphere is neither owned by a thing or the subject interacting with it, it is rather a co-shaped haze where the network of participating people and things influence each other.
Mikkel Bille brings this theory into a lighting perspective.

The Social perspective. Is how we give meaning to the way we practice lighting and how narratives are created to support this practice. How we as humans relate and communicate with each other and ourselves by the help of light.

The Cultural perspective. Is an unfolding of differences between practices of residential lighting in different cultures. First showing differences between the use of lighting in non-western, and western countries, followed by answering the question if cultural differences in lighting practices also is seen between western countries, exemplified by a comparison between Northern and Southern Europe.

The functionalist perspective

The functionalist perspective, starts from the assumption that "time is money" and lighting is seen as a part of a production machinery, where it is essential for lighting to help the light user to perform different tasks correct and efficient. This is done by creating the best visual performance for the given task, which is defined "*in terms of the speed and accuracy of processing visual information*"(Rea & Oullette, 91). From a lighting producers point of view this type of scientific research should provide standards and minimum requirements for illumination of for example an office table, or amount of daylight entering a room, and the

design criteria to evaluate the economical difference between mediocre and quality products (Boyce, 2004).

Peter Boyce (2004) points out that it is not only light' impact on *the visual system*, but also the impact on *the circadian system*, and *the perceptual system*, which affects the human performance (Boyce & Rea 2001).
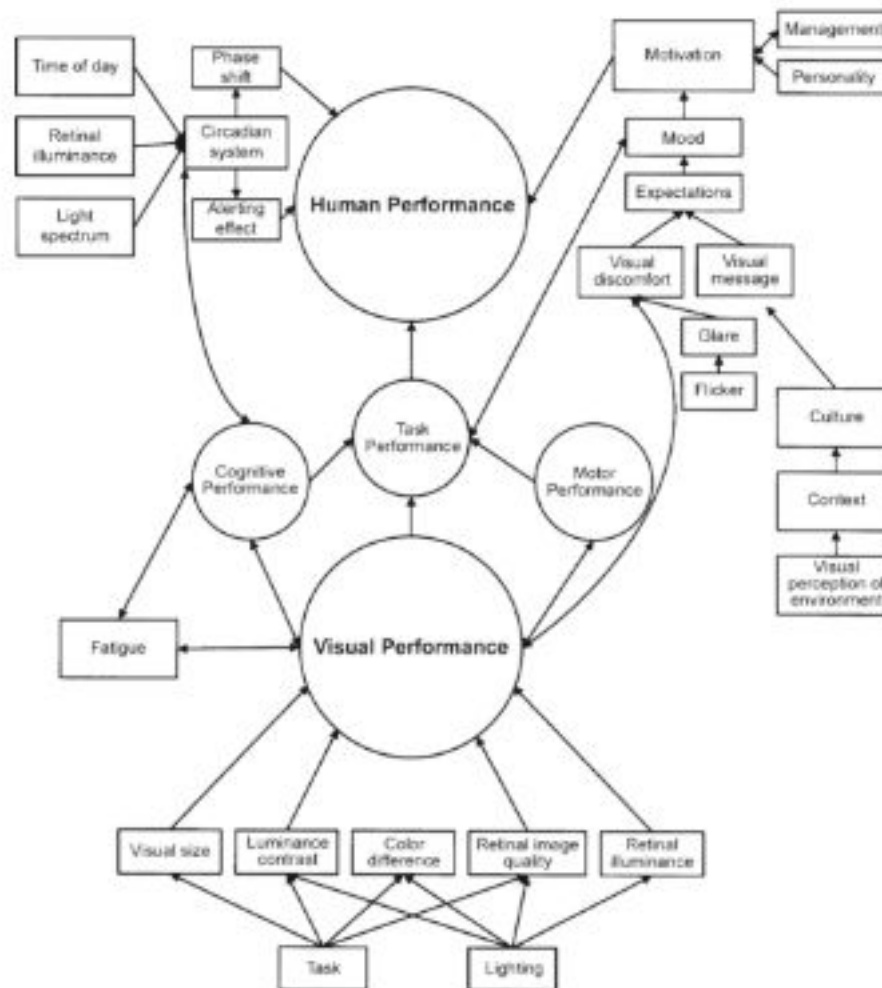
Figure 1: Lights impact on human performance through the visual, circadian and perceptual system (from Boyce & Rea, 2001)

In short the three areas can be described

The visual system

Boyce and Rea (Ibid, 2001) establish lighting and tasks as the characteristics affecting the 5 metrics which defines the visual performance, seen in the lower part of Figure 1.

The circadian system

As seen in Figure 1 the circadian system is affected by the lighting spectre, timing of light exposure and retinal illuminance. Changes to the circadian system course alerting effects and phase shift to the wake/sleep cycle.

The perceptual system

The perceptual system is affected by visual discomfort, and the general visual perception of the environment, both are matched to expectations, affecting mood and motivation to perform (Boyce, 2004, p.p. 284).

In the following the three different systems will be unfolded in detail.

The visual system

The visual system should in the functionalist perspective aid visual performance by giving visual information as fast and accurate as possible. As seen in the lower part of Figure 1, it is the task and the light that defines the 5 parameters of visual performance. The 5 parameters that are considered to score the visual performance are: visual size, luminance contrast, color difference, retinal image quality, and retinal illuminance.

90 years of research in the functionality of the visual parametres, through physiological, biomechanical research has informed this field of knowledge thoroughly, and quantitative mathematical functions defining a visual performance index, have been made taking the above parameters into account. This is the work by Rea and Oulette from 1991, and CIE publication 145 from 2002 which are empirically validated models build on the knowledge accumulated over the last century (Boyce, 2004).
In this way the lighting for many different tasks can be predicted. Calculative models for interior lighting design which can generate predictions for a specific product, in a specific environment used for a specific task. This field of research has generated standards and guidelines for lighting usage, though mostly interior lighting for offices and factories have been specified, as this is where health, wealth and safety (Boyce 2004) needs to be assured.
Standards which can be used as guidelines from the corporate field in the residential lighting field are for example DS/EN 12464.

The circadian system

Same year as Boyce and Rea published Figure 1, while asking for more scientific research in this specific field (Boyce, 2004), evidence of a non visual photoreceptor regulating the circadian rhythm were presented. The fundament for research in the circadian system is like the visual system based on quantifiable measurements, but is more based on biomechanical empiri than human performance metrics (Brainard et al., 2001). The new discovery started a big scientific effort in this field (Boyce 2004).
These photoreceptors is intrinsically retinal photosensitive ganglion cells (ipRGC) in the human retina (Berson et al., 2002; Berson, 2003), which does not give impulses to the visual system, but directly to the suprachiasmatic nuclei (SCN) of the hypothalamus, in other terms the human clockwork (Pechacek 2008). The SCN then signals the pineal gland which will suppress the secretion of the hormone melatonin. The secretion of melatonin is highest at night, and controls the diurnal wake/sleep rhythm (Mardaljevic, 2012).

As Boyce points out in his model, the circadian system can be affected by 3 different parameters: the light spectrum, retinal illuminance and time of day. This is shown in the following model:
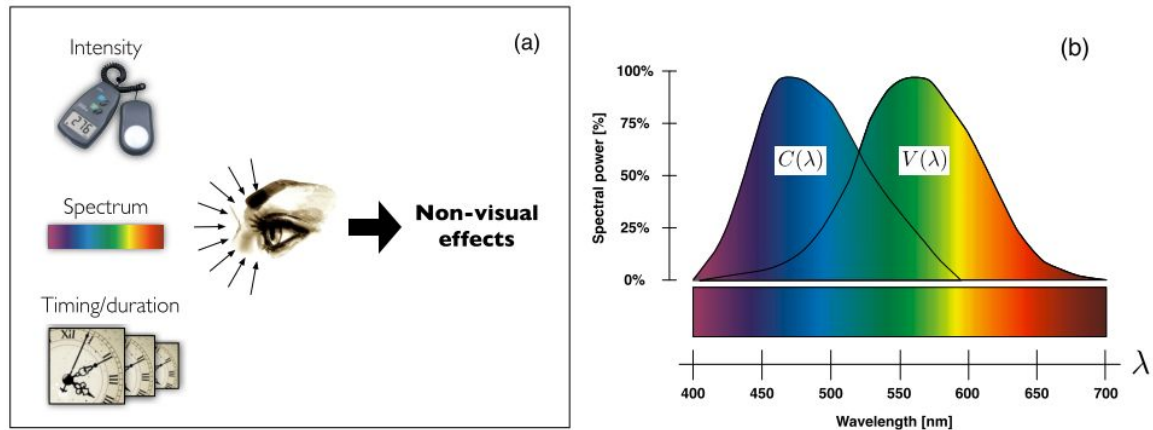
Figure 2 :Visualisation of the factors affecting the circadian system (a). The light spectrum, and difference in between circadian C(lambda) and photopic V(lambda) spectral response effectivity (b). (from Mardaljervic 2011, p.p. 11).

Spectrum and intensity

The photopigment found in the ipRGCs is melanopsin (Kumbalasiri and Provencio, 2005), which spectral power efficiency curve is seen above in Figure 2. According to Berson (2007) maximum absorption is at a wavelength of 480 nm (blue), though this value differs +- 10 nm in between different publications (Pechacek 2008).

The illuminance intensity at the retina also has a power efficiency distribution for ipRGC. The illuminance intensity power efficiency curve has not been thoroughly investigated yet (Mardaljevic, 2011). Though Mardaljevic proposes a ramp up curve, starting at the highest lower boundary illuminance intensity at the eye for circadian entrainment and subjective alertness, with a minimum efficiency, and ending at the highest maximum efficiency as shown in Table 1.

CIE prefix	Minimum efficiency (lux)	Maximum efficiency (lux)	Temperature (Kelvin
D55	210	960	5504 K
D65	190	870	6504 K
D75	180	830	7504 K
A	390	Unknown	2856 K

Table 1: Minimum allerting efficiency, maximum efficiency and light temperature for D55 (direct sunlight), D65 (overcast skylight), D75 (blue clear sky) and A (incandescent light bulb) (sources: CIE, 1931, 1965; Mardaljevic 2011)

These data and Cajochen's "*Dose-response relationship for light intensity and ocular and electroencephalographic correlates of human alertness*" study from 2000 suggests that daylight is more effective than artificial light in delivering the non visual lighting spectre, and therefore it has to be ensured by architects, more that interior lighting designers. While Mills et al. shows that a 17000 K Phillips fluorescent lamp can be used for this purpose, showing higher efficiency than D55, D65 and D75, "*The lighting is well tolerated and has the potential to be a cost-effective means of impacting upon employee wellbeing and productivity*" (Ibid, 2007 p.p. 8), The effect of high correlated colour temperature office lighting on employee wellbeing and work performance Peter R Mills, Susannah C Tomkins and Luc JM Schlangen). However, it is questionable if a lamp with such a high light temperature would be used in homes. Another argument in favor of both using natural and artificial lighting, is that the colour temperature of daylight varies between 3000 K and 30,000 K, but before entering a window it is normally blended with light reflections from vegetations and buildings (Fontoynont, 2002), and after transmission through a window, and indoor reflections, the CCT range has diminished to 3000 K - 8000 K (Chain et al., 1999).

CIE has announced that they will publish a guide for non visual spectral and illuminance efficiency calculations and thresholds in 2017, though it has not been published yet.

Timing
In relation to timing, and which time of the day you expose yourself to light findings show that light stimulation (over the given threshold) before the minimum core body temperature (CBT) which normally is at 5 AM (Boyce, 2004) can delay the phase up to 3.6 hours, while exposure after CBT minimum advances up to 2 hours.(Khademagha et al., 2016, p.p.268).
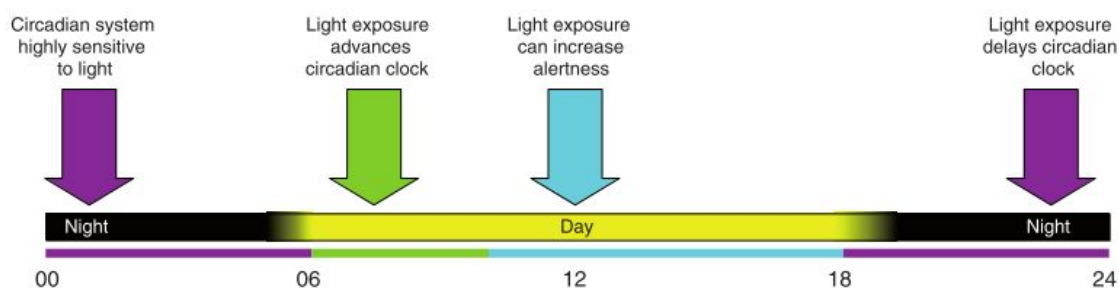
Figure 6 The day is divided into three episodes according to the type of non-visual effect that applies to each one

Figure 3: According to the circadian effects of light, the day divides into 3 periods, marked with purple, green and blue, depending on the non visual effects in that time of the day.(After Mardaljevic, 2012a, p.p.46).

Age
Another timing design factor to take into consideration is which hours of the day, we are at home depending on age and culture. And which of the nonvisual factors can be applied to being at home. That means fx that there is a difference on how to create artificial light for a family expected to be in school or at work from 7:30-16 or for a retired couple,who are assumed to spend most of their day at home.

Taking a look at the time of a whole life, there are also some biomechanical factors which changes over the years, affecting the light before sensed by photoreceptors.
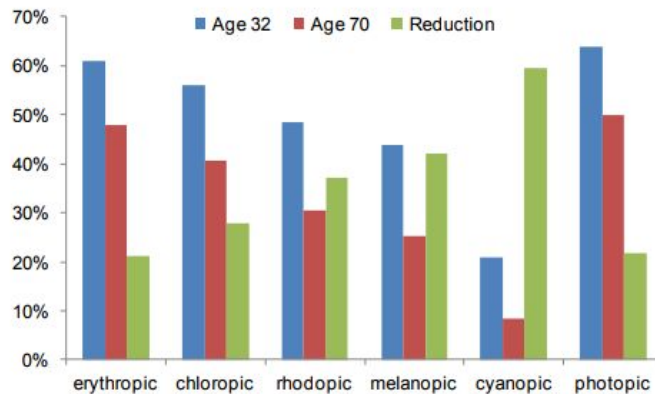
Figure 4: Age related reduction in percentage of irradiance measured at the outer surface of the eye that reaches the retina, from left it is, red, green, monochromatic, circadian and blue photoreceptors, with a gathered photopic example at last. (copy from CIE TN 003:2015, p.p. 11).

Above you see the age related difference of how much light from the outer surface of the eye that reaches the retina, depending on the photopigment in the different photoreceptors. This both gives an understanding of how non-visual effects from light can help focusing the circadian clock for elderly as the light spectrum activating the ipRGC (melanopic) is reduced 45%, but also in general which spectral difference you could make to the artificial lighting used by a 70 years old to make his/her sight be as good as a 32 year old. The biggest difference is seen in the cyanopic (s-cone, blue light spectre) activation, with 60% less blue light reaching through the eye to the retina. (CIE TN 003:2015)

The perceptual system

The perceptual system is double stranded, with one strand, visual discomfort being well studied, while the "message" that light sends is not. Boyce points out "*There is a need to develop better methods for measuring the 'message' delivered by a lighting installation.*" (Ibid, 2004, p.p. 289). By this quote he also reveals his underlaying methodological restriction to quantifiability. Even though he point out that the perceptual system differs from the visual and circadian, by light only being one of many affecting factors and points toward a useful method to study those, "*The field of environmental psychology is one in which the effects of all the different aspects of the environment are integrated and in which there are theories that span the effects of many different environmental and personal factors*" (Boyce, 2004, p.p. 287). So on one side he sees the need for looking at the human individual, while still adhering to quantifiable measures.

The first strand is described below, while the second is not due to the lack of research in this field, probably stemming from its complexity, and its hard to quantify subjectivity. This is

though described from a non functionalist perspective in the later subchapters of atmosphere, social and cultural perspectives.

Visual discomfort

Visual discomfort mainly flicker and glare, can both affect the human performance through the visual perception, but also through annoyance affect mood and motivation and thereby human performance. Furthermore stroboscopic flicker can cause epileptic seizures.

Glare

"*When faced with a very high luminance in the visual field, the usual behaviour is to blink and look away or to shield the eyes from the source of high luminance. This behaviour can be taken as an indication that glare is present*." (Boyce, 2014, p.p. 170)

8 forms of glare has been suggested (Vos, 1999), while discomfort and disability glare is the most important for interior lighting design.

