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The present study argues for a holistic engagement with the relations that occur between man and phenomena of light. With a neuropragmatist approach towards lighting, that fuses scientific and humanistic approaches, the study conducts electroencephalography (EEG) experiments of how we experience color illuminations when the ocular sense is disabled. In this respect, the paper reveals new insights into how the skin can sense and differentiate between different colors of light, seen in neurological variations in the brain. By these means, the paper proposes a revisited awareness of how we are related to the experiences of lighting. Our knowledge of it might not be as fixed and understood as we think.

Eyes of the skin - A Neuropragmatic take on lighting

Aalborg University Copenhagen, Spring 2019

MSc Lighting Design

Master Thesis

By: Mads Deibjerg Lind

Supervisor: Georgios Triantafyllidis

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Abstract

Light and its colorful illuminations surround us in many aspects of our lives, most of which we experience with our visual sense for aesthetic or practical concerns. Throughout history the ocular sense has been privileged over the other senses, emerging into an ocularcentric human living. However, it can be questioned if light and its color is only to be experienced with the eye.

The present study argues for a holistic engagement with the relations that occur between man and phenomena of light. With a neuropragmatist approach towards lighting, that fuses scientific and humanistic approaches, the study conducts electroencephalography (EEG) experiments of how we experience color illuminations when the ocular sense is disabled. In this respect, the paper reveals new insights into how the skin can sense and differentiate between different colors of light, seen in neurological variations in the brain. By these means, the paper proposes a revisited awareness of how we are related to the experiences of lighting. Our knowledge of it might not be as fixed and understood as we think.

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Introduction

Throughout history, explorations of light has impelled man from early masterings of fire to intricate lighting technologies providing new potentials for human relations to lighting (Nielsen et al., 2018). Light as the general term of either natural or artificial form are phenomena that surround us, guides, accommondates and facilitates our daily existence, all of which fundamental aspect of our lives. Throughout ancient times, thinking of the human modalities maintained the sense of sight as a knowledge of light and fire, that was an ocularcentric view in which sight became privileged over other modalities (Pallasmaa, 2005; Levin, 1993). When simply "looking" around in our daily lives, it is obvious that we are creatures of vision, in which light renders our vision possible. Such a treatment is common nowadays as it is fundamental for vision that:

> *The will to power is very strong in vision. There is a very strong tendency in vision to grasp and fixate, to reify and totalise: a tendency to dominate, secure, and control, which eventually, because it was so extensively promoted, assumed a certain uncontested hegemony over our culture and its philosophical discourse, establishing, in keeping with the instrumental rationality of our culture and the technological character of our society, an ocularcentric metaphysics of presence. (Levin, 1993, p. 212)*

This ocular will of ours seems further to be carried along by new technologies such as the television, smartphone and other visual media. Also in the field of lighting, practices and innovations towards lighting from gothic stained glass windows to modern developments of dynamic LEDs, thrive the visual sense into functional and aesthetic characters by colorful illumination qualities (Nielsen et al., 2018). The current technology and quick innovation in lighting equipment that can produce functional and aesthetic implementation of light and colorful illuminations, have "(...) made their way into private homes, as well as public spaces, such as office and healthcare environments" (Nielsen et al., 2018, p.1). With such tendencies making way for the visual sense, one should not try to fight the ocular gift that we are given, but instead, examine a potentiality in light and color for human, and whether other sense modalities could be in play for this matter. Can we experience light and its color outside the visual domain and if so what would this mean for our experiences in life?

While this might be an odd question, it is exactly with this quest in mind that the current paper is concerned. This is exploring how light and its color can affect us, not as ocular but as bodily outside the visual domain of the eye. By this, it is to question the dominant role of vision as an only knowledge of light and rather direct attention towards our non-ocular-body and haptic sense (found in the skin). Hence it is no means to question the role of vision as the dominant sense of light but merely to explore how human is related to the world, and whether its relation to light and colored illumination could also be of a different character. The project will be highly inspired by philosophical notions on body, mind and experience but it will also be engaged with scientific understandings in neuroscience. Hence the aim is to bridge science and humanities, in the hope that they will contribute to our explorations.