Disability glare reduces the visual performance and is caused by scattering of light in the eye, which creates a luminous veil reducing the luminous contrast of the retinal image (Boyce PR, Rea MS. 2001). Two equations is widely used to calculate disability glare. The most general is CIE General Disability Glare equation, covering from 0.1 degrees to 100 while the Stilles-Holladay disability glare formula is valid from 3 to 30 degrees (Vos, 2003). Discomfort glare is the sensation of annoyance and/or pain due to luminance, and for indoor light sources and luminaires this subject has widely been studied for more than the last 60 years (Boyce, 2014). It is harder to calculate as it depends on psychometrics, and has a large deviation in glare ratings as seen in Figure 5. There are two main ways of calculating discomfort glare. One is the North American visual comfort probability (VCP) (Boyce, 2014), and the other is the unified glare rating (UGR) (Sorensen, 1987; CIE, 2002).
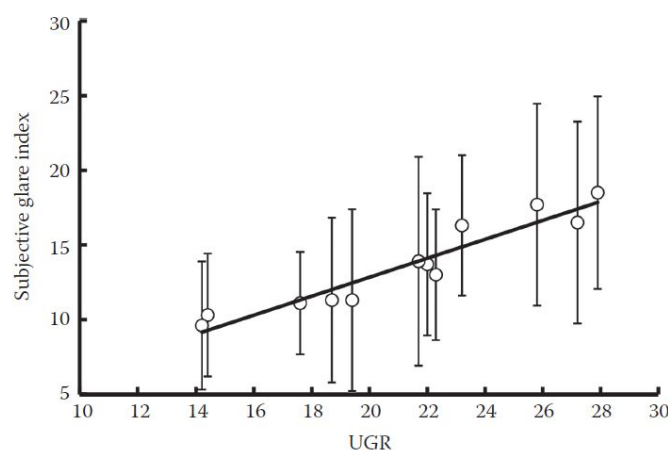

Figure 5: Glare rating with standard deviation, plotted against UGR calculations (After Akashi, Y. et al.,1996, p.p. 199)

Flicker

Flicker is the visual detection of a fluctuation in light.

"The main factors that determine whether a fluctuation in light output will be visible are the frequency and percentage modulation of the fluctuation at the eye, the proportion of the visual field over which the fluctuation occurs and the adaptation luminance. The higher is the adaptation luminance and the larger is the area, the more likely it is that a given frequency and percentage modulation fluctuation will be seen" (Boyce, 2014, p.p. 184-185)

Relying on different light sources there are different concerns relating to flicker. Flicker relates to electricity supply. Incandescent light sources is not affected greatly by high frequency oscillation of a power supply, while low frequency oscillations can affect them. Power discharge light sources are less sensitive to power supply changes(Boyce 2014). Though a change from the 100-120 Hz oscillation, to 25-60 khz power supply has been associated with lower occurrences of eyestrain and headaches (Wilkins et al., 1989).

LED sources are solid state and has a very short response time, and can therefore easily cause flicker (Boyce 2014).
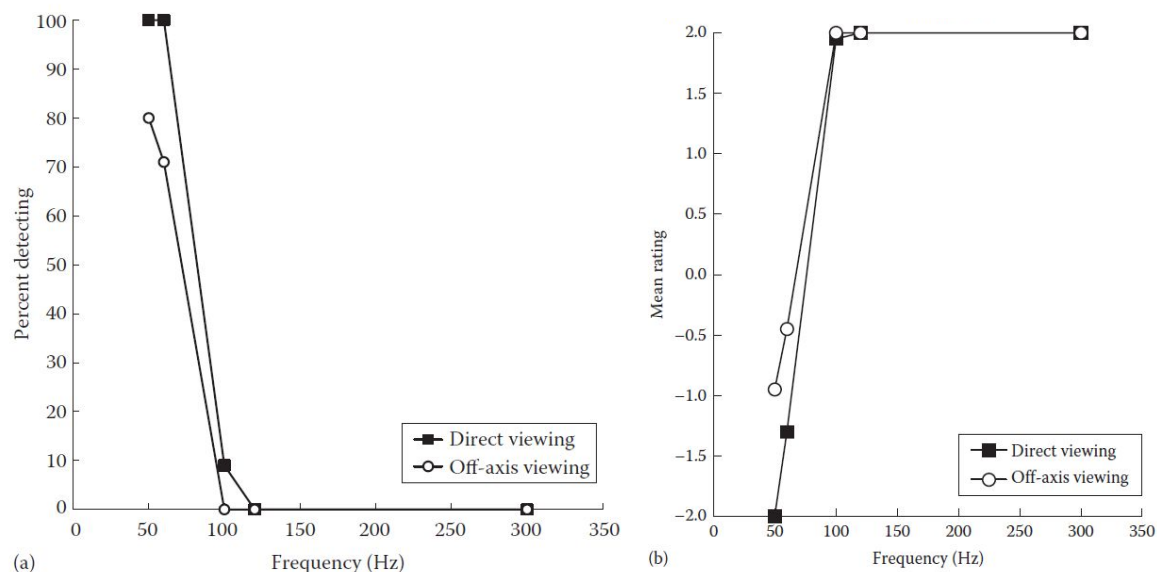
Figure 6 (a) Percentage of observers who could detect 100% modulation flicker at different frequencies when looking directly at the reflector of an LED desk lamp and 40° away from it and (b) the mean ratings of acceptability for observers who detected flicker. The acceptability ratings were made on a scale of −2 = very unacceptable, −1 = somewhat unacceptable, 0 = neither acceptable nor unacceptable, +1 = somewhat acceptable and +2 = very acceptable. (From Boyce 2014, p.p. 186;After Bullough, J.D. et al., 2011, p.p. 337)

In Figure 6 after research by Bullough et al.(2011) detection of flicker and the acceptance of flicker have been demonstrated. And the IEEE PAR1789 (2015) recommended practice for LEDs, setting flicker frequency to minimum 100 Hz if the fluctuation is under a certain threshold is supported. Thereby allowing LED power supply from a rectified AC source.

The limits of the functional perspective

The functionalist perspective is encapsulated in Boyce and Rea' model from figure 1, which in their perspective is a model reflecting interior lighting in general. Though it is mostly based

on studies around interior lighting for offices, factories and schools, for which top performance is essential. But is that the only thing we use light for in our home?
An observation on the functionalist perspective is that it assumes that human performance and visual performance can be explained as a general universal human system exemplified in models and equations, based on quantifiable data.

Even though Boyce points out new branches of research in the field of interior lighting, they will still be pointing back at the quantifiable and justifiable reason to do good lighting, to make the human perform better, safer, faster and be more healthy.

Danish architect and researcher in lighting Carlo Volf directs his critique:
"Since "Mechanization took command" many things have changed, and functionalism has reduced light into measurable figures in the Western World in the attempt to produce and plan the best physical environment for human beings. But this has been a poor attempt, reducing experience and atmosphere to zero-value and neglecting the emotional wellbeing of the inhabitants in our built environment." (Volf, 2011, p.p. 107).

Carlo Volf states that the industrial revolution, and thereby functionalism has overruled a pre-existing light culture, and culture in general, where the flavor of experience, atmosphere and emotional wellbeing was part of "our build environment".
The functionalist assumption is, if we want to produce and plan the best lighting environment, we need measurable figures. Volf argues that this search for quantifiable measures has thrown away the qualities of good lighting as the experience, atmosphere and emotional wellbeing lighting creates. Stating that good residential lighting partly is not existing, because of the functionalist paradigms (Burrel & Morgan, 1979) epistomological and methodological approach. If this is true, research from opposing paradigms are needed, and should be implemented. This argues for that we should not only design for measurable thresholds, either quantified by humans or machines, but also design for different qualities and values.

In the next subchapter I will change to a Marxist, radical structuralist paradigm perspective reflecting on Volf' point of view. Asking the questions, if we assume Volf to be right, how did such change happen, and how has it inflicted our use of residential lighting?

The marxist commodity perspective on residential lighting

In the former chapter I have discussed functionalism, its design criteria and its imprint on the modern use of lighting. In the following I take a step back and explain how functionalism from a Marxist commodity perspective, has changed our culture's understanding of work, time and social life. How light and lighting has played a big role in that movement, and how leisure and the home has become an opposition to work, a place where you can do what you want, opposed to what you are defined to. Thereby arguing for that lighting in your home should be more than functionalistic with an ambition of effectivity and high performance. It should instead be lighting we choose because we want to, here termed as "leisure lighting".

Sociologist E. P. Thompson argues that before industrialisation, people had a different perspective on time and work. The relation with time was connected with light, with the sun's movement across the sky, and the seasonal shifts in nature. Sun was the daily timekeeper we adjusted to. In a part of J. M. Synge's "Plays, Poems, and Prose", from his stay at Aran islands from 1898-1902, the different perceptions of time is captured.

"*While I am walking with Michael someone often comes to me to ask the time of day. Few of the people, however, are sufficiently used to modern time to understand in more than a vague way the convention of the hours and when I tell them what o'clock it is by my watch they are not satisfied, and ask how long is left them before the twilight.*" (Ibid, 1941 p.p. 257)

Antropologist Tim Ingold follows Thompson' argumentation, and combining with the aforementioned view of time argues that in traditional societies time and work was interrelated in a task-oriented understanding of time, opposed to the functionalist clock time. Following he expands on task-oriented time.

"*Now if, in traditional societies, time is intrinsic to tasks, and if tasks are the technically skilled activities of particular persons with particular social identities, then it must follow that there can be no real distinction between work and social life, and moreover that time is the movement or flow that inheres equally in both*" (ingold, 2000, p.p. 325).

This view of time Ingold calls "social time", and represents what he calls the dwelling perspective, what I will expand upon in the following chapter.
Ingold and Thompton states that capitalism, and the functionalist "theorists of growth" (Thompton, 1967, p.p.93) has created a commodity perspective, which is "*epitomised by the phrase 'time is money' ... time is seen as a quantity to be budgeted, with a clearcut demarcation between work and leisure*" (Ingold, 2000, p.p. 337).
Leisure as opposed to work, in the commodity perspective becomes a urge for freedom. An urge for "Free time" as opposed to "clock time", a counter reaction to efficiency, an expression of the separation between work and life (Ingold, 2000).

"*For the goal of modern technology has been to override the constraints of the natural world, to bring its forces under control, so that the rhythms of society can be brought into conformity with an imposed, artificially contrived schedule. Activities can now go on – as we say – 'around the clock'. Developments in the fields of transport and communications have had a decisive impact in this regard, though probably no single innovation has been of greater consequence than the electric light. The effect was to install a new kind of time as the dominant regulator of human activity.*"(Ingold, 2000, p.p. 326).
The clock and artificial lighting is here seen as the two biggest denominators in the creation of Homo Faber, by creating our own clock and artificial lighting, we have taken the power from the sun, and put humans over nature. Giving us possibility to create economic growth.

Ingold argues that capitalist worklife is "*governed by laws of mechanical functioning that have no regard for human feeling*" (Ingold, 200, p.p. 329). As Marx postulates, in Economic and Philosophic Manuscripts of 1844, the worker "*only feels himself outside his work, and in his work feels outside himself. He is at home when he is not working, and when he is*

working he is not at home" (Cited in Ingold, 2000, p.p. 331; Marx,Economic and Philosophic Manuscripts of 1844,1964: 110).

So why are we going into deep societal analysis when we were actually supposed to talk about residential lighting?

Because when we turn Marx, Thompson and Ingold's arguments around, it states that home is the place for feelings, and as opposed to being at work in the office or in a factory, or kids being at school, where interior lighting is governed by the before mentioned functionalist perspective, our home is a place where we are allowed to have feelings. Opposed to making lighting for human performance, in our home we should make lighting for human feelings.

Furthermore the cornerstone of the Marxistic world perspective is that it assumes that capitalism has reduced us to either being commodities when being at work, where our labour are bought and consumed by others, while we are consumers of commodities when we are not working (Thompson, 1967).

The aesthetical economy

"... the aesthetic economy must necessarily bet upon desires, i.e. upon needs which are intensified rather than allayed by their satisfaction. The development of these desires – desires to be seen, to dress up, to stage oneself – forms the basis for a new, practically limitless exploitation. On this basis, consumption can become an obligation, affluence a stress, extravagance a duty." (Böhme, G, 2003, p.p. 81)

Gernot Böhme revises the critical theory of the commodity perspective in 2003, and argues for a new economic era, the aesthetic economy, where desires rather than needs are meet. Böehme concludes three basic conditions for the aesthetic economy to unfold in society. *"Three basic conditions must be respected. All three are closely connected, and today they let aesthetic production as well as aesthetic consumption appear in a different light. The first basic condition is the state of capitalist development itself. One can indicate this state with the catchwords 'consumer society', 'affluent society' or 'luxury economy', and one can regard it, from a global perspective, as a local phenomenon: only in those few societies marked by this phase of capitalism is a large part of production and consumption determined by aesthetic values. The second basic condition is a transformed attitude toward the pleasure principle: the good life is no longer determined through work, saving and ascesis, but through leisure, consumption and play. The third basic condition is the end of class society."* (Böhme, 2003, p.p. 79).

This can for example be seen in our modern lighting choices in Denmark. In her article "We would rather like designer lamps than good lighting" (Ibid, 2017 (politiken 16 februar 2017) lighting architect Pia Stautz states that *"Functional light does not need to be equivalent to ugly lamps, aesthetics and function can off course all come together, but for many consumers an orientation towards lumiere fashion rather than light, has been a prevailing development."*(Ibid, 2017,own translation (politiken 16 februar 2017)) .

A "consumer pattern" which also can be seen as a reflection of *"a close connection, for example, between the ideally spontaneous expression of selfhood and the modern Western notion of artistic creativity, which is likewise opposed to the industrial technology of mass production as novelty is opposed to replication"*. (Ingold, 2000, p. 329).

The Dwelling perspective

In the former chapter, Thompson and Ingold has shed light on how humans lived before the industrialisation, from their perspective. As Ingold termed it the dwelling perspective. In Figure 7 the dichotomy of the dwelling perspective, and the commodity perspective is listed:
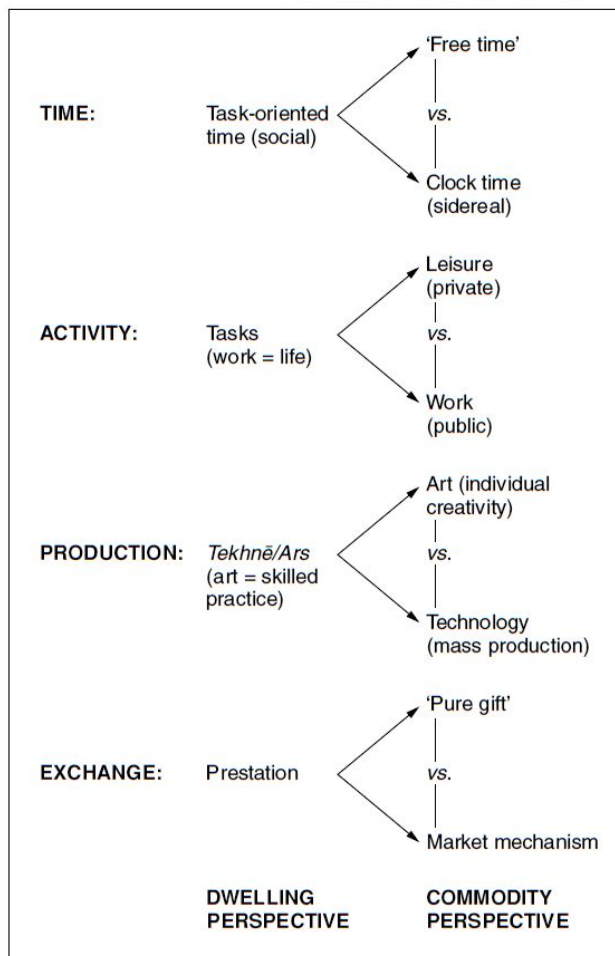
Figure 7: The opposition from the dwelling perspective and the commodity perspective, in the spheres of time, activity, production and exchange (after Ingold, 2000, p.p. 329).

Taking a closer look at dwelling Ingold argues that

"...home may represent a certain perspective on the world, which I have called the perspective of dwelling. Its focus is on the process whereby features of the environment take on specific local meanings through their incorporation into the pattern of everyday activity of its inhabitants. Home, in this sense, is that zone of familiarity which people know intimately, and in which they, too, are intimately known. As such, it encompasses all the settings of

everyday life: whether the house, street, neighbourhood, or place of work" (Ingold 2000, p.p. 330).

Following Ingolds argumentation, home may represent the dwelling perspective. Relating that to residential lighting, or in this perspective dwelling lighting. Residential lighting should be seen as a part of our lives, both emotionally, socially, and culturally.
Opposed to the "leisure" lighting, dwelling lighting should be reintegrated with tasks, as tasks is a natural part of everyday life in the dwelling perspective. But tasks in the dwelling perspective, is not per se meant to be done with high efficiency, as skilled practice and task oriented or social time is governing this perspective, social life and the personal experience is part as well. Residential lighting is part of home, and part of "*that zone of familiarity which people know..*".

As Gaston Bachelard poetically notes that, *"Reveries of this faint light will lead us back to the wee space of familiarity. It seems that there are dark corners in us that tolerate only a flickering light"* (as quoted in bille, m, 2015, p.p. 262)

In a bigger perspective Ingold argues as Thompson that in modern society we are trying to establish a synthesis of the commodity and dwelling perspective.

I see this reflected in the anthropological work of Mikkel Bille on residential light practices in Copenhagen where he concludes that *"Light is used to guide the moods around an activity; it shapes one's attachment to the activity, whether it is something that should simply be dealt with quickly or something one can dwell upon.*" (Bille, 2015a, p.p.62) As Bille in his work shows familiarity with the work of Tim Ingold, I believe the above can be seen as a comment on the dwelling perspective contra functionalistic perspective.

"*The dwelling perspective has not been replaced by the commodity perspective. Indeed the whole thrust of my argument is to the contrary – namely that task orientation, with its attendant socially situated skills and prestations, is the primary condition of our being at home in the world. As such, it constitutes the baseline of sociality upon which the order of modernity has been built, and from which we have now to come to terms with it.*" (Ingold, 2000, p.p. 333).

So if home is the place where we are dwelling, where we live and act from social and cultural integrity as opposed to our functionalistic worklife, what is then good residential lighting? How can we grasp the qualities of the personal experience of lighting in our familiarity, in the place where we are intimate and act from social and cultural integrity, where we take the time to dwell?

The atmospheric perspective as senciticing device

"I argue for the importance of studying light as one of several elements in the atmospheric orchestration of space that works as a powerful tool in "gathering" material infrastructure, moods, and cultural expectations."(bille, 2017, p.p. 28).

Above anthropologist Mikkel Bille, argues that light should be studied as part of a context, be it social, cultural, material or emotional. He promotes the use of Gernot Böhmes concept of atmosphere (Ibid, 1993) as a sensitizing device for exploring lighting, while Böhme uses it to describe aesthetic.

"Aesthetic work consists of giving things, environments or also the human being such properties from which something can proceed. That is, it is a question of "making" atmospheres through work on an object. We find this kind of work everywhere. It is divided into many professional branches and as a whole furthers the increasing aestheticization of reality. If we enumerate the different branches, we can see that they make up a large part of all social work. They include: design, stage sets, advertising, the production of musical atmospheres (acoustic furnishing), cosmetics, interior design-as well, of course, as the whole sphere of art proper. If we examine these areas in order to apply their accumulated knowledge fruitfully to aesthetic theory, it becomes apparent that this knowledge is in general implicit, tacit knowledge."(Böhme,G, 1993, p.p. 123)

Atmosphere

Böhme states that
"Atmospheres fill spaces; they emanate from things, constellations of things, and persons [...] Yet they cannot be defined independently from the persons emotionally affected by them; they are subjective facts. Atmospheres can be produced consciously through objective arrangements, light and music [...] But what they are, their character, must always be felt: by exposing oneself to them, one experiences the impression that they make. Atmospheres are in fact characteristic manifestations of the co-presence of subject and object." (as quoted in , Bille, 2015b, p.p. 267).
An atmosphere is something which can be felt. Even though it can be consciously created, it has to be experienced, rather than understood.

This can be exemplified in Bille's article "Hazy worlds: Atmospheric ontologies in Denmark" Where an informant points out that
"It is like I mentally tell myself that now I want to make it cosy, so I turn on this light. I guess it is like that. When I do this it becomes cosy. But it doesn't. It may not lead to cosiness – I also know that. But the frame is sort of set for it. The stage is set by lighting the candle." (bille, 2015b, p.p. 262)

The informant is describing what Bille explains as the Danish atmosphere "hygge" or "cosiness".
"Hygge" can be something you experience by entering a room, and then you become a part of the atmosphere. While it can also be something as for the informant that you try to reproduce, by reusing a specific lighting practice, but it is not sure that this preset will work, but the stage is set.

Ecstasies

*"In this take on atmospheres, the properties of an object are not something it
'has' or is enacted to 'have'. The object's properties do not separate from its surrounding.
Rather, this happens through the 'articulation of its presence, the way and manner of its
presence' (Bo¨ hme, 1995: 32). The being of an object, in other words, is not defined by its
physical, tangible separation from other things but by their presences and absences, their
'ecstasies' (Bo¨ hme, 1995: 155–76)."* (Bille, 2015b, pp 269)

Bille translates this into the use of lighting

*"One of the central features from the examples of the use of light is the way in which light
bulbs and candles are ecstatic in the sense that they transcend their own tangible borders
and impose themselves onto the material world; a bulb with lower colour reproduction
changes the perception of the object's surface, and thereby following Ingold, also the thing.
But light does more than simply impose itself on other things. It also imposes itself on
people: the feeling of being at home, of being part of a community, and in quite biological
ways of producing serotonin and melatonin."*(Bille, M, 2015, p.p. 62)

This can for example be seen in the photo below, where the ecstasies of the lumieres and
candle lights, with their presence and absences "carves out spaces of light and darkness"
(Bille, 2015a, p.p. 60)

Figure 8. 'Carving out spaces of light and darkness' (from Bille, 2015a, p.p. 60)

Thereby Böhme and Bille questions "*a focus relying on architecture and material objects as
contained within their own tangible borders.*" (Bille, 2017, p.p. 28).
As Bille further argues

"*The important point here is that, when focusing on the ecstasy of things, what is needed is not an understanding of what a thing is but how the totality of (temporary) ecstasies makes it what it is and, by extension, how these ecstasies affectively shape the way objects are perceived by the viewer.*"(Bille, 2015b, p.p. 261)

Wirklichkeit und realität

Bille brings forth the difference between wirklichkeit and realität in Böhmes work (2001:57), which I see as the difference between looking at a "realität" which can be observed and measured, and in this sense I see it as an expression of the functionalist observer (Bille 2015b). While "Wirklichkeit" "is the 'actual fact' of how things are experienced (Bille, 2015b, p.p. 268).
Looking at lighting through the lens of the hazy ontologies of atmospheres, where the ecstasies of things, objects and persons in togetherness creates the atmosphere.
To work with the notion of atmospheres in the aspect of lighting, one has to accept that lighting is only a part of the "Wirklichkeit" you live. It is one of the things that through its ecstasy tinges other things.

As Bille emphasises in Heidegger's essay on building, dwelling and thinking, from which Ingold has developed his concept on dwelling,
"*A boundary is not that at which something stops but […] the boundary is that from which something begins its presencing*" (as quoted in Bille, 2017, pp. 26, Heidegger 1971a: 154, original emphasis).
This quote goes hand in hand with Volf and Ingold, pointing out the flaws of the former described functionalistic view, where quantifiable measurements are the basis for science and design criteria.

No one can be objective

But it is not only the things which by their ecstasies impose themselves on other things and humans, it is also you...
"*Yet informants and anthropologists are not just in, but a part of this atmosphere since our moods and practices co-shape it. In some instances we cannot verbalize the feeling of space, or the concepts we have are too imprecise to fully satisfy the feeling. It is the 'something' that is taken for granted or overwhelms us that nonetheless shapes our conceptualizations and orchestrations of the world (Crapanzano, 2006). The interplay between language, affect, materiality, normativity and practice as subject of ethnographic analyses, in this respect can be explored through the impact of atmosphere on informants and anthropologists. In other words, how the world came to appear as it does becomes the focus rather than what the world is.*"

Bille argues that as we are to describe light as a part of atmosphere, we will not be able to assume our own objectivity, as in contrary to the functionalist approach we do not study the world as it "is". Which I will assume means an understanding of the perceiver as objective, while studying objects, through measurements. We explore how the world came to appear,

through the impact of atmosphere, in which our mood and practices co-shape with the materiality, and its ecstasies.

The social perspective

"*We have suggested that understanding light must infer a three-way relationship encompassing lumen, lux and their social orchestration.*" (Bille, 2007, p.p. 280).

"*Therefore, questions concerning how light is used in relation to social identity are also questions of what role different modes of light (bright light, dim light and so on) have, what types of light (sunshine, electrical, gas, candlelight) are used to do what, why, and how this is socially manifested and experienced.*"(Bille, M, 2007, p.p. 269)
Through his qualitative research Mikkel Bille illustrate the role light has on the way we as humans relate to each other and ourselves.

"Hygge" a cozy perspective on Danish hospitality
As introduced in the former chapter "Hygge" is a specific Danish atmosphere which Bille observes being attached to values of informality, intimacy and relaxed ambience " with sweets, wine, comfortable seating, pleasant conversation and – in terms of our argument – subdued lighting, preferably, although not exclusively, using candlelight."(Bille, 2007, p.p. 275)
He further explains that

"*...the movement of the shadows and the inability of the candlelight to fully light up the room are considered more hyggeligt (cosy) than what the light of a bare electrical bulb would offer*" (Bille, 2007, p.p. 275)

"*When inquiring into why people do what they do, most informants would explain how they light candles to remind themselves and others that they need to relax, that they are not at work any more. The 'cosy-light' hence signifies that one should relax*"(Bille, 2015,p.p. 60)
This could from a commodity perspective be identified as an expression of the former presented leisure lighting. An invitation to relax, as opposed to work. While from an atmospheric perspective say that we with the socially constructed narrative are as much a part of co-shaping the atmosphere as the light, with our ecstacy.
The social perspective and its influence on residential lighting is not well represented in the literature, therefore to take this perspective into account interpretivist studies of the resident, should be an active part of developing good residential lighting.

The culture perspective

In Bille's study of residential lighting in 60 Danish homes, he draws out some lighting preferences "*Despite variations in dwelling type, income, class and preference for interior decoration, all informants describe hygge as shaped by a particular kind of lightscape defined by dimming and shielding the electrical lights or using candlelight (called 'living light'). Some informants, of course, challenge cosy-light for being too stereotypically Danish*

or enforcing a mood that is not welcome. Yet no one would light up a room with bare light bulbs but would always orchestrate it to some degree by shielding off or subduing the direct glare."(Bille, M, 2015b, p.p. 261)

This shows both a general understanding of how atmosphere "hygge" is co-created with lighting, and a general preference of shielding of the direct glare of a lightbulb. A Danish lighting culture with preference to create lightscapes from values of informality, intimacy and relaxedness.

Hospitality in a Jordanese Beduin home

From Billes conclusions on Danish lighting, to his work on Jordanian lighting, you could argue that there is a rather big cultural difference. The photo below (Figure 9) depicts a Jordanian reception room. This and the kitchen is the place most things happens in the home.

Figure 9: A reception room in Jordan (From Bille, M, 2017, p.p. 28)

"*Guests come and go, men and male guests, such as an anthropologist, sleep here, and school children do their homework here. When a television is located here, it is the heart of the house, where men meet at night, and women listen to talk shows and Islamic guidance programs during the day.*"(Bille, m, 2017, p.p. 29).

As mentioned above it is the place where guests are invited in, as part of the Jordanian Beduin practice of hospitality. Contrary to the Danish hospitality which is expressed also with "hygge", the Beduin practice of hospitality is shaped by "*... a great deal of formalized behavior and impression management, and is associated with ideas of honor, with religious duties, and with social control.*"(Bille, M, 2017, p.p.31).

Light is co-shaping this atmosphere of hospitality
"*uncluttered interior spaces exposing every corner of the room creates the impression for someone seated on the floor that the room is more spacious than it actually is. The visual illusion of an expanded space ties to the notion that the bigger the reception room, the more people one knows and offers hospitality—and hence, the higher one's social prestige. Light*

is not merely reflecting prestige, but part of a material and sensuous consolidation of such. Beyond enhancing visual perception, luminosity also ties into religious ideas. Shadows and dark areas are thought of as places where the spirit (jinn) dwells and misfortune lurks, further suggesting the importance of orchestrating illumination and avoiding shadows in the house" (Bille, M, 2017, p.p. 35).

As seen on the picture above (fig. x) a bare CFL bulb or fluorescent light tube is placed mostly in the center of the room, to fully lit the room, while the 3000 K CFL bulb is preferred over the reddish incandescent 2700 K. As an informant says *"it gives a clean (nathiif) light"* (Bille,M,2017, p.p. 35).

Comparing the Danish cultural ideas about *"good residential lighting"* and Jordanian, shows a big cultural difference of lighting preferences and practices, and what values are part of shaping these atmospheres.
This makes me curious if such big cultural differences would be seen if you compared two Western countries?

Lighting preferences in Northern and Southern Europe

The Danish study of lighting atmospheres by Lone Stidsen (2014) which concluded that lighting is placed in different zones HIGH, CENTRE or LOW − according to the activity in the space. Showing a general specific characteristic of Danish residential lighting. Concluding on light fixtures placement in relation to the tripartation:
"*The results showed that HIGH was used for corridors and bathrooms. CENTRE was used for living rooms, dining rooms and sitting activities. Lastly, the study showed that the LOW was used in bedrooms, and the light for standing activities was mostly characterised by a combination of CENTRE and HIGH.*" (Stidsen, 2014, p.p. 133).
Stidsen sees a future study perspective in looking into a similar study as brought forward in the article, but in a Southern European context. She explains why
"*Many Danes recognise the unfamiliarity of light situations when they travel to the southern part of Europe or in public domains; e.g. being a patient in a hospital ward*" (Stidsen, 2014, p.p. 133).

The response was the thesis "Northern and Southern Lighting Cultures in Europe Lighting Scenarios for the Indoor Living Spaces" by Noskaitis et al. (2017).
Building on Stidsens research and the hypothesis normally put forth by Danish architects and designers (Mathiasen, 2015; Volf, 2011), that Nordic residential lighting design is a product of the Northern natural sunlight, it investigates if there is difference of lighting preference in Southern and Northern Europe. The thesis is that, in the south due to being positioned at a lower altitude, the sunlight is generally shining from a higher vertical position, with a brighter light than in Denmark. Hence the geo-biological evolutionary pattern has transformed into these differences in interior lighting patterns and preferences.
Their main conclusion was that
"*On the northern regions of Europe, people are more consistent with their choices about light, its CCT, and directionality. On the south regions though, people are still experimenting with the variety of their choices*"(Noskaitis et al., 2017, p.p. 35)
While also concluding that the hypothesis was reflected in their imperi

"people from the north prefer light on an average intensity coming from numerous sources indirectly, when people from the south prefer a bright intensity, coming from one or two fixtures, sometimes indirectly and sometimes directly"
This is also reflected in their lighting practices when socialising
"people from the south showed that while they are socializing they prefer a brighter environment and sometimes direct light and people from the north prefer an average or dimmed down intensity, indirectly." (Noskaitis et al., 2017, p.p. 35).

This concludes that also differences in lighting preferences can be seen between westernised countries. But the conclusions above is rather proving a biological evolutionary perspective on differences rather than a cultural perspective.
This could be a misleading perspective, if you look at countries of the same latitude as Denmark the empiri shows that the light culture differs by longitude as well.
Furthermore you can instead of seeing Noskaitos et al. in a biological evolutionary perspective see it in a culture evolutionary perspective, as Ingold proposes
"Human children, like the young of many other species, grow up in environments furnished by the work of previous generations, and as they do so they come literally to carry the forms of their dwelling in their bodies – in specific skills, sensibilities and dispositions. But they do not carry them in their genes, nor is it necessary to invoke some other kind of vehicle for the inter-generational transmission of information – cultural rather than genetic – to account for the diversity of human living arrangements." (Ingold, T. 2000, p. 186)

Thereby Noskaitos et al.`s main conclusion that Northern europeans are more aware of their lighting preferences than in Southern Europe, can be seen in the light of Böhmes notion of *"aesthetic economy"*, by questioning if the southern countries are permeated by an aesthetic culture.

What does all these perspectives have in common?

Besides reflecting on different aspects of what is good residential lighting, they have the commonality, that they are all biased in some kind of way. They all have specific paradigmatic views on knowledge, how to conduct science e.g. qualitative or quantitative, relating either to the human as a subject or an object, as an individual or as a group, looking at society, norms and culture as oppressive or stability for the better.
Another thing is that they have a hard time relating to one another, each approach, be it functionalist, socio cultural, atmospheric or dwelling, are keeping their own ontological, epistemological, methodologies and views on the human nature clean, and thereby their arguments has no glue in between their paradigmatic boundaries. They are sliding of each other, as there is no reason to listen, at least as long as their loyal idealised point of departure is kept safe.

The literature review shows that research in interior lighting partly has made a change in direction as proposed by Boyce (2004). New knowledge for example in fields from biology, biomechanics, architecture, anthropology and philosophy has evolved, and has expanded the technical, biological, cultural and social understanding of residential lighting. But we are still not much further than *"the end of the beginning"* (Ibid, 2004, 291).

I think we will not create better residential lighting as long as each paradigme keeps "inside their box".