On this journey, the reader will be presented with a a bckground section illustrating the motivation for the paper. A state of the art section is followed, touching upon colored illumination in cultural and environmental contexts. This will be followed by a brief but important section on neuropragmatism, as this is the methodology framing the project in general. A literature review will then be presented focusing on a philosophical thread that is inherent to this undertaking as well as touching upon some neurological aspects that are important for the later understandings. A problem statement will then be given and followed by a design and experiment section. After these, findings from the EEG study will be presented, and afterwards discussed in relation to the literature. Lastly a section on future works will address how research further can illuminate what the paper has presented.

Background

This section will provide a brief background into which this project is motivated and inspired. It will shortly illustrate how prior research and existential considerations have formed a profound interest and strive for an examination into lighting that might differ from traditional research in this field. Moreover, this section will also allow itself to be of a slightly personal character, as a strong motivation (by the author) has guided the project.

Lighting - how it affects us, alters our experiences, modulates qualities in life, and potentially enriches being in the world is at the heart of this study. These considerations carry at its roots a deep curiosity and interest towards human experiences, actions, emotions, and epistemological as well as ontological nature. Furthermore, how a cognitive intertwinement with bodily sense modalities and its relation to the environment is of an intricate dialogue and such a dialogue that is between human and its world is the ultimate motivation for the research undertaken here. Furthermore, the present study is deeply fascinated by the nature and potentiality of human senses and especially how lighting may implicate these modalities to which our experiences manifest. Much of these considerations steam from philosophical readings ranging between phenomenology and pragmatism (the philosophical thread will be unfolded later). Just as much is the matter of light and its implications for the human body and its senses, grown from contemporary research from humanistic as well as scientific disciplines.

A great deal of acknowledgment and inspiration is to be dedicated to the research performed by Stine Nielsen (Nielsen et al., 2018)[1]. In her study, she investigates the bodily response to lighting and colored illumination from a phenomenological perspective, with a qualitative anthropological methodology. In doing so she aims to examine the bodily presence in architectural space and how colored illumination can mediate the atmosphere of such experiences. In this quest, she comes to question the dominant sense of vision as the only qualifier for the experience of light and colored illumination in architectural space. She notes (when referring to the famous architect Juhani Pallasmaa and ancient philosophy of Aristotle) that the dominant belief that light is a visual phenomenon has its roots throughout history and is also grounded in general tendencies towards studies and design of light. Henceforth in challenging the dominance of vision, her project strives to investigate the

> *(...) body as a multisensory organism not only affected on hormone levels, performance and mood, but also on sensations of body and space, in an attempt to unfold a knowledge of the ambience potentials and applications of coloured illuminations as an essential design element in architecture. (Nielsen et al., 2018, p. 2)*

Through various experiments performed in an artistic/performance context, she exposed 55 people to three colored illumination settings, in which 1-3 people could participate at the same time. Participants would be blindfolded part of the time, and the rest of the time, they would not be blindfolded, as a means to compare the two stages. She used interview and painting as a means for the participants to express their sensation under different colored illuminations. Her experiments showed that much of what was experienced in the blindfolded scenario was the same kind of experience in the non-blind scenario. As such, she illustrates the potential impact of illuminated architectural space as having both bodily (in the sense of non-ocular) implications as well as visual implications.

The reason for not digging further into her findings is due to the fact that, the motivation and background for the present paper is not as much in Nielsen's findings, but moreover in the approach of challenging common beliefs (light as knowledge of the eye) as to explore something unnoticed that might be of relevance to the field of lighting design. Furthermore, she utilizes an approach that intertwines a philosophical concern with a potentiality of lighting, that is raising the importance of such research to a level that comes to explore critical aspects of experiences in life. Henceforth, her research has been a dominant motivation for the present paper that the reader will begin to explore.

Nielsen's research carries a holistic phenomenological concern for human being. When differently looking at a reductionist view on human, research and scientific undertakings has for some years shown that the skin is at some level sensitive to light. Such research is dealing with the physiological effects of sunlight and its dangers with UV radiation and benefits of certain vitamins, but moreover the radiation of artificial lighting on the skin. Such research is at most, attentive to the very cellular level of the skin in which multiple studies have found certain photoreceptors in the skin cells (Castellano-Pellicena, 2017; Cronin, 2017; Hadlington, 2008). This is evident in that "(...) photoreceptors are expressed in human skin and they mediate DNA synthesis, migration

1 Stine Nielsen is currently making her PhD at Aalborg University Copenhagen. I have had the pleasure to consult with her as a means to inspire the current thesis.

and differentiation of epidermal keratinocytes"[2] (Castellano-Pellicena, 2017, p. ii) and can also affect cell and protein processes and modulations in the skin (Uzunbajakava, 2016). Researchers refer to techniques as Low-Level Laser Treatment (LLLT), phototherapy, photobiomodulation and photomodulation, etc. to refer to processes in which light can alter and modulate the cellular activity in the skin (Avci et al., 2013).

As it is evident that research and scientific agendas highlight the photosensitivity in localized skin structures, it is not any new undertaking to examine if the skin cells react to light exposure. What this kind of research is not as much occupied with and remains at large unknown is how and if the sensitivity of the skin to light and colored illumination is only to be seen in localized areas or if this might also have implications for cognitive states in the brain.
Therefore the project undertaken here is inspired from these research and approaches described but more significantly aims to emphasize a need not only to research light and its implications on localized parts of the body from a cellular perspective. We instead need to look at the cortical correlates that might be of significance in the brain under exposure to light and colored illumination that is beyond the eye. This approach might allow for infant steps towards how light can affect our thinking, emotions, behaviors, and experiences at large on both a conscious and unconscious level. This paper tries not to explain the relation between phenomena and the body as localized instances in human cells but rather as a holistic undertaking, unifying cognition and bodily sensations questioning the dominant sense of vision as the only qualifier for lived experiences between lighting and human.

2 Keratinocytes constitute most of the cells that are found in the epidermis, that is the outer layer of the skin.

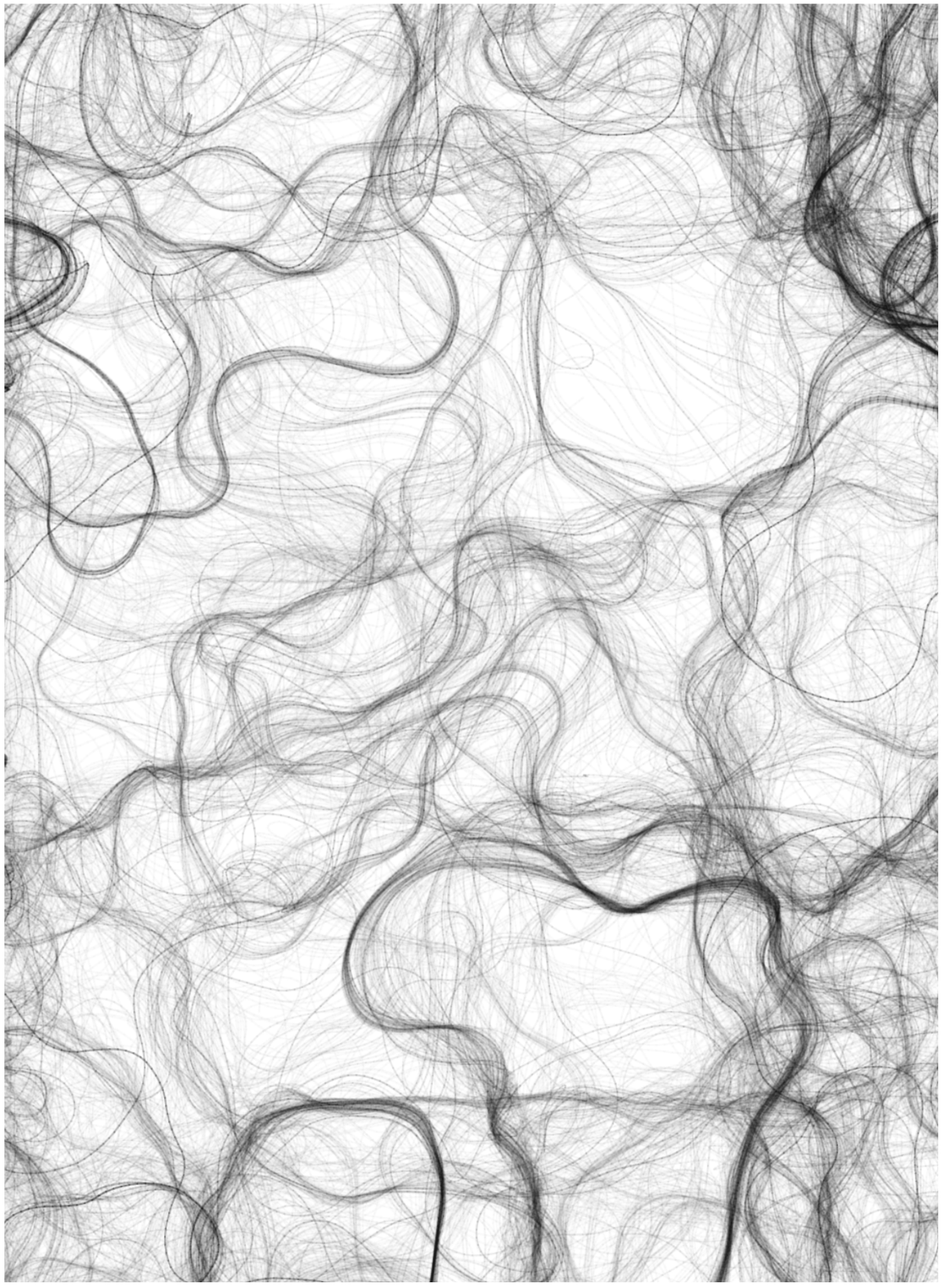


Figure 1: Creative representation of the entangled, intertwined and at times unnoticed relations between human and its environment (own figure)

State of the art