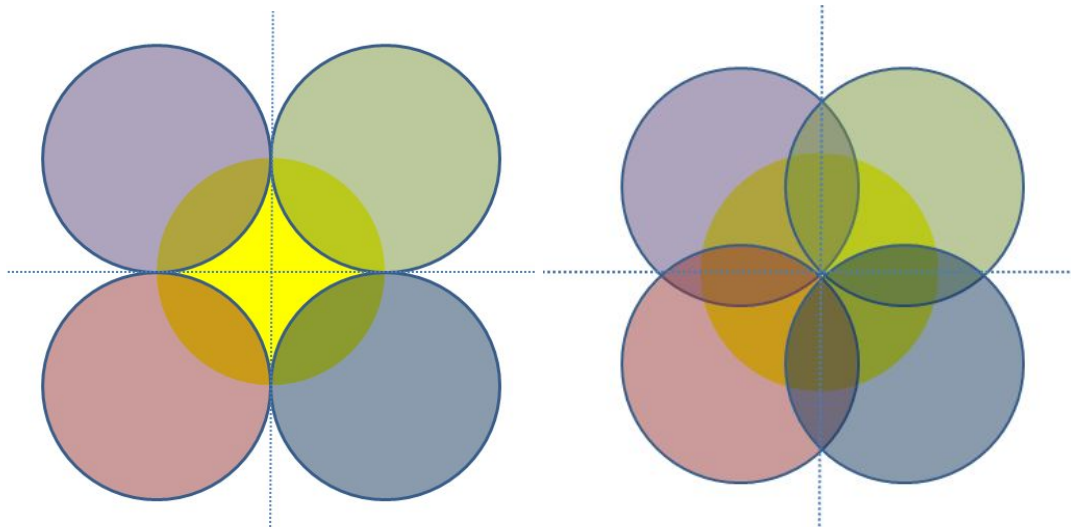Figur 10: The four perspectives depicted above to the left are each looking at residential lighting (yellow circle) from their own angle, while to the right a transformation of individual and shared knowledge allows the field of lighting to be better understood.

As reflected in the Figure 10 above, the different perspectives does not have a meeting point, or point of reference from which to depart from. They are all gravitating towards their common field of interest, the light, while their knowledge boundaries push each other away. I propose a pragmatic and transdisciplinary approach, forcing/allowing the different communities of practice to share knowledge and challenge each other's entrenched ideals, while co-creating shared knowledge. This will not be easy as the creation of good residential lighting atmospheres is based on tacit knowledge according to Böhme.
This also emphasises the dichotomy between atmosphere based in tacit knowledge and design parameters taking departure in quantifiable measures.

Instead of me being the only critical researcher, trying to connect the knowledge stemming from different communities of practice as in the literature research, I will facilitate games for a heterogene group of communities of practice, letting them be each others critical researchers, exposing and questioning their own and each others strengths and weaknesses. On a quest to find the glue connecting communities across different practices, both a theoretical and methodological preparation was made, which is reflected in the following two chapters.

Chosen research theory

The theoretical framework provided in this subsection, is gathered to support transdisciplinary knowledge sharing and creation. The framework aims to create a meeting point in between the perspectives (Figure 10), and the corresponding communities of practice involved in residential lighting design, from which they can inspire each other and

create a novel value base for design of good residential lighting, and co-shaping of design criteria.

Taking a closer look at transdisciplinarity

For now we will take a closer look at disciplinarity, and will return to the meaning of the abbreviation trans after introduction of relevant theories on knowledge transferring, translation and transformation.

Disciplinarity refers to a specialisation in a certain community of practice, as architects, designers, anthropologists or engineers. "*So, as communities of practice are defined by their communal practice, they are likely to have communal know how developed from that practice. If shared know how or tacit knowledge make it possible to share know that or explicit knowledge effectively, then such communities, sharing common embedding circumstances, will also be effective at circulating explicit knowledge.*" (Brown & Deguid, 2001, p.p. 204-205). As Brown and Deguid mention above each discipline has certain implicit and explicit shared knowledge within their community of practice. While in the bundle of atmosphere shaping communities of practice is an emphasis on the tacit knowledge according to Böhme.

The specialisations in different communities of practice makes a startup as well as a big organisations effective and productive, because of its possibility to be specialised in a combined field of practice networks, instead of one person trying to manage everything at the same time.

But for this to be successful a coordination and understanding is needed between these communities of practice (Dorothy Leonard-Barton, 1995).

This can be managed in different ways, some more successful than others.

Research in organisational studies (Star & Griesemer; 1989, Carlile, 2002;2004) has shown that the use of boundary objects is used to facilitate successful communication between disciplines, allowing explicit and implicit knowledge sharing. So I will expand on this in the coming section while expanding on what is meant with trans, and how this connects with disciplinarity.

Boundary objects

Star and Griesemer studied the cooperation between researchers from different disciplines, both professional and amateurs, patrons, hired hands and administrators in their development of a natural history research museum.

A study of problem solving in complex institutional environments doing scientific work, and how constructive cooperation happened despite heterogeneity of "*social worlds*" amongst actors. Star's use of the term "*social worlds*" is probably from Strauss terminology in his sociology of academic practice, where social worlds "*indicates that practice does not only bind small, tight communities together. It also allows extensive academic disciplines, most of whose members will never know one another, to form and communicate*" (Brown & Deguid, 2001, p.p. 203). In other words "*social worlds*" can be seen as a parallel to "*communities of*

practice", where members of this community share practice, which allow them to communicate and share knowledge.

Through Star and Griesemer's inductive research they found that the before mentioned success was partly due to "*boundary objects*", which objective was to translate knowledge cross the knowledge boundaries between the heterogene communities of practice. (Ibid, 1989).

Star describes a boundary object as follows "*This is an analytic concept of those scientific objects which both inhabit several intersecting social worlds and satisfy the informational requirements of each of them*".(Star and Griesemer, 1989, p.p. 393).

So the boundary object should "inhabit" more communities of practice, and live up to their individual requirements for knowledge sharing, allowing knowledge to flow in between the combined communities.

And why is this so important? An example would be looking back at the literature study and the observation that these sources of knowledge all come from different communities of practice, creating separate views of lighting, in specific contexts and scientific standpoints. This is examples of communities of practice which has a hard time communicating and sharing knowledge, also in the light of the tacitness of their knowledge. And this knowledge boundary makes it hard to create a panoramic understanding of good residential lighting, while also making it hard for these different communities to inspire and help each others research.

Paul R. Carlile further elaborated and concretized Star and Griesemer's theory, by studying boundary objects in the context of new product development in the automobile industry (Ibid, 2002,2004). The product development context makes the theory more relatable to the subject of creating good residential lighting, while also the fact that Carlile in contrary to Star and Griesemer takes part in his study, makes it easier and more concrete relating to product development in residential lighting.

Over a year he followed and participated in transdisciplinary development work in the automobile industry with teams of engineers, designers and sales workers developing new car models. Categories of boundary objects, put forth by Star was adapted into the following understanding of knowledge boundaries, the corresponding boundary objects and their characteristics.

Type of Knowledge Boundary, Category, and Characteristics of Boundary Objects

Types of Knowledge Boundary	Categories of Boundary Objects	Characteristics of Boundary Objects
Syntactic	Repositories	Representing
Semantic	Standardized Forms and Methods	Representing and Learning
Pragmatic	Objects, Models, and Maps	Representing, Learning, and Transforming

Table 2 : Here is seen Carliles characterisation of knowledge boundaries, their corresponding boundary objects and their ends (from Carlile, 2002, p.p. 451).

In the following section I will expand on the boundary objects relating to Carlile's three different types of knowledge boundaries.

Syntactical

An example of repositories could be a lexicon (Star & Griesemer, 1989), through which sharing and accessing knowledge across a syntactic knowledge boundary helps problem solving (Carlile, 2002). This implies an understanding that the knowledge written in the lexicon is understood in the same way independent of the readers profession. In that way knowledge is "transferred" across a boundary, as a common syntax is believed being present. This approach can illuminate differences and dependencies between knowledge domains, and therefore show them "*unproblematic*" (Carlile, P R, 2004), but can shift to be ineffective if novelty is present at the boundary. In relation to residential lighting, an example of a syntactical boundary object could be the illuminance level of incandescent light bulbs, a shared knowledge where designer, producer and users can communicate the products intended illuminance level through the wattage of the bulb. While with the transition to LED light, wattage and illuminance does not correlate any more, and therefore novelty is present at the boundary.

Semantic

"*When new requirements and/or new actors are present, interpretive differences in what a word, measurement, or outcome means limits the effective management of knowledge between actors*" (Carlile, 2004, p.p. 556).
The semantic boundary emerges when novelty presents itself and changes former understanding of differences and dependencies between knowledge domains.
A semantic boundary object is then a standardized form or method to translate and learn about the interpretive differentiation (Carlile, 2002).
If this happens successfully and a new common knowledge is created there is a possibility that it leads to changes in a specific or several knowledge domains, which puts their knowledge "at stake" creating a new knowledge boundary.

pragmatic

As mentioned above
"*The transition from a semantic to a pragmatic boundary arises when the novelty presents results in different interests among actors that have to be resolved.*" (carlile, 2004,559)
The objective for the pragmatic boundary object is to negotiate and create understanding of the different interests among actors and facilitate creation of new common interests. Thereby a knowledge and interest transformation is made possible within each knowledge domain, and access and shareability of knowledge across the boundary is restored.(Carlile, 2004).
This means that a pragmatic approach is needed when a compromise of ideals and interests is unavoidable to solve the problem.
This occurs because knowledge is "*...not only localized but also invested within a given practice. Because knowledge takes investment—time and resources to acquire it should be*

seen as "at stake"..."(Carlile, 2004, p.p. 556). In the context of residential lighting design, this is seen in the lack of cooperation and understanding between the communities of practice adhering to either the functionalist, dwelling, sociocultural or atmosphere perspective.

According to Carlile the 3 levels of knowledge boundaries and the process of untangling and erasing them by the help of boundary objects, is a process iterating shared and specific knowledge through transfering,translating and transforming knowledge, visualised below in Figure 11.
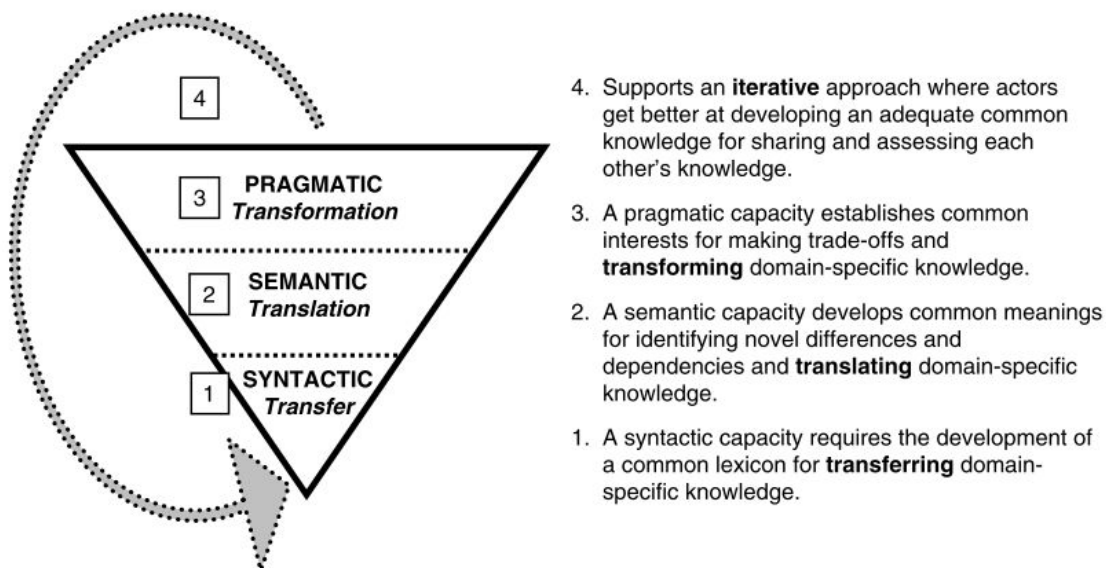
(Figure 11: Carlile's iterative process of knowledge boundaries and boundary objects , (From Carlile, 2004, p.p. 563).

Differences, Dependencies and Novelty

The main denominators across syntactic, semantic and pragmatic knowledge boundaries, is differences, dependencies and novelty. It is a catch 22 as a clarification of differences and dependencies is needed at knowledge boundaries, while novelty creates new differences and dependencies.

Differences

Difference refers to difference in accumulated knowledge, exemplified by the difference between novice and expert, and the difference of domain specific knowledge which is seen in specialization. A complex product often needs presence of different specialised problem solving knowledge, distributed with responsibilities and levels of responsibility (Carlile 2002). "*This in turn creates differences in levels of experience, terminologies, tools, and incentives that are unique to each specialized domain.... ...For this reason knowledge is not only localized but also invested within a given practice. Because knowledge takes investment—time and resources to acquire—it should be seen as "at stake," indicating the significant costs associated with giving it up and acquiring different knowledge* "(Carlile, 2004, p.p. 556).

Dependencies

Is here understood as the interrelation of different problems related to designing a new product, and the consequences of solving one domain specific problem, on another domain specific problem (Carlile, 2004). An example related to lighting could be the industrial designers aesthetical choice to create a "thin and compact lumiere design", which problematizes the product developers need for a large surface area for heat distribution from the lightsource.

Novelty

As mentioned in the description of a semantic boundary, novelty can be introduced by new requirements or new actors, and create interpretive difference of established common knowledge.

"A less-obvious source of novelty comes when an actor is unfamiliar with the common knowledge being used to represent the differences and dependencies between domain-specific knowledge. When novelty arises there is often a lack of common knowledge to adequately share and assess domain-specific knowledge at a boundary."(Carlile, 2004, p.p. 557)

Furthermore Carlile describes that

"...the most challenging aspect of the relational nature of knowledge at a boundary is that for each actor there is novelty to share with others and novelty to assess from others." (Carlile, 2004, p.p. 557)

Figure 12 below by Carlile illustrates the relation between novelty and the different knowledge boundaries.
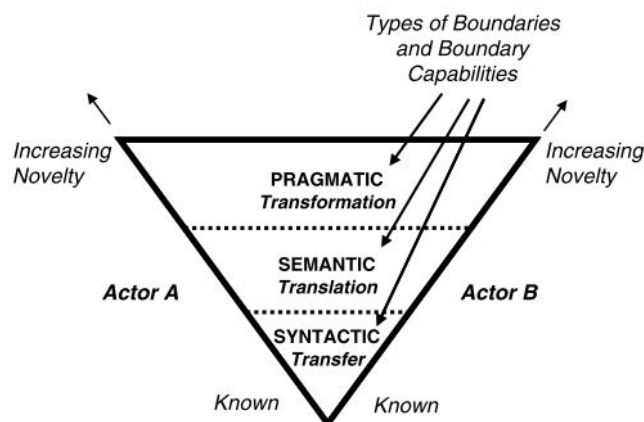
Figure 12: A visualisation of the interrelation between degree of novelty and category of boundary object used (Carlile, 2004, p. 558).

Pragmatism

The pragmatic view of a boundary is an understanding of knowledge boundaries in a political perspective taking departure in the work of Peirce (1898) and James (1907).
It is a search for the best solution to a problem.
John Dewey one of the early pragmatists related pragmatism to the political world, and societal relations. As he saw the world as being in constant conflict, he brought forward the look at things that we needed to express our differences for to find a pragmatic resolution to a given problem. An understanding that compromises needs to be created for a successful collaboration to find place, a transformation of knowledge, interests and practices.

Transformation

This leads back to where we started. In my understanding of transdisciplinarity, which is a pragmatic approach to ones own discipline, trans stands for transformation. Transdisciplinary means a discipline in transformation. Due to its relations with other disciplines in terms of knowledge, practices and interests, while being pragmatic as novelty changes the differences and dependencies amongst those disciplines, it is transformative. So transdisciplinary does not mean that everyone should have the same knowledge and become each others professions, as working in specialised disciplines is a key in our society. But instead it means that at a given time where novelty changes the boundary between two or more disciplines, an understanding, facilitated by boundary objects, of the implications which these changes will have in common knowledge but also in domain specific knowledge, common interests are negotiated and agreed upon, and this leads to transformation of the individual disciplines.

Transdisciplinarity, now seen in the light of pragmatism and knowledge boundaries, is the ability to see your profession as a processual iterating entity instead of a solid rock. It is the compromise you do with your idealistic view of your profession, by integrating knowledge and understanding from another discipline, because you have learned in the meeting of knowledge boundaries. You are willing to transfer and translate knowledge from other disciplines in spite of the time and work you have put into your knowledge and practice, and integrating it by transforming your own specific knowledge domain and practices.