This section will provide a brief observation of some of the potential applications of lighting and colored illumination in different cultural contexts. The aim here is to set a context, in which the neurological findings and philosophical debate in later sections, should be understood in terms of. This context is a wide one, as it simply aims to cover the very diverse applications of lighting and colored illumination in cultural life. The idea here is not to develop a history or theory of lighting and colored illumination in various cultural applications but rather to exemplify a few contexts as to render clear what might be at stake as we proceed in later sections. As it is rather evident that light in the general sense of both natural and artificial character is evident in almost any cultural context (Edensor, 2015), this section will provide a focus towards colored illumination.

In various fields, colored illumination influence how people engage with and perceive things, endowing the lived space with an aura and energy that can change the way people relate to their surroundings (Bille, 2007). In architecture, colored light is generally considered to be an essential foundation in the experience of atmospheres and sensory stimulation (Nielsen et al., 2018). Ranging from the ancient glass mosaics found in gothic churches to contemporary applications of colored glass windows in a variety of buildings, the means of modulating natural daylight into colorful experiences has a long history in architecture (Nielsen et al., 2018). Exemplifying this, one can look towards the old glass mosaics of Notre Dame, the modern applications in Miami International Airport and the colorful experience at the top of Danish art museum Aros.

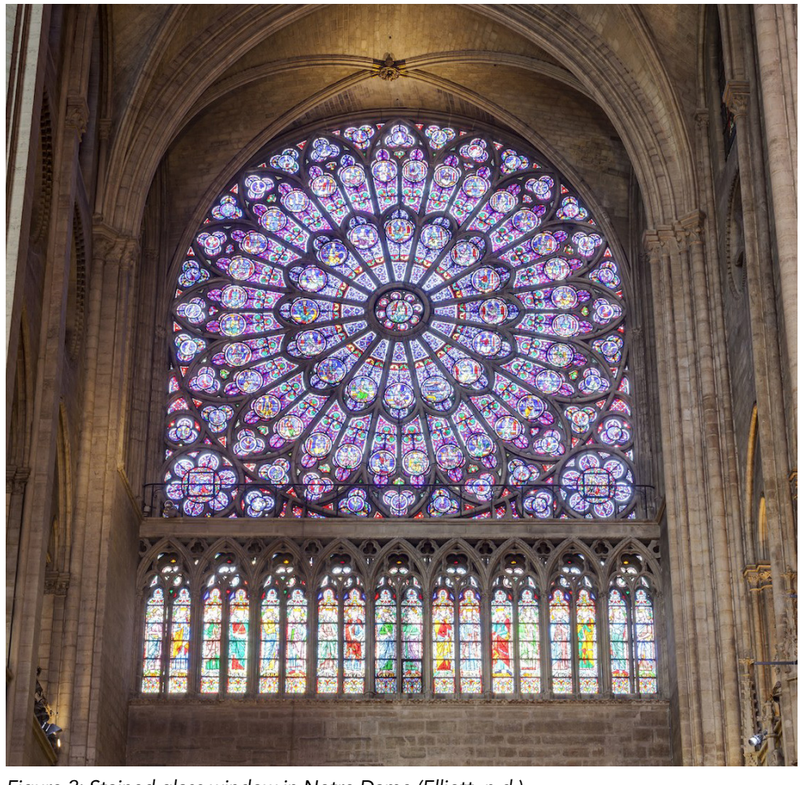


Figure 2: Stained glass window in Notre Dame (Elliott, n.d.)

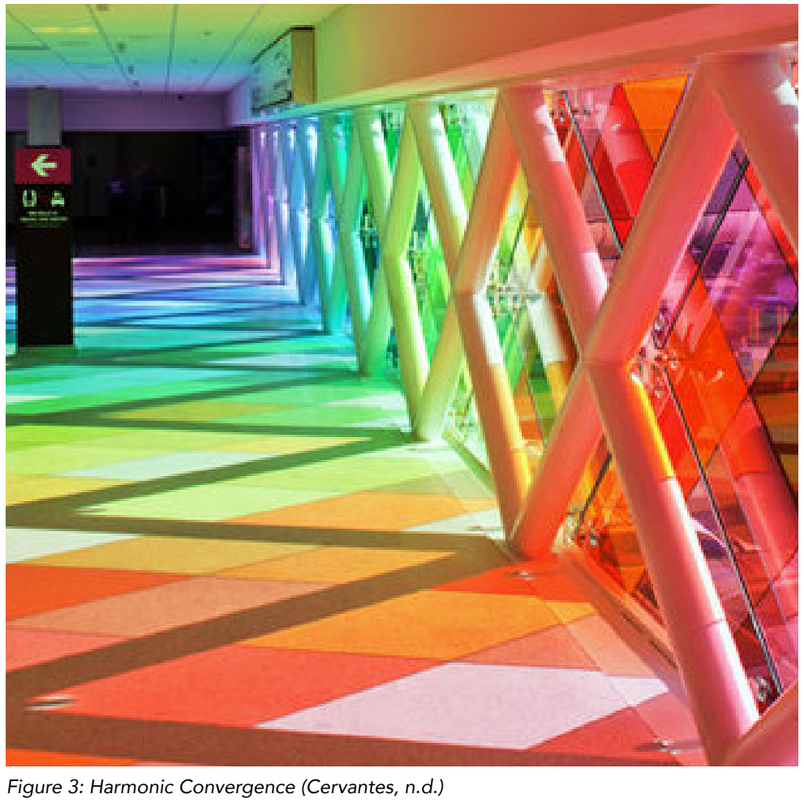


Figure 3: Harmonic Convergence (Cervantes, n.d.)

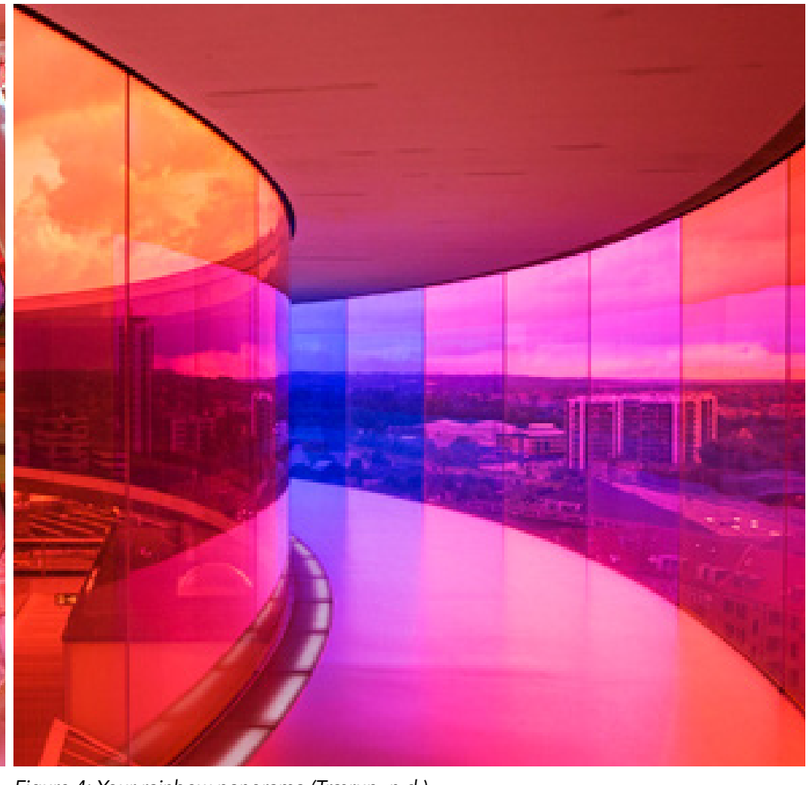


Figure 4: Your rainbow panorama (Trærup, n.d.)