The vision for this project is to gather different knowledge domains, specialised in solving different problems related to residential lighting, let these fields meet and aspire for these different communities of practice to challenge and transform each others idealistic and invested knowledge, and "stomach feelings" of how to do things right. I will not assume that this is an easy task. Aiming for a co-creation of a transdisciplinairy and pragmatic stance, and common knowledge from where novel design can develop. In the following chapter, I will integrate the displayed theory into a methodology, forming a strategy for the empirical research design.

Methodology

"transdisciplinary programs start with the issue or problem and, through the processes of problem solving, bring to bear the knowledge of those disciplines that contribute to a solution of resolution."
Richard Meeth's characterisation of transdisciplinary learning programs (Ibid, 1978, p.p. 10).

Taking a transdisciplinary and pragmatic departure in line with the problem based learning model (Knudstrup, M. 2004), the research question is asked:

How can we find out what good residential lighting is?

First of all we can ask for whom residential lighting should be good. The obvious answer is the residents of the house, it could also be Louis Poulsen or other organisations involved in producing residential lighting but that is another discussion.
Where is the residence situated and is good lighting created for a specific resident or a normative understanding of the resident ?
Who are "we" which create and decides what good residential lighting is, the users, the lighting designers, the lighting engineer ?

Due to the questions dependence on a heterogene field of different stakeholders and communities of knowledge, a heterogene ensemble of research techniques is proposed both using existing literature, interviews and design games as knowledge source.
As reflected in the literature review, researchers on the topic of good residential lighting, if including the atmosphere perspective "*are only at the end of the beginning*" (Boyce, 2004, p.p.291) . The atmosphere perspective, and the underlying notion of social, cultural and narrative co-shaped lighting environments needs more attention, and from this thesis perspective, a transdisciplinary and pragmatic attention. Aiming to clarify these notions, and possibly uncover new areas which needs attention when designing residential lighting, a deeper research into the field was initiated.
This resulted in a knowledge gathering by interviews with users and interviews and design games with the communities of practice involved in the creation of residential lighting.

Stakeholders for transdisciplinary knowledge creation

Who are "we" which create and decides what good residential lighting is, the users, the lighting designers, the lighting engineers ?
The choice of different knowledge domains represented in the empirical study was inspired by the literature review and the approach to design research by Koskinen et al.(2011), and the model for transdisciplinary knowledge innovation of Hansen, E. K. (ibid, 2014;2016).

Koskinen et al (2011) argues for constructive design research, which creates research in design, spread into different fields "the lab", "the field" and "the showroom". "The lab" referring to natural sciences, which in this context means psychology and phenomenology. It could be exemplified with de-contextualising design, and make it possible to isolate certain design parameters of a design through prototypes, so these features or parameters could be tested.
"The field" stems from field research, could be ethnographic observations, culture probing,following prototypes with users and has a social science perspective. "The showroom" is more in line with design and art and is showing/exhibiting a prototype, a concept, photos and videos, a way to show new ideas, and see how these are tried out in the imagination of visitors. "*Showroom is about exposing, debating, and reinterpreting problems and issues. Ambiguity and controversy belong to it, just as they belong to contemporary art.*"(Koskinen et al, 2011, p.p.103).

Ellen Hansen reinterprets these categories in her PhD (2014), where she inductively proposes a work model for creating new knowledge within different professions working together on the subject of architecture and light.

This model is interesting in its approach to creating new knowledge through what Ellen refers to as transdisciplinarity. She reificates "the lab", "the field" and "the showroom" into a natural science approach, a social science and the humanist/artist approach.

Triangulating her approach with my research question and literature study, makes me choose representatives from the professional field of engineering, anthropology, industrial-design and lighting-architecture as stakeholders.

Engineering as in product developers in the field of residential lighting, representing their knowledge and technical knowhow which goes into creating residential lighting fixtures. Typically representing a functionalist perspective.

Anthropology as in social scientists researching in the field of general and residential lighting, as a representation of the user and their practices. typically being agent for the atmosphere and socio cultural perspectives.

Industrial design as in industrial designers designing residential lighting fixtures, representing the artists relation to light as an object, and a source of light. Assumed to representing mostly atmospheric and dwelling perspectives.

Architecture as in lighting architects working with both sun and electrical light and its relation to the residential environment. A spatial sensational relation to light. Representing atmospheric and functionalist, but also dwelling perspectives.

Processual design of research method

In the work previously mentioned by Ellen Hansen (2014) she proposes the EX model, a model for creating transdisciplinary knowledge based design and design based knowledge, stemming from design research, innovation and knowledge management in organisations and practice theory. Furthermore her work is inspired by pragmatism and Carlile.
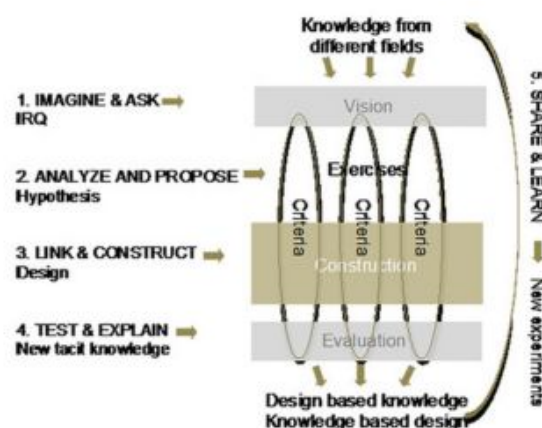
Figure 13: EX model (From Hansen, E. K. et al. 2016, p.p. 6)

The EX model was created from a case study in which a zero energy house was ideated, created and evaluated (Hansen, E. K., 2014) . A big project spanning over several years with organisational and economical support. I reframed this model into the context of creating ad-hoc networks were stakeholders should participate outside of their organisational contexts and with no economical support. Taking departure in Pierre Bordieu's expansion of the forms of capital (Ibid, 1986), into economic, social and cultural capital, the cultural and social benefits from joining these ad-hoc networks was promoted, while recruiting stakeholders.

In difference from the EX model's criteria created by the individual communities of practice, the proposed model lets the communities involved co-create the visions (instead of EX models criteria) in a pragmatic process, which is more in line with my definition of transdisciplinarity as stated in the theory section.

No specific methods were given in the EX model for how the different steps should be facilitated, but taking departure in the literature review and research theory the method was clarified and transformed to the purpose of the thesis.

Going back to Star's discussion of the development of the natural historical research museum, she described the different visions brought forward by each "*social world*" or group of stakeholders, and in the following quote she describes the roadmap to meet the goal of the museum.

"The worlds listed above have both commonalities and differences. To meet the scientific goal of the museum, the trick of translation required two things: first, developing, teaching and enforcing a clear set of methods to "discipline" the information obtained by collectors, trappers and other non-scientists; and generating a series of boundary objects which would maximize both the autonomy and communication between worlds." (Star, 1989, p.p. 404). Translating this into a roadmap for the design of my research method resulted in first establishing an understanding of the knowledge domain and practice of the different stakeholders and their visions for good residential lighting, by interviewing them individually. Then taking Carliles concepts of difference, dependency and novelty and the syntactical need to create a common language for the stakeholders to share their knowledge and visions, and creating a semantic for them to have a common interpretation of the given syntax. This asking at least for a syntactic and semantic boundary object to device this process.

A pragmatic approach to design games, a method for transdisciplinary enquiry

In "Facilitating Collaboration through Design Games" Eva Brandt and Jörn Messeter argues that design games, stemming from participatory design, is the solution to the following problem
"In recent years both companies and research communities call for collaborative work practices and user-centered approaches in various design fields. There are several challenges and issues to take into consideration. For instance there is a need to find ways of collaborating across various competences, interests, responsibilities and perhaps

professional languages both within one organization, between several organizations and between the organizations and a group of (potential) users."(ibid,2004, p.p.121).

This is a strong argument for using the design games as the method for deviceing the above stated process. Brand and Messeter explains that

"The overall aim of the design games is to help facilitate a user-centered design process for cross-disciplinary design groups early in the design process. Framing collaborative design activities in a game format, arguably improves idea generation and communication between stakeholders. " (Ibid, 2004, p.p. 121).

Furthermore they ensure that the frame of design games are improving communication and ideation in a joint venture of different communities of practice.

"By shifting focus to the game, power relations and other factors that might hamper idea generation, are downplayed." (Ibid, 2004, p.p. 121)

Though the last statement of downplaying power relations is in contrast to the proposed theoretical pragmatic framework in this thesis. Furthermore Brandt postulates

"Design games are not an arena for negotiation and compromise. In the playful dramaturgy of design games politics of negotiation are postponed. Instead, a level ground of co-creation is nurtured, making both designers and users true participants in what can be called a participatory inquiry." (Brandt et al. 2008, p.p. 129).

This is questioned by Per Ehn which in "Participating in design things" takes one of the early pragmatist John Dewey as a corner stone to reflects on design games and participatory design. John Dewey argued that the public is characterized by heterogeneity and conflict. (Dewey, J. 1927).

"It maybe challenging enough to design for, by and with communities-of-practice in entangled design-games where common social objectives are already established, institutionalized or at least within reasonable reach. Social communities supported by relatively stable infrastructures. But the really demanding challenge is to design where no such consensus seems to be within immediate reach, where no social community exists. In short, where a political community, a public characterized by heterogeneity and difference with no shared object of design, is in need of a platform or infrastructure. Not necessary to solve conflicts, but to constructively deal with disagreements - public controversial things where heterogeneous design-games can unfold and actors engage in alignments of their conflicting objects of design. Participation in the making of such things stands out as the ultimate challenge for professional design." (Ehn, P, 2008, p.p. 100)

This argues for using the framework of the design game, while taking the theory of Star and Carlile in as informers, to allow the design game to be a pragmatic and transdisciplinary space for negotiation and politics as well, an approach inspired by the work of Hansen, P. R. put forth in "Political processes in participatory business model design games".

Brandt et al propose the following framing of a participatory design game

- *"A diverse group of players are gathered around a collaborative activity guided by simple and explicit rules, assigned roles and supported by pre-defined gaming materials.*
- *The game materials typically point to either or both existing practices and future possibilities.*

- *The games are played within a confined and shared temporal and spatial setting often removed from the everyday context of the players.*
- *The purpose of the game is to establish and explore novel configurations of the game materials and the present and future practices to which these materials point.*
- *At the end of the game, the players will have produced representations of one or more possible design options."*
(Brandt et al. 2008, p.p.54)

Design games for envisioning and mocking up residential lighting

Taking all these reflections into consideration a serie of 2 design games was put forth.
The first called "visions for good residential lighting" inspired by "the landscape game" of Brandt et al.(2008), taking departure in the visions delivered in the analysis of the interviews. From each of the 4 interviews 5 visions for good residential lighting was extracted, giving 20 visions, from which the 4 participants should evaluate which 4 was the most important.
The visions and the knowledge each of them represent was put "*at stake*" (Brandt et al, 2008 p.p. 61) in the design game, which worked as a negotiation and evaluation game of visions for good residential lighting. Meanwhile creating and understanding of differences and dependencies, while "*the most challenging aspect of the relational nature of knowledge at a boundary is that for each actor there is novelty to share with others and novelty to assess from others*".(Carlile, 2004, p.p. 557).

The second game called "mocking up good residential lighting" was informed by the 4 visions from the previous game and used them as obstructions for design ideation.
The use of obstructions was inspired by Brandt and Messeter which says that studies in creativity shows that obstructions and restrictions in ideation processes can improve the outcome. Which they have found the rules of design games very positive in terms of ideation.(Brand and Messeter, 2004).

Procedural steps

The design of the research method, combining the EX model with methods of design games by Brandt et al. and theory from Star, Carlile and Ehn results in following procedural steps

- Step 1 is the research question "What is good residential lighting?", which can be understood and interpreted across the different disciplines.
- Step 2 Is the "Vision game for good residential lighting", with its preliminary interview face informing the game and its participators, to create visions (instead of criterias)
- Step 3 is "Mocking up good residential lighting", where the visions is used as a frame for product ideation, resulting in design criteria.

- Step 4 The visions are evaluated through step 3 by participators, and is as well evaluated in the analysis thereof.
- Step 5 Sharing and learning is happening through this thesis.

Practicalities

The empirical research took place in February 2017 and from July to September 2017 and consisted both of interviews (Spradley, 1979) and design games (Brandt, E 2004; Hansen, P 2016).

Semistructured interviews was conducted in Copenhagen with 3 lighting users in their homes. And 4 interviews was conducted with the four informants participating in the first game, representing their specific knowledge domains of either industrial design, architecture, anthropology or engineering.

Taking departure in Spradleys (1979) ethnographic interview I interviewed both users and experts in the field of residential lighting. Spradley writes

"*Using the ethnographic approach, I set out to study men who had lived long years on skid row. I listened, watched, and allowed these men to become my teachers. I discovered a complex culture that gave shape and meaning to the lives of men who most people wrote off as "derelects"* (Spradley, J; 1979;p.p. iiv). This approach to interview was chosen, because of its transdisciplinary nature. An investigative curiosity, allowing others to become your teachers. Qualitative data collection stemming from the interpretive paradigm.

The 3 lighting users were chosen because of their differences in age, their different levels of interest in lighting and their apartments difference in incident light from the sun.

By using guided grand tour questions (Spradley, 1979, p.p. 87), the informants walked through their daily routines and practices including residential lighting, from waking up to going to sleep. These opening up to more intuitive questions, mini tour questions and structural questions.

The 4 informants participating in the first game, was prior to the game individually interviewed, regarding their understanding of good residential lighting, and how they approached the subject in their profession. Furthermore it was also to understand which knowledge and assumptions each of their views contained, and to inform the coming design game, to create an arena for these different viewpoints to meet.

The data from the interviews was collected both by taking notes and audio recording, which were transcribed.

The vision game participators was found matching the 4 different communities of practice mentioned earlier.   A thorough description of the vision game gameplay is displayed in the following chapter, research context.

The vision game was video recorded transcribed and visually reconstructed, for in depth analysis.

Due to practical difficulties, a new team was assembled for the mock up game. As for the previous game they all matched the 4 communities of practice, while also representing the same vision as their former community of practice representative.

The mock-up game was video recorded and directly coded and analysed from the video. Furthermore the participants created notes while analysing different kitchens and ideating, which also took part of the empirical body for analysis. In all cases NVivo11 was the tool for these tasks.

Material

The material in itself is interesting in its qualitative measures.

Both investigating the experts by interviewing them one on one, and in a group constellation, is contributing to the understanding of use of knowledge and sharing of knowledge in question of group dynamics, and transdisciplinarity.

Also the use of an abstract linguistic boundary object in one design game, and a material boundary object in another, makes it possible to look closer on factors connecting practices and boundary objects in a transdisciplinary context.

The 2 design games was intentionally made with 2 different atmospheres in mind. The first was competitive and conflict oriented, while the next was focused on a co-creative spirit. This combined with the shift of participators from the first game to the second made observations possible of participators in design games, and their receptiveness to other participators knowledge and inputs, depending of game structure and setting.

In the first game, visions from the interviews with the different experts was translated into the first game, and in-game explained from each experts point of view. In this way an ongoing sencemaking was allowed. The concluding visions from the first game was translated into design defining visions in the second game, and was subject for reinterpretation as it was not the same group using them as creating them. Observations is thereby made possible of differences between the 2 approaches of either continually building visions, or being "served" visions, and the possible difference in ownership.

You could question if the different communities of practice was represented in the same way throughout game one and two, due to the shift of cast. From an objective functionalistic perspective you could say that this was not the case, while from the more interpretive perspective the questioning is legitimate.

Research context and analysis

In this chapter the research context will be presented and analysed chronologically following the procedural steps of the research design method. First the vision game as a transdisciplinary inquiry into the future value base for design criteria is presented. Then followed by an analysis thereof which partly informs the following mock up game using the values in a pragmatic design game approach to create design criteria, which is analysed and evaluated.

Introduction to stakeholders

Interviews was the introduction to the stakeholders and their domain specific knowledge into the project, as well as a test of their ability to contribute to the vision game. Furthermore the interviews informed the structure and facilitation of the game, connecting stakeholders, theory and methods. How could they fit in a transdisciplinary ad-hoc setting to innovate a pragmatic resolution of visions for good residential lighting?
Stakeholders are presented in the same chronological order as they were introduced to the project.

Light architect **Pia Stautz** design lighting solutions that people enjoy living and working in, with a focus on function, story-telling and well-being.
Pia has more than 20 years experience in the field, working both in big organisations, lately as independent light architect, now as a partner in Lightscapes. Amongst many projects she has designed the light at Nimb (Tivoli), D'angleterre and various private homes. She represents the atmosphere and functionalist perspective.