Artificial lighting of a colorful character, largely pushed by the advent of new technologies such as dynamic LED lighting (Ronchi, 2015) has also found its way into the modulation and changed perception of architecture. One can simply look towards the widespread trend of facade lighting of buildings, monuments, and landmarks. Here the media facade of "Industriens Hus", in Copenhagen makes a great example, as it utilizes programmable LEDs to change the appearance of its architecture as well as endowing the city space with a colorful glance (Kollision, 2013). On a similar thread, the large LED project featured at the YAS Hotel in Abu Dhabi, reveals the theatrical and serious application of colored illumination in architecture, in which scale and impact break with conventional lighting applications (Contemporist, n. a.).

Figure 5:
Dia lights (Kollision, 2013)

Figure 6: LED project at YAS Hotel (Arup, 2009)

Figure 7: The weather project (Tate Photography, 2003)

While architecture of different kind feature lighting and colored illumination in numerous applications and form, color in lighting is also highly evident in artistic practices. The famous light artworks by the artist James Turrell examplify this practice. With his unique treatment of light and space and his focus on colored illumination he enters into a an installation art practice where he with his rooms of colored light and their gradients creates an atmospheric experience in which the participant is alone with colors of light, establishing a sensory relationship between the phenomenon and the self (Bishop, 2005). A similar trend can be seen with some of the works by the Danish artist Olafur Eliasson, such as his artwork named *The Weather Project*.

Figure 8: Breathing Light (Holzherr, 2013)

Such artistic practice, as illustrated with Turrell and Eliasson, is not only to be seen in the museum context. Colored illumination practice often mixes the fields of architecture and art into a more public character allowing for direct interaction, that inhabits the urban cityscape. Here works of Danish company Vertigo Obscura can be emphasized, most often highlighting by their famous light installation *The Wave* (see figure 9). Here, the audience is in direct contact with a colorful landscape of a dynamic character, in which the audience themselves manipulate the visual content by their body movements (Bugbee, 2018).

Such public lighting interventions manifest as a growing tendency as seen with the growing number of lighting festivals around the world celebrating the colorful interventions into the public realms of the cities, endowing the urban fabric with a twist on the habitual life, allowing for a new perspective (Schielke, 2013; Edensor, 2015). Such events can at large be seen as a kind of entertainment lighting. Another kind of such entertainment qualities of colored illumination finds many uses in the domain of concert and theatre practices, in which colored illumination, its sharp contrasts, and dynamic rhythms often are utilized to set a mood or a shift as a dramatic change occurs at stage (Dunham, 2015).

While emphasizing that lighting and its colored illumination qualities enter into many spheres of cultural and environmental contexts, its applications are also finding its ways into the private homes, especially with the introduction of smart lighting systems, such as the Philips Hue series. With this new introduction of smart bulbs that has feature control or various parameters through mobile applications, people customize their homes with color illuminations, dynamic flows of color rhythms, and personalized scripts, such as light flashes when an email is received (Chew et al., 2017). Such technological innovation has paved the way for colorful illumination that extends the cultural spheres of artistic and architectural practices.

So far, it is seen that lighting and its color illuminations obtain widespread applications all around cultural and environmental branches of human life, both public and private. The narrow range of examples presented here can never do justice to the multiple fields in which these lighting qualities are inherent. Although the aim here is to exemplify the context of which this paper is concerned with, namely all aspects of human life where such lighting qualities appear.
It might occur uncommonly to allude to a context this broad, but this is utterly essential for the present study as later sections will examine the scientific findings and bring it into a philosophical debate that is founding this vast field.