Øivind Slaatto is a designer inspired by nature, and a philosophy of thinking by doing, and keeping things simple with a human touch.
Since he graduated in 2008 as industrial designer he has amongst many things designed Beoplay A9, Beosound Shape and lamps SWIRL, Patera and Spaces.
He represents mainly the atmospheric and dwelling perspectives.

Nuno Neto has been working professionally in the field of lighting applications over the last 15 years. He has worked in R&D of led lighting, with lighting design for shows, architecture and performances, and is currently working as product developer and manager for &tradition, developing Luminaries. Nuno holds a master in light engineering and lighting design.
He represents partly the functionalist and dwelling perspectives.

Mikkel Bille works in the field of anthropology, and his research is in human practices and thoughts with and about material things. He has a special interest in the way architecture and spaces are formed through sensations and cultural conceptions.
In relation to light he has published many articles on the subject of residential lighting, lighting atmospheres both in Denmark and Jordan, and research in "hyggebelysning" , all based on dozens of qualitative interviews and observations. Mikkel is associate professor at RUC and holds a phd. in anthropology. He represents the atmospheric, social and cultural perspectives.

I brought them together with the objective to create visions for good residential lighting. But I assume that their motivation, besides from being very friendly and helpful to me and my thesis project, was meeting other established professionals working in the field of residential lighting, but from another community of practice. I assumed there was a curious wish for learning, so in the invitation letter the description of participators seen above was included, letting them know who was the other participators (see full invitation letter in Appendix I). The individual value and vision proposals from the different interviews can be found in Appendix II.

The vision game

The vision game was a prioritization and negotiation game, with knowledge at stake, and new knowledge to win. But to win new knowledge you probably have to compromise you own hard won and embedded, localised and invested knowledge (Carlile, 2002). This game was about good residential lighting in general, with no location in the home, or on the globe geographically as a factor. So defining visions for good residential lighting in general. The game was played out at Øivind Slaatto's design studio, on the 3rd of August from 1730-19.

Figure 14. The visions before the participators picks their three main priorities. Photo by Frederik Pors Jakobsen

The game play, rules and procedural steps is explained in the following Table 3.

Game Play phase	Explanation of phase
Introduction	First the players was introduction to rules and stages of the game
Choosing visions	By turn taking players picked their 1,2 and 3 priorities amongst the visions (se Figure 14)
Explain discarded visions	The players explained by turntaking, why they had not chosen the leftover discarded visions
Introduction of gameboard	See Figure 15 underneath this table
Main game	By turntaking the players introduced and argued for their first priorities, while the other players scored the vision on a scale from 1-5: 1:Disagree 2: Disagree partly 3:Neutral 4:Agree partly 5: Agree fully

	Following by turntaking the other players argued for their scoring, creating discussion around the presented vision. This was following done for 2nd and 3rd priorities as well.
Discard vision	By turntaking players was asked to discard a vision from the gameboard and argue for their choice.
Level up vision	By turntaking players was allowed to move one vision on the gameboard up into the vacant gamefields, and argue for their choice.
End of game	Unframed discussions on the topic followed

Table 3: Game rules and gameplay steps.

Figure 15. The circular gameboard is here seen, with its 4 fields representing each player, the three concentric circles is 1st, 2nd and 3rd priority counting from centre an out. On the gameboard edge is marked 5 fields from - to +, showing the scale 1:Disagree 2: Disagree partly 3:Neutral 4:Agree partly 5: Agree fully. The candle lights is the scoring marker. The picture is taken in between the game phase discard vision and level up vision.

The four visions as seen in Figure 15 were the 1st priorities from each player, and these are the visions which will be guiding the next design game.

Figure 16 : The main visions from "Visions for good residential lighting".
These visions was statements with room for many interpretations, so following I will introduce the different explanations and discussions around each of them.

Good residential lighting is something we do

Was Mikkel Billes first priority.
The group scoring which is explained and exemplified in Figure 15, was for this vision:
Mikkel (m) 5, Pia (p) 4 (moved 3 to 4), Nuno (n) 4, Øivind (ø) 4 (moved from neutral 3 to 4 after his own argumentation).
Mikkel explains
"*I think first of all that lighting is something we do... It is a continuous practice of attuning the space to the kind of mood or emotion you want to be in.*"(All the quotes from the vision game can be found in Appendix III).
And later he continous:
"*good residential lighting is something we do, because the home is the place where we are allowed to be our self that is where we can determine how we want it there. It should not be determined for us, but it also means at certain times of day we want something in particular. We may for instance, when I get up at night, I don't want to turn on the light, because it would wake up my kids, so lighting is something I do, it is associated with the point in time where I use it. So it is something that allows us to see on the one hand, but it is also something that allows us to feel. So when we get home, sit down, light a candle to remind us to relax, because now we are not at work anymore, it is a practice more than it is about visuality. I would say we continuously do lighting at home.*"
Pia agrees and explains:

"*I agree, because it is all about creating the atmosphere that you feel like in the moment, and that depends on the day you had, the light outside, øhm if you feel happy or sad, who you are with. So I agree with you. But I think there is also some technical things to it. Things that we know influence our brains and stuff like that.*"

We see that both Mikkel and Pia relates to the emotional relation to the doing of light, while Pia also brings forth that our biology also has a relation to good residential lighting. A good axis for later discussions between emotion and biological needs can be seen here.

Both Pia and Nuno agrees on the biological perspective while Øivind has some critics for this understanding.

Øivinds counter argument is "*for me the best lighting is simply the sunlight. And I know I'm a fundamentalist but I really just like to go to bed when it gets dark, and get up when it gets light and then you don't have so much influence on.. you don't do the lighting.. you follow the light in a way. And this is for me the best light, and I know it is not possible in a modern world..*"

Øivinds argument is also reflected in the user studies, where an informant told that he was awake when the sun was up, and slept when the sun was down. His circadian clock was that well functioning that he did not need an alarm clock, he woke up by himself.

Øivinds argument also marks one of the key discrepancies alike Pias comment on biology. While Slaatto focus on the difference between seeing light as something you do, and something you follow. I suggest this as a good axis for creating discussions for good residential lighting, creating pragmatic solutions between the involved actors. So this I will further introduce in game number 2, also in relation to Burrel and Morgans paradigms, on the relation between subject object, and order conflict.

Øivinds argument can be seen as a relating to nature and the dwelling perspective, while Bille also in his second argumentation puts emphasis on his cultural approach, by saying that in our home "*it should not be determined for us*". This could both be related to nature but also to let us say workplace norms for lighting, or the choice of light installations.

Good residential lighting is variable

Was Pias first priority:
Group scoring: p 5 n 5 ø 5 m 3
Pia argues that good residential lighting is variable: "*Because you put up different lighting fixtures in the room, your living room for instance. And because of the change of the sunlight outside and what time it is during the year. And again how you feel you have to be able to change how much light, which one of your lamps you would want to put on. If you want to have light all over your room or if you want to have intimate light just around you. And you have to be able to change the light all the time, depending on how you fell, or the function that you need. If you have to work or if you have to look at tv, reading a book, talking to people. So it has to be variable.*"

For example this can both be seen in varying the light intensity, having more light fixtures in a room, or being able to change between light only around me, or the whole room.

While Øivind and Nuno agrees, Mikkel is counter arguing in his answer to Pia`s vision:

"I agree of course, the only thing I have is this somewhat, I would almost call it, ethnocentric way of illuminating residential homes that simply has the premise that we have multiple light sources, and that is the good lighting. Whereas most of African homes and Middle eastern homes, and probably might even Chinese homes, they have one light bulb, because they need to see and that is what makes sense. In that way it is not so variable, but on the other hand outside light is also variable and changes, so you now I could put it (the voting light) anywhere here. I do not fully agree, but anywhere here (in between 2-4)."

So with this comment Bille relates to the geographical and cultural context of the vision, where as he also makes the cultural slutning that African, Middle East and probably Chinese homes have different residential lighting preferences. In the light of the different sensemaking tools introduced in the literature perspective, looking at Billes statement can be seen as the developing countries light preferences relies solely on the lower part of Boyce model Figure 1, the visual performance, while Danish lighting preferences are more atmospheric. In that light I see the cultural difference more as a cultural difference of either adhering to the functionalist perspective of good lighting, meaning human performance, while the Danish culture as an example of an aesthetic economy, meaning atmosphere. Thereby making it more a paradigme discussion than a aesthetic opposition.

Later in Pias answer relation to the vision "Good residential lighting supports functionality" she mentions variability:

" When I do lighting projects, I always look at the function and then I find the right light to support that function. And if there is different kind of functions, I have variable lighting."

Later Mikkel Bille takes his third priority:
"In Northern European homes, residents, I think "good residential lighting is a symphony of different light sources" in Northern Scandinavia", which had the group scoring: m 5 p 5 n 5 ø 5.
Pia totally agrees on this and, says it is the same thing as her first priority (variable)
Which both Nuno and Mikkel agrees upon, while Øivind expands
"This is the lighting philosophy of Louis Poulsen and Poul Henningsen and I totally agree."
When I asked if Pia wanted to change her "variable" with "symphony", she says no and explains:
"Because light sources sometimes is no good to put different light sources together, that depends on which kind of light sources and what kind of temperature these light sources have and this is kind of different technical things, I think this one covers more."
So a relation between lamps and their temperature is argued for.

This makes the vision embrace light sources instead of light fixtures, meaning that it is the relation between the sources of light which must be emphasised in this vision, and also seeing the sunlight as a lightsource in this perspective.
Mikkel Bille also makes a point in stating that this is good light in Northern Europe.
And in that geographical and cultural context it seems as if they have a better understanding of each other.

Good residential lighting is universal

This was Nunos first priority.

Group scoring: n 5 ø 4 m 1 p 5.
"*Nuno:Because as I have referred many times, all our lighting is based on sunlight, our body programming and our brain programming, it is based on sunlight. And light is quite an important aspect on it, and light includes many different things from science, that it is not even totally developed. Even the doctors doesn't even exactly know what are the.. they know about the circadian rhythms, but they don't know exactly what is the color spectrum that is harmful for you. They are starting to have a grasp of it, fx and then they have the statical part of it, so I think light is quite universal. And we need to know more.*"
Nuno puts emphasis on science and facts for good residential lighting, about living in light which supports the human bodies biological health relation to the sun. So he puts a functionalist biomechanical perspective forward.

Øivind in terms of biology takes a more soft holistic angle to the subject. And then moves into a more political and cultural talk about difference in lighting in Scandinavia and Vietnam.
"*ØIVIND:… light is basically based on the sun, and and and the sun øhm is in the solar system, the toneangivende, the dominating everything, and when the sun is gone you try to limit - imitate it and I know that there is very different perceptions of light in Scandinavia and Vietnam and all this. So in this way what is good for us in Denmark is not always good for people in Vietnam or Asia. I would now actually dare, and there are many many reasons for this, most of them is, in Vietnam one room will be used as a kitchen and a living room and a playground and a mechanic to fix the scooter, and we have four generations in the same room simultaneously, while in Denmark or Scandinavia you have, one corner only to read a book, and this table is to make homework and to cook and bla bla bla. So we want to variate very much, where they want one light bulb for everything, so this is against it is universal, but for us it is not the same as for them. But I would also say that some of, what I think is bad lighting in Asia is actually because of, this really sounds racist, but it comes from a lack of culture actually. And we can see the old Japanese house they have a beautiful use of light, but when the Americans came in with the super capitalism they destroyed everything with the fluorescent light bulb, and I think this will change, but I think it´s caused by a destroyed culture.*"

This can also be seen in a commodity perspective, where the "american" functionalist culture takes over and destroys a dwelling valued culture.

In relation to Nunos biological claim, that good residential light is universal Mikkel agrees:
"*In terms of biology there is good light and in terms of technology, but we are talking about residential lighting, and I think that residence is a place where you have emotion, it's a place you have social life and so on, and as you just illustrated that residence has very different kinds of ways. It looks very different, different places so therefore a good residential lighting in Denmark is very different to other places in the world. So I agree if we are not talking about residential lighting.*"

In general lighting Bille can agree to Nunos functionalist biomechanical perspective, but in terms of an emotional social human perspective he does not agree to universality.

Pia partly agree to the biomechanical claim that good light is universal
"*Cause I think that there is just one sun for all of us, doesn't really matter where we live, and good lighting is for me the light which has the same kind of øhm, how to say color spectrum, there is no light which has exactly the same, but as closer it gets the better. So that is why I think it is universal because there is just one sun.*"
For her this vision means a very specific thing, that the light should have the same color spectrum as the sun.
This is a circulating conflict going through the different visions, a discussion between which of functionalistl, dwelling or cultural values should have the biggest emphasis when designing residential lighting. As mentioned earlier, a conflict in between light is something you do, or light is something you follow.

Nuno makes a counter argument later for his choice, when talking about Øivinds 2nd priority "Good residential lighting supports our biological needs", with group scoring ø 5 m 5 p 5 n 5.

" *if you only follow this one (biologically needs) you might end up as the Danish standard guys. They put up this spreadsheet, has to be biological and no matter what situation you are looking at*"
In this argument an earlier agreement around the discarded vision "Good residential lighting is following Danish Standard", was reflected, where all players agreed that these standards were ridicule.
So he also asks for a flexibility of how to follow biological scientific proven relations to light, in relation to which situation the lighting is set for.

In Øivinds argument for his 2nd priority he mentions the misuse of light, in its relation to biology:
"*We want to switch a morning on as much as possible. To get as much production as possible, but the consequence is that people they get sick. And in the long term I do not think it is the best investment. And if you kind of supporting the biological needs by mimicking sunlight. I know we can't do it exactly, and we should also respect, that we can't only have 5 hours light in the winter. So we can make it longer, but by mimicking the sun we will get much better sleep, and the efficiency will go up and the well being will go up so that is why it is very important to support, especially in the north.*"
He argues for a dwelling health perspective with focus on a lighting setup relating to the sun, rather than a functionalist perspective on how we can be most effective in terms of using light to increase alertness. Thereby arguing for that technology should be determined by nature, rather than technology in the name of "economical growth" should make us as humans independent from nature.

Good residential lighting supports functionality

Was the 1st priority of Øivind Slaatto. Group scoring: ø 5 m 5 p 5 n 5

In the choosing round, functionality was not chosen, until the participants should argue for why they did not choose this vision, the Øivind Slaatto changed it for his "Does not need instructions", and later he put it as his first priority.

Mikkel starts with asking me

"Mikkel: what do you mean by functionality?

Frederik: It could be , it could support me in the function of cutting out vegetables in my kitchen. Or it could be the functionality of reading a book fx.

Mikkel: so everything we do is functionality, so good lighting is about shaping a social space here. so that would also be a functionality. so if it in that case I would say yes. if good lighting is supporting what it is we want to do.

ØIVIND:

if you are in a bar fx, øh then a candle is a really functional lighting, because it makes you look beautiful. you can't see how horrible people look so then I would say it is more functional than a fluorescent light bulb, or something like this (points towards his own lamp hanging over the table).

MIKKEL:

it was just to be sure that supports functionality means that if there is a place down here where we don't want the juvenile delinquent to be standing and making a fuzz, we can also in what we otherwise would call "bad lighting" but that is then good lighting because it removes the anti-social behavior and in that sense it supports functionality, but it is seen from the sort of government municipality point of view, not the users point of view. so it supports …xxxx.. (can't understand the word).

FREDERIK:

And you (to pia)

PIA:

yeah, we can also use good lighting to move people away.

But definitely it's the most important in lighting it supports functionality and functionality could be an atmosphere but it is also when you are cutting your vegetables in the kitchen. and when you have to look at things, so you have the right 3 dimensional view yeah.

FREDERIK:

so it is not in line with, it is not as important as these (points at the cards she already has)

PIA:

øhm I think it , I think the three of them is a part of that one (the 3 she has chosen "creates atmosphere", is variable", "does not blind you" is a part of "supports functionality").

FREDERIK:

ok. so this is like overarching over all of those.

NUNO:

yeah it is pretty much the same. good lighting should for each function each purpose, should support its purpose. it's a very important definition of what.. but again all the others are included in it

Later when Øivind presented the vision he said:

ØIVIND:

Good lighting supports functionality, sometimes is to look good, so candle is better than spotlight, and sometimes functionality is that you need to see all the details, if you are a

doctor you really need to know where to cut, so you really need some clear light. so it should support functionality but what is very very important is to understand functionality is many different things, it should not only be calculated on a excel ark, but you need the cultural, situation need to..
PIA:
I totally agree. when I do lighting projects, I always look at the function and then I find the right light to support that function. and if there is different kind of functions I have variable lighting.

Pia:
"it's the most important in lighting it supports functionality and functionality could be an atmosphere but it is also when you are cutting your vegetables on the kitchen. and when you have to look at things, so you have the right 3 dimensional view."
So what comes to my mind, which Mikkel also express, if functionality is all we do, then what is the difference between, "good residential lighting is something we do", and "good residential lighting supports functionality"? (p: gentagelser! Jeg har læst det før!)

What is emphasised by Pia and Øivind is that Functionality is supporting a situation, it has an active purpose in relation to a given function. I want to read my book, I want to cut vegetables, I want to look good. I want to create this atmosphere. It is more that light is serving a purpose. You can say that this is more practical physical related than "something we do" which is more emotional, psychological. It is more a tool, than a music instrument.
It is hard to clearly find out what is meant by this vision, as it was not mentioned much in the game, and therefore its distinction from "good lighting is something we do" is hard to define. As they all totally agree on this, but from their different perspectives. Mikkel is agreeing on it from an atmospheric perspective, Pia from a functional spacial perspective, Øivind and Nuno from a more technical lighting perspective where the light serves a certain purpose. As Nuno comments
" yeah I agree, I think It's because we are all in the lighting field , because we are thinking a function that the light is doing for that purpose. It's about thinking in lighting."
The thing is that they all have different understandings of the lights purpose. You could say that the semantic diversity is big for this vision.

Analysing vision game

The visions identified was summed up and reflected with an icon, and put in the invitation letter for the following design game . As a semantic boundary object translating knowledge from the vision game, and into "mocking up good residential lighting", aspiring to become a pragmatic boundary object, transforming knowledge of the participants in the coming game.

The 4 visions

Good residential lighting is something we do

Our home is the place where we allow ourselves to be ourselves. That is where we can decide how we want it. The light should not be chosen for us. We choose ourselves. That also means that at different times of the day,we would like something specific. On the one side residential lighting allows us to see, but it is also something that allows us to feel. For example, when I get home from work, and light a candle to remind me that now I can relax. So it's a practice more than it is to see something. Light at home reproduces your practice and feelings.

Good residential lighting is variable

Because we put more light sources in each room and because the sunlight changes in relation to time of day and year.
Therefore, we must be able to vary how much light there is and where it is so we can change the light set, from a full lit room to intimate light just around us. You can vary the light in the room depending on what you want to use the room and light for,and what mood you are in. If you have to work, watch TV, read a book, talk to people. So it has to be variable.

Good residential lighting is healing

The essential lightsource is the sun, and our body and brain are evolutionary programed in relation to that source. Hence good residential lighting supports our biological dependence of the sun. We spend 90% of our time indoor in Denmark, and if the indoor light sources does not resemble the light of the sun, it can adversely affect our health and psyche. For example luminous blue light in schools kan affect activity and learning level, while exposure to the the same light in the morning or evening can change your sleeping rhythm.

Good residential lighting supports functionality

Because candle lights are better than spots for a romantic dinner, because the soft light makes your date more beautiful. While a focused sharp light, for example can be useful for needlework and reading. Functionality is many things, not only technical, functional lighting can also be cozy lighting.

Theoretical and methodological (Re-)reflections on gameplay

Iterating from "visions for good residential lighting" to "mocking up good residential lighting".

Did the game work as a boundary object?
Evaluating the game, I found that the players did not really find compromises, there was a lot of defending your own argument.This shows a lack of pragmatic reliability in between the participators, and questions if the game setup in itself did not support this.

There was a big difference in how much the different participators contributed with their knowledge. Looking at the raw word count data
Bille spoke   61 times using 2306 words
Øivind spoke   59 times using 3532 words
Pia spoke   48 times using 1602 words
Nuno spoke   37 times using 1749 words

This supports my intuition from the game, which was that the game worked as an expression facilitator for Bille and Øivind, but not for Pia and Nuno. Billes professions practice of expression is with words, written or spoken. While Øivind also is used to speak in public, but more in the reason of being a public known person in the design world while his work practices, is more around expression as drawing, cad work, and building prototypes. Pia and Nuno talked less and participated less and it could be in relation to the the design game as an abstract boundary object as it was centered around discussion, which is not that represented in their normal work practice. In that way you could say that Bille was in favor of the others. So this argues for a more tangible and concrete boundary object for the next game.
In question of Pia`s involvement it could also be a question of the game being in English, as she mentioned before the game that she would have preferred if it was in Danish.
Referring to Carlile's note on common knowledge "*A common knowledge could be the use of the English language by actors to communicate and collaborate or more specifically the use of a prototyping methodology*"(Carlile, 2004, p.p. 557). This argues for changing the game language to Danish in the next game.

Localised, embedded and invested

Another evaluation point on the game as a boundary object is that knowledge is localised embedded and invested in practice, and it seemed that the global context of residential lighting did not serve as connecting the knowledge domains of the different participators. It seemed as Bille related his arguments to a global multi cultural context as he practices his profession more global, while the other participators took departure in the Scandinavian lighting environment, as that is where their practices are localised.

So a note for the next game would be that to make a meeting point in between the different professions practices. I need to take a certain geographical and cultural location where all four practice their professions, as knowledge is localised. Going from global to local, for obvious reasons I pick Copenhagen, Denmark as cultural and geographical meeting point. Another thing that inspired this decision was a postgame email correspondence with Mikkel Bille, where he explained

"*I found it interesting that questions on "good residential lighting" all the time became to good light in general, as if the good light in your residency is the same as good light for the workspace or public spaces. In relation to what lighting is practiced, I do not buy any of the comments made. Residential circadian lighting would mean a big amount of red light on a winters night, when you are cooking, and I don't believe that others also would think that it is good light for the task.*" (Own translation of mail).

This was a great argument for choosing a very specific location for the next design game.

Furthermore in question of letting knowledge flow more easily between actors, the boundary object should relate to their practice, so their tacit knowledge and know how can be expressed and shared.

The only boundary object where all their practices could be expressed in was…. a home.

It was as if I have had such a great focus on my search for good residential lighting, that I had forgot about the residence.. So the boundary object for the next design game was chosen to be a home.

Furthering the choice of localisation was to choose the kitchen as it is a room in the home which reflects a lot of different practices, and it is also the room which has evolved the most over the last decades, from being the workplace of the house mother, to now being a hangout, a workplace, a living room etc. in that way it is a room which points into new possibilities.

Relation to users

At the same time there also was a reflection about the participators different relations to users. And I wished for the user to be more connected into the game (participatory design games) and how these should be related to in matter of design. Bille which in some way was actively chosen as a participator representing the user, meant that you should take departure in the users practices and knowledge of light, and thereby let a normative understanding of the residential lighting user be the denominator for a design solution for good residential lighting.

While Pia and Nuno moreover meant that the user needed to be educated.As she mentions about lighting users

"something I just think they do not know better if they got that only bulb in the middle of the room, or maybe they don't have possibilities to have other light fixtures. but I think they could be much more happy with more light fixtures if they could chose that. and I think it is just a habit that they just put that one".
While Øivind says
"I think also sometimes design is just about culture and the way my mission is being proud of my culture. I am proud of my culture, so rather than trying to make a universal design, which makes lot of people kind of happy, but nobody really loves it. then I do what I love, and if I will be Asian then I would make an Asian light, which I would love. but I don't really believe in this kind of one product that fits all, or this kind of"
So he is designing from his cultural aesthetics, and from what he loves, instead of trying to make everybody happy *".. then you get the kind of ikea. lot of people can live with it but nobody loves it. and that's not my job."*

So the choice of going from global to local was also a reflection on taking the user into the game, and let them be represented through being in a home, while also connecting the participators through their daily private practice of being lighting users.

Reflections on dependency in vision game

Another remark on the vision game was that it did not really show much dependency, as almost non compromises was made. So how can the next design game be a successful boundary object and help the participators reveal their dependencies in between each others?

Trying to accommodate that I made time in the next game for an introduction round for each participator where they told about their work, and how they expressed themselves through their work, and how they could contribute to the process of creating good residential lighting in this group. This was to create an understanding of differences while being mutually dependent.

Using conflicts as key generators for design criteria

Some different conflicts were reflected in the game, there was a subject-object conflict in the assumption that residential lighting is emotional, atmospheric (is something we do) or light is given from biology (is healing). A culture-nature conflict.
While light is variable (is a relation between different light sources) is an aesthetic subjective view of lighting while "supports functionality" is the more functionalistic, objective view on lighting.
These conflicts will be used in the coming game setting to create ideation frames which emphasizes pragmatic residential lighting solutions.

Relating to subject object, this is done by creating a gameplay which displays the differences, while creating mutual dependency. Therefore the ideation framing for mocking up good residential lighting is

-Create lighting in a given situation happening in a kitchen, while taking point of departure in that "good residential lighting is something we do" while also "good residential lighting is healing".
Followed by
-Create lighting in a given situation happening in a kitchen, while taking point of departure in that "good residential lighting is variable" while also "good residential lighting supports functionality".

"Mocking up good residential lighting"

Due to practical reasons Pia Stautz was the only participator from design game one which also participated in game two. The new participators was found fulfilling the criteria of representing the specific knowledge domains, and the vision connected to that particular domain (Find the design game invitation in Appendix IV). The participators in the game was

Stine Maria Louring Nielsen
Anthropologist and ph.d. student in lighting design.
Among other things she has researched in lights influence on learning levels in schools, circadian light impact on older people, adaptive intelligent light management, as well as art's impact on health and how it can be used in the health system. Stine represents the same community of practice as Mikkel Bille.

Christian Flindt
Is a lighting, furniture and industrial designer.
Within lighting Christian has designed the Flindt 220 floor lamp, Flindt 220 pendant, Flindt 475 pendant and the LP Grand pendant, the Flindt bollard, all produced by Louis Poulsen. Regarding the Flindt bollard he was awarded elforskprisen 2014 for energy effective lighting in public spaces. Christian of course represents the designer community of practice.

Lighting architect **Pia Stautz** designs light with a focus on functionality, storytelling and wellbeing.
Pia has worked in the field for over 20 years, both in big and small organisations. The last 5 years as independent, and now as a part of Lightscapes. Amongst many projects she has designed lighting for Nimb(Tivoli), D'angleterre and many private homes.

Design engineer **Mathias Christiansen** is founder of Shade Aps. He is managing product and production development in Shade, which launched the Orb in December 2017. The Orb is a multifunctional pendant, with smartphone interface, which has been presold through crowdfunding in thousands. Mathias represents mostly an engineering community of practice, but also the design field.

Gameplay and rules

The game play, rules and procedural steps is explained in Table 4
.

Game Play phase	Explanation of phase
Introduction	First the players was introduction to rules and stages of the game
Personal introduction	Everyone explained of their work, how they did their work, which tools they used. And which competences they contributed to the group
Kitchen tour	A short tour visiting kitchens of three different apartments in the same building, reflecting on their lighting from each specific knowledge field. The participators was encouraged to take notes, which was collected for each kitchen
Introducing visions	The visions from game one was introduced and discussed(p:husk at de kan fungere som et design brev, der begrænser (det kan være godt og skidt)
Ideation of "cutting onions" situation in kitchen	Going back to the kitchen, the group was asked which situation was common in between the 3 kitchens, and for this situation they

	should create lighting, while taking point of departure in that "good residential lighting is something we do" and "good residential lighting is healing". Followed by Create lighting in a given situation happening in a kitchen, while taking point of departure in that "good residential lighting is variable" and "good residential lighting supports functionality".
Ideation of "eating and playing with lego at table" situation	Same 2 assignments as above but for a situation which was possible in one of the two other kitchens but not the one we were ideating in.
Mocking up	One of the above scenarios was chosen for mocking up. Because of practical reasons only Mathias and Christian took part in this
End of game	Unframed discussions on the topic followed

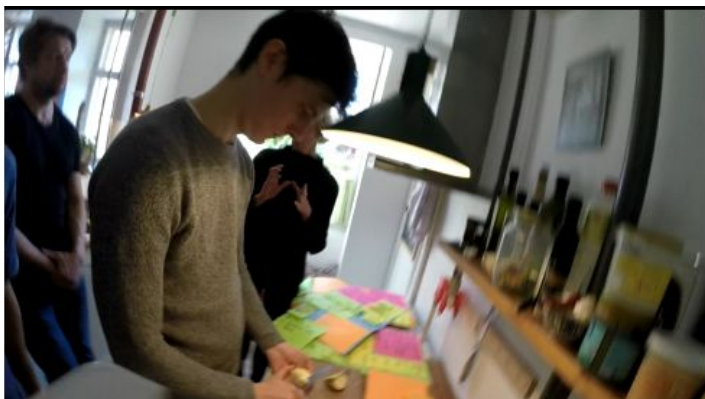Table 4: Game play, rules and procedural steps

Figure 17. Mathias chopping apple in lack of onions. In the background colorful notes from the kitchen tour is seen, (photo by me).

The ideation processes, resulted in a draft for design criterias, which can be found in the Appendix.
Design criteria for good residential lighting for chopping onions, or chopping, working at a kitchen table in general can be found in Appendix V.
Design ideation criteria for eating and hanging out at a foldable table (or fast stoved away table) in a small kitchen can be found in appendix VI.

Feedback on the visions

As the goal for transdisciplinarity was not seen fully obtained in the vision game, a part of the mock up game, was also to test the visions, and see if they was accepted and used as tools for ideation and creation of design criteria, and if they allowed transdisciplinary inquiry.

Despite I had sent out descriptions of the new visions to the new team, we used more time than planned to discuss and clarify the visions during the game. There was a semantic need to identify and clarify the visions.

As mentioned by Carlile "*A less-obvious source of novelty comes when an actor is unfamiliar with the common knowledge being used to represent the differences and dependencies between domain-specific knowledge.*"(ibid, 2004, p.p. 557)

After the game Christians feedback was

"*I surely think that having those categories, I actually think it was a plus that they were not totally sharp, and put in boxes, and we did not all know what kind of tool is this. Maybe I think it was quite good that there were these overlaps, I think that created something new.*"

(video:mock up 2, 4:30-5:00) While Mathias noted

"I am a little bit more of an engineer for that".(Video: mock up 2, 5:00-5:30).

A few weeks later when I had a postgame interview with Mathias he mentioned, that the visions was good, and it was quite the same as those they worked around in his company. My conclusion is that it is rather the vision names than the description of their meaning which needs to be evaluated, and maybe changed to a more sharp interpretation of the described meanings.

Furthermore Mathias pointed out that it has to be defined if "good light is healing" is in a scientific way or a more holistic way. And when looking through the design criteria created during the game, not much was mentioned about healing light, like if we did not have someone among the group to fight for this point, or that people in game 2 did not find the evidence around circadian light strong enough to take it serious.

Theoretic and methodologic evaluation of mocking up good residential lighting.

Domain specific knowledge was shared in between the participators during the ideation part. While both Christian and Mathias asked the two other participants questions, for them to share their knowledge. I see this as a sign that a transdisciplinary situation emerged, where the group understood their differences but due to a dependency, obtained by knowing that the other person's knowledge was useful and they needed to work together on this task. Furthermore the paste that Pia listed criteria for good residential lighting in a kitchen "chopping onions situation" was impressive(video:visioner 2, 4:12-4:20). Her tacit knowledge was easily shared in the given situation.

So as a semantic boundary object the game, the setting and the visions worked. But the question is if there was enough newness which made the different participators in need of questioning their own knowledge, and transform their knowledge?

The way the visions in combination worked as obstructions in the ideation process, created this pragmatic knowledge boundary. By asking the participators to first ideate on good residential kitchen lighting for chopping onions, which was both "something we do" and "Healing" which I will define as, are you controlling the light or is the light controlling you. Two distinct visions which is put together to show difference and to create compromise.
 followed by a ideation round for "Is variable" and "supports functionality".

The differences in between design game one and two, in relation to knowledge boundaries is like Carlile`s observation from his work in the automobile industry *"we can see that the*

updated assembly drawing provided a shareable object and the creation of shareable ends at the boundary, where before the objects used actually reinforced the boundary." (Carlile, 2002, p.p. 451)

As we ran out of time we did not get the time to mock up as a follow up on the generated design criteria. This was a shame because the domain specific knowledge of Mathias and Christian, was not fully activated in the setting. Neither their tacit knowledge was fully activated, as seen when they stayed to mock up. Their practice is more "inside the lamp" than the lighting architect and the anthropologist which is more "outside the lamp". Therefore we do not see the full potential of the setting and game as a pragmatic idea and knowledge generator.

Discussion (20%)

The main focus for the discussion is to answer the question what is good residential lighting. The discussion will be organised in 3 main parts, going into depth with which design parameters the different chapters have contributed with, and their perspectives on residential lighting.

Design criteria from literature review:

Functionalist perspective

Design criterias for good residential lighting, can not only be built on the functionalist values. The best visual performance, and absence of visual discomfort, does an excellent job helping me do different tasks efficiently, but at its best it leaves me indifferent to the lighting. The specific design criterias emphasised in the literature review is very useful, and in some regards statutory. Special weight has been put on gathering knowledge from the relative new field of circadian lighting, which both can contribute to the "theorists of growth" by inducing alertness and focus, while on the other hand taking a health perspective by helping to stabilise the sleep/wakecycle.