Figure 9: The Wave (Frost Festival, 2018)

Method

This section will outline the methodology that is inherent to the undertaking of this project. The section is important as it strives to illuminate the framework that is belonging to the intersection of philosophy and neuroscience, namely in the methodology of neurophilosophy or more precisely neuropragmatism. One might consider this an unconventional take on what a method section would typically be, but nonetheless, it manifests a strong argument as well as a foundation upon how science and philosophy can contribute to one another. Here we will look at what neuropragmatism means as well as how it differs from neurophilosophy and lastly draw upon why this is essential to this paper.

In the treatment of neuropragmatism, what it means and how it can help us, professors and scholars John Shook, Tibor Solymosi and Mark Johnson have dedicated much work to this matter (Solymosi & Shook, 2017; Johnson, 2018; Shook, 2013). Neuropragmatism - in their account is at large build on the philosophical notions from pragmatists such as John Dewey and William James (as well as the other pragmatists) - is a thorough and serious treatment of body-mind relation, knowledge, learning, cognition, agency and more issues, that is unfolding in the intersection between neuroscience and philosophy. Johnson stated that "In short, pragmatism without neuroscience is (partially) empty, but neuroscience without pragmatism is (partially) blind."(Johnson, 2018, p. 96). It is essentially in this respect that both traditions inhere to one another. In this sense, Solymosi and Shook affirms that

> *Neuroscience properly studies the interrelated processes of brain activity, but cognitive neuroscience cannot help explain the processes of learning and knowing by referencing brain activity alone in isolation from any context. Philosophy, for its part, will be unable to show how to integrate body and mind if knowledge is examined quite apart from any bodily context. (Solymosi & Shook, 2017, p. 5)*

As such one can not come to any full explanations if restricted to explain in one domain solely. A cross-examination drawing on knowledge and insights from these two fields is what makes neuropragmatism so strong. Both neuropragmatism and neurophilosophy pay close attention to the way the brain quickly is capable of collecting all sorts of stimuli in order to form rapid action in the lived moment (Solymosi & Shook, 2017).

The reader might wonder why this paper is not just dealing with neurophilosophy as it might seem to be in line with neuropragmatism. Furthermore, neurophilosophy might, after all, seem more natural to relate to, as it is a construction of well-known fields of neuroscience and philosophy. The reason is that there is a crucial difference among neurophilosophy and neuropragmatism, and a short survey of this will provide a strong case for why neuropragmatism matters for this paper. This difference is primarily found in a conflict that resolves between science on the one hand and the humanities on the other hand (scientific image and versus humanistic image). To both neurophilosophy and neuropragmatism

> *The concern is that the scientific image ultimately shows the humanistic one to be illusory, thereby bringing into serious doubt genuinely human concerns about dignity, freedom, responsibility, and living a good and meaningful life. Science, it is feared, will rob us of our humanity. (Solymosi & Shook, 2017, p. 14)*

While this is a genuine concern for both parties, there is an internal disagreement between neurophilosophy and neuropragmatism. Both see that the humanist image develop first, which leads to that science reacts upon this. However, the conflict arises in that the traditional neurophilosophers believe the two images (scientific and humanistic) to be competing for the truth. With this neurophilosophers see that man-in-the-world is in a constant fight between scientific truth and humanistic truth.

The strength of neuropragmatism is found in its take on this problem, as it denies this separation and competing nature between science and humanities. Solymosi & Shook show with reference to the philosophy of Dewey, a motto the neuropragmatists live by

> *To see the organism in nature, the nervous system in the organism, the brain in the nervous system, the cortex in the brain is the answer to the problems which haunt philosophy. And when thus seen they will be seen to be in, not as marbles are in a box but as events are in history, in a moving, growing never finished process. (Dewey, 1958, P. 295)*

Thus what is illustrated with this motto is that traditional philosophy holding that there is a dualism between science and humanities is, in fact, a misconception. It is in the failure to realize that

the smaller processes are part of larger process "(...) that the cortex is in the brain, the brain in the nervous system, the nervous system in the organism, and the organism in nature (...)" and that these things are in ever becomings with one another (Solymosi & Shook, 2017, p. 15). Hereby it is for the neuropragmatists that science and humanities are related. Science is then developed out of the common sense/humanities, that is to say out of everyday enjoyments and practical concerns and ordinary interest in life. These findings and methods undertaken by science will then feedback into the humanist and common sense life.