Commodity perspective

The commodity perspective on residential light, is a perspective which as opposed to functionalism addresses people's "free-time" needs. This perspective asks for "leisure" light, or well being light, and in the marxist commodity perspective you want to find out what people's needs are and give them a use. The marxist commodity perspective on light, is turning around the game but is still a part of the capitalist regime. Before in the functionalist perspective, the human was seen as a commodity, which as per se their working "force",

they are a commodity which helps create other commodities which economically will make them possible to buy and become users of commodities in their "free-time". In this way we are "commodified" both in our work and at home. But the commodities at home is not guided by the same values than at work, instead of the light at work, where it as the worker works for creating commodities, effectively, done fast and acuite(both light and worker), now light becomes a commodity which should address the needs we have in our home. This could be good light for reading, good light for cooking, or good light for waking up, good light to feel at home, good light for eating, good light to ensure our health. So instead of measured design criteria for visual performance (bottom of Boyce model fig 1), build on work task, visual performance design criteria should be focusing on tasks identified in the home. Criteria build on the values of felling home.

While in the later capitalist society, Following Böhme (2003) the aesthetic economy, instead of generating light which accustume the users needs, it is creating light which the user desire, or help create desirable atmospheres. Therefore lighting should support my desire to look beautiful, a desire to feel like a real chef when I am cooking. You can say that residential lighting should stage you, and help recreate your own self image, like "I'm a tech guy" or "I'm fashionable". You can say that residential lighting is designed to take advantage of the societal opposition to work, by building design criteria on the residential light users needs and desires. In the commodity perspective you are still objectified in your"free-time" as in "work-time", to make the wheels of economy turn.

Dwelling perspective

Following Ingolds argumentation, home may represent the dwelling perspective. Instead of supporting "tasks" residential lighting supports "activities", and a way of living where one is not bound up to "clock-time" but "social time". Lighting as a part of our familiar and intimate environment, part of life in general both emotionally socially and culturally.
Furthermore dwelling light engages with nature, and supports a living determined by nature rather than by ourselves.

Atmospheric perspective

Is a sensitising device, of how you can understand the aesthetics of light as a part of a whole. It is a perspective on how residential lighting can co-shape atmospheres, and a opening up to a subjective understanding of the light user, as a participator in the lightscape. We can objectively aim to create a certain atmosphere with a lighting design, but it is as well dependent on which "light" the resident shines on the lightscape. What just happened before the resident opened the door to the house? what emotions are present inside?
And on the other side I as a light user, can also use the lighting to express my emotion, or try to change them by turning on a candle light. This argues clearly for the light user as a part-taker in staging the lightscape.
Though the candle light has different meanings and different narratives bound to it. In Denmark it co-shapes an atmosphere of "hygge", while in Southern Europe you lit a candle in remembrance and honoring of the dead, and connects with a melancholic atmosphere.

As shown in the litterature social and cultural differences has an impact on residential lighting. Social and cultural different preferences, narratives and values guiding these can be unfold and can be transformed from tacit implicit knowledge to explicit through an interpretivist approach. During this process the specific social, and cultural design criteria will unfold.

Design criteria from empirical research

"Vision game"

The vision game was an exploration of what is good residential lighting in general, which visions and values should we build design criteria from.

Good residential lighting is something we do

Is a vision build on the values of voluntarism and understanding residential lighting as a practice. We act and create the environment we parttake in, while we let the environment help recreating ourselves and staging our self image. Light is something we do because we want to care for ourselves and others, or want to show we care. In general it is attuning a space in relation to emotions, moods and atmospheres to create a good home. In matter of designing residential lighting which "is something we do", on the one side we should therefore see the resident not as a objective user, but a subjective co-designer. A co-designer which should have the possibility to stage light for different atmospheres. And thereby a design criteria for good residential light is attunability.

Good residential lighting is variable

Is a vision build on a lightscape variability in the physical space. That means for example in a living room, when dinner is served, the dinner table is the physical space in focus, this is where we need light, as opposed to the sofa table, where the light is dimmed or shut off during dinner. But afterwards when we turn on the tv and sit in the sofa, this is where focus is needed. This is an understanding of that light should be focused physically where it needs to be in space for a certain activity, and if a room has different activities there should be a possibility to change the lightscape to emphasise that specific activity. This also means that light sources illuminating the same room relates to each other, and as the sun change direction, lux, diffuse or direct over the day, artificial light should be able to co-create the lightscape with the sun as with other light sources.

Therefore the artificial light source should be designed to focus in a specific direction, and have the ability to make a distinct lighting boundary, between what is supposed to be illuminated and not. As mentioned by Pia Stautz it is about creating rooms in rooms.

Good residential lighting is healing

Originally the name for this vision was, "is universal", but what was given to be universal was that the human health has a biomechanical dependency to sunlight which can be mimicked by specific artificial light. And hence the name was changed to healing. This express itself for example in circadian light. Combined with the research exposed in the literature review this means good residential lighting should not phase shift the circadian rhythm, while on the other side it should be used to enforce a regular natural circadian rhythm. When future research has made the frames for this topic clear, this can be done by avoiding or enhancing the circadian light spectrum, and general level of luminosity, at given times of the day.

Good residential lighting supports functionality

The fourth vision, is best explained as a redefinition of functionalism, depict as visual performance by Boyce and Rea in Figure 1. Good residential lighting should support functionality of activities in the residence. That means that not only activities like reading or cutting vegetables, but also good lighting for eating together, or putting on make-up.
Boyce definition of visual performance, is guided by the values of "speed and acuity", while supporting functionality of putting on make-up does not. Light makes you look beautiful by not showing an acuite vision of shadows by the use of diffuse light.So this is a redefinition of functionality, saying that the science based in the "functionalist" perspective should be reapplied to support residential activities while also taking into consideration which underlying values these threshold should enforce.

As mentioned in the research context these are values and visions to guide the general focus when designing residential lighting.
In the following game these visions was tested as creative obstructive design criterias, and applied in a specific, social and cultural context, in a specific room of the home, for specific activities.

"Mocking up good residential lighting"

In this design game the values from the former game was used as obstructions to create design ideation and criteria in a specific context. The context as argued for in the research

context was a small old Danish kitchen in an Copenhagen apartment (Nørrebro), while the participators choose to ideate on 2 kitchen situations.

First the activity of cutting apples, or in general chopping cooking ingredients activities on the kitchen table.

Second having a cozy spot in the kitchen, with some form of table, where you can eat and read your newspaper, have you kids sit and play while you cook.

Comparing the criteria and ideation for the 2 different scenarios (Appendix V, Appendix VI) and what general ideas came up, there was a striking difference. For the eating/hangout/cozy table light the biggest concern was how to create a room in the room which was cozy, by "lowering the ceiling" with the light of a pendle. Both Pia and Signe described how the light should emanate from the table reflection, and gather people around it.

While for the more functional objective of cutting apples using spots from the ceiling was fine. Furthermore it was recommended to first put functional light, and then ad an atmosphere creating lamp in the room as well, to emmenate throughout the room.

While to the "chopping onions/apples situation" Christian had a tripartational reflection of what had been discussed during the ideation process. First the scenography, which is the kitchen, cupboards, floor, window, glasses, cooking books etc, then the atmosphere you have created in the scenography, and then the remedies to do something, kitchen table lighting, the knife, the chopping board the apple. (Appendix V)

In this I see an understanding of how space, atmosphere and our redefinition of functionalist lighting can work together, and create good residential lighting.

So a proposal of how to create good residential lighting in the specific social and cultural context of a Copenhagen kitchen, in the light of the mock up game and Christians reflections, goes like this:

Context: Denmark, Copenhagen, Nørrebro, Kitchen
Activity: cutting an apple, or chopping up ingredients in general for cooking
1a: Experience the room, its materiality, and their contributing ecstasies. What character does the atmosphere have? In the mock up game the 4 participators characterised 3 different kitchens, with three different atmospheres. **First** the "idealistic home" (Stine, video: idekøkken 3), with a new "samtale" kitchen made from the thought of how it "should be" in a normative way, as an example of a designer "Bo bedre" home, what could be seen in Böhmes words as a normative created "desired" home. **Second** the nostalgic home with pictures telling stories, an old kitchen, with things in order,newspaper on the table, coffee cup, cozy. Has a feelling of both being living room and kitchen, a place where you don't do tasks but activities, a place where you dwell.

Third is my own kitchen, which was defined as a old cozy kitchen, compact use of space like on a boat, order in chaos, hiding functional ikea elements and dishwasher, behind carpenter handmade cupboards from the 40's. A clear choice of covering the functional in an artisanal dwelling atmosphere.

1b: In co-creation with the given materialities atmosphere from point 1, you either enhance or sculpt the atmosphere in a new direction by adding a "signal værdi" lamp", signaling you are home, and possibly who you are. This is done with a cultural representation of homelliness, in this context the lighting would be "hygge belysning".
The normative practice is to do this by a subdued "warm" light for example by a candle light, a wall mount lamp or a pendant over a table. Thereby creating an intimate room in the room, telling yourself that you are home and decide yourself. Another signal is also which story the design of the lamp tells you and others about yourself.

2: Use the functionalist design criteria from the literature review, in the revised edition discussed above plus the specific criteria listed in appendix V. What is expressed as best practice in the Appendix VI, is that lightsources should be placed over the "workplace" and sink, while the light should be focused (not diffuse) to ensure with the specific task of cutting apples in your kitchen, that you have the best 3 dimensional understanding of the apple, and not cutting your fingers. Furthermore the lightsource should have a high CRI to give the best visual understanding and pleasure of the state of the apple, does it look ripe, or does it look rotten? A light which lets you enjoy the apple, and anticipate its deliciousness.

Pia argues opposite that she would first look at the function of the light, and then when all the functional tasks were solved regarding lighting she would add here "signal lampe".
So 1a and 1b is connected but it does not matter much if you do 1 first or 2 first, as long as you do both.
The next scenario was how do we create a cozy atmosphere for eating or reading a newspaper in the kitchen. This became more a focus on how we could create a cozy light for a folding table or stove away table, as the kitchen was to small for a stationary table. If we assume the table design was fixed, the specific lighting criteria could again be created using the model above. Though the difference is that, the activity is to, eat, read, socialise and dwell in an intimate cozy atmosphere. In this situation light from the same pendant can meet both the functional, and atmosphere criteria. You could still add candle lights, or use a ceiling spot though it would not give as good an atmosphere as the two others, as it would not in the same way create an intimate room in the room as it does not lower the perception of the ceiling height as the pendant.

Conclusion:

It is recognized both in the literature and empirical research that design criteria for residential lighting does not work as an effective boundary object anymore, as it is based on the "realität" of the functionalist perspective, and therefore the "realität" of the atmosphere and sociocultural perspectives can not be shared, and thereby the "virklickheit" of good residential lighting is not expressed in the design criteria, and thereby not designed.

What the theory and method in this thesis is build upon is the notion of Star that boundary objects should maximize both the autonomy an communication between communities of practice.

Design criteria as of today does the opposite, it maximizes the autonomy, while neglecting communication between communities of practice.

If a translation from shared knowledge into the boundary object of thresholds and measurements happened, it would be a subtraction of "wirklicheit" into "reality", and probably with the loss of the sensual experience, the stories it tells us, and the things we want to express with it. this is very useful for the functionalist communities of practice, and if this translation did not happen they would not be able to get work done. But if we forget to understand that this is only a part of the full picture, and expresses this as "wirklichheit" we will end up creating lightscapes that "at its best makes you indifferent".

On the other side, as seen in the empirical research from the vision game, the "functionalist" community of practice' "reality" is not accepted by the other communities, due to both the implication of conflicting invested knowledge, but also in the opposition of not being recognised, like the marxist culture analysis, saying that the human as a whole was not recognised by the functionalist economical growth values, and thereby creating a counterculture.

If this happens then we will neither get good residential lighting.

What was actually observed in "Visions for good residential lighting" was a separation, between the four communities of practice, though mostly seen towards the functionalist perspective expressed by Poul Henningsen quote from 1958 "lysets blinde bogholdere" ("the blind bookkeepers of the light") from the others, by ignoring the legitimite "realities" of the other which somehow made them individually comfortable, as they could then keep to their own field of knowledge, and do what they found right, without giving others the legitimacy to have a say so. Thereby giving another perspective on the observed lack of pragmatic reliability amongst participators in the vision game.

This is also a comment to the notion of boundary objects, and Star and Griesemer expresses that the boundary object ""is an analytic concept of those scientific objects which both inhabit several intersecting social worlds and satisfy the informational requirements of each of them".(Star and Griesemer, 1989, p.p. 393). In line with Carlile (2002,2004) I say that this needs a reformulation, the boundary object should as in "the mocking up game", make it possible for each community of practice to share their "realität" or perception of "wirklicheit", in a way that create a common ground for negotiation and sensemaking. A sharing of perspectives which can inspire for pragmatism towards one's own perspective.

A recognition that we all due to our specialisations only hold our "reality" at hand, but with the growing speed of specialisation into more and more specific fields of knowledge and communities of practice, there is a growing danger for knowledge to be disintegrated and done unrecognisable by any other but that specific community, and thereby the strength of

specialisation ends up becoming the opposite, a creation of paradigmes which either can not or will not understand each others specific knowledge. This argues for a recognition of which boundary objects is used in the knowledge sharing and creation of residential lighting, and products in general, and a reconsideration if these boundary objects (thresholds and measurements) "effectively" has the power to tie all the different disciplines together, or rather creates dealignment and unnecessary power struggles in itself. Both the literature and the empirical research propose that the dominant boundary object to communicate and create residential lighting from is of a syntactical character, dominated by standards and quantifiable measures stemming from a "functionalist" perspective.

I suggest that new boundary objects should be invented to create better products, not only from a place of shared explicit knowledge, but from a place of shared tacit knowledge, especially the aesthetic part of creating good residential lighting suggests this as Böhme points out that the creation of atmospheres is almost only based on tacit knowledge. Furthermore the social and cultural subjectivity of the individual should be held accounted for as well as for the objective human facts.

A transdisciplinary reevaluation of the values which design criteria is based upon, has been taken forth, and The empiri points towards future residential lighting based on the visions of
"Residential lighting is something we do"
"Residential lighting is variable"
"Residential lighting is healing" and
"Residential lighting supports functionality"
Creating design criteria from these values has been proven successful through the use of pragmatic design games.
Taking the example of Pia Stautz sharing different design criteria for creating "hygge" and intimacy, in the mock up game.
The connection, and the boundary spanning process, of the different communities of practices represented in the game happens when the situation inspires one´s tacit knowledge to be shared, and is accepted as useful or true. Legitimised by the others because of their presence in the shared physical space and the atmosphere at the given moment when the knowledge was expressed, and their recognition of this as a shared "wirklichheit" both in their physical emotional systems response and in their cognitive response.
From sensing, to the emotional recognition, or intuitive response, and the shared felling of recognised knowledge, expressed in the etymology of the sentence "this makes sense".
And if the certain understanding of how an intimate lightscape should be expressed is not shared then being together in the situation makes space for negotiation and "sensemaking".

Instead of making thresholds and numbers be the boundary object for communicating between the different communities of practice, but values been put to the test of ideation into the situation and atmosphere makes it possible for creation of new shared knowledge, and thereby knowledge does not have to be translated into new measurements, to "make sense" as they are recognised for what they are at "face value".

A specific example of how a pragmatic meeting of ends , is seen between these as a specific design criteria brought forth by this research. As both functionalist and atmosphere perspectives recognises the need for customizability, and user control of residential lighting. Good residential lighting in countries where the aesthetical economy is present, which according to critical aesthetic theory is most western countries, the atmosphere perspective and the functionalist perspective asks for an integration of the user as an active co-shaper. From the functionalist perspective because of the statistical dispersal which standards and guides for good residential lighting is based on, and by giving the user the possibility to change the light inside the given threshold values, the light can be corrected specifically to the users needs. The dispersal can for example be an expression of biomechanical differences on visual performance created by age, eye color, illnesses etc.
While on the other side the atmospheric perspective argues for subjective control, due to our subjectivity as humans both emotionally, socially and culturally. Our desire to create a certain atmosphere at home, the lightscape should not only stage us, but we should be able to stage the lightscape as well.

Therefore on the base of the literature, theory, methodology and empirical research in this thesis a transdisciplinary design approach is suggested with the use of pragmatic boundary objects allowing both recognition of tacit as explicit, and subjective as objective knowledge for creating good residential lighting.
This thesis propose that design criteria should be co-shaped through pragmatic design games by the involved communities of practice. These games should be based on values of the known functional and health perspectives but also through inclusion of the resident as and active part of lighting, which shapes atmospheres with the help of light, guided by emotion and their social and cultural perspectives.

Acknowledgements:

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Appendix