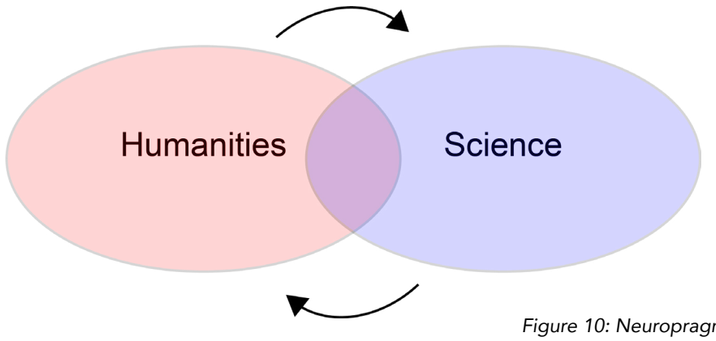


Figure 10: Neuropragmatism, (own figure)

In this respect, the worlds of science and the worlds of common sense/humanities are not final in themselves, but they need each other to contemplate one another. If the scientific world is kept for itself and develop knowledge for itself, the mission and encouragement that started the scientific inquiry will never reach its vast potential. Hereby the neuropragmatists take on experience aims for an establishment of the intercommunication of science and humanities as a means to elevate the richness and quality that the living experiences are potential of. (Solymosi & Shook, 2017)

Now, this is essentially the frame and methodology from which this paper is concerned. It strives to conduct a science or so to say a neuroscience (electroencephalography EEG) based on a commonsense concern for lighting and its potential implications for human, as a means to bring it back again into the matters of human lived experiences. This is essentially a neuropragmatic methodology.

As a means to undertake this scientific inquiry, electroencephalography (EEG) has been the method of preference. EEG is the physiological method of recording electrical activity that is generated from the brain. It is looking at the behavior of the cortical neurons, that is seen in that thousands of neurons can obtain a certain rhythmic potential producing a flow of current generating voltage fluctuations or an electrical field that can be measured from the surface of the head (Nidal & Malik, 2014). This method has the potential to reveal some of the cognitive states that a person might be subject to within a certain situation (Greenfield et al., 2010).
Hence the framework is built from a neuropragmatic approach framing phenomenology and pragmatist philosophy and neuroscience. These work together over the subject matter of lighting and its color illuminations. This interplay can be seen in figure 11.

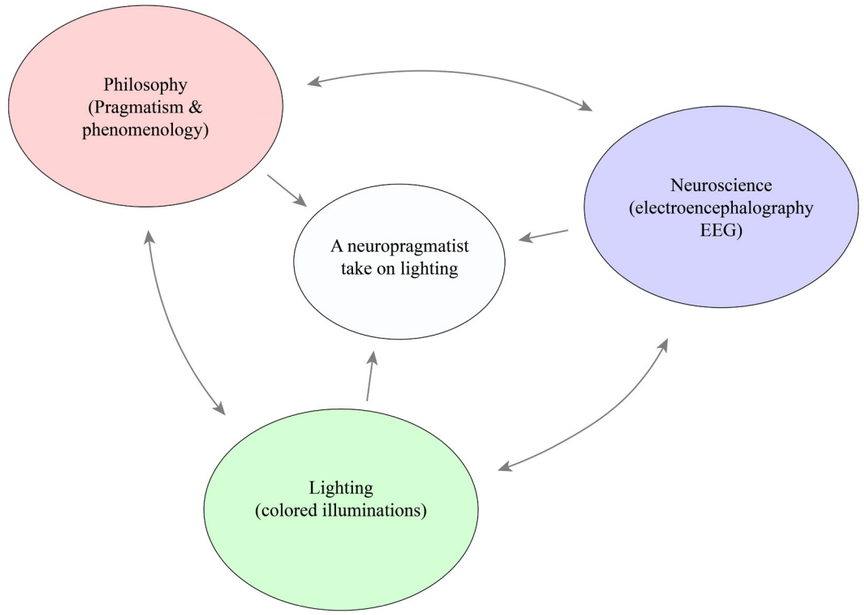


Figure 11: A neuropragmatist take on lighting (own figure)

The idea has not been here to elaborate on the history and nature of EEG but moreover to show how neuropragmatism with the aid of EEG is the core framework that will help us gain insights into the possible complications that light and its color qualities might have for human lived experiences. Future sections will provide a more thorough understanding of how EEG is used in this respect.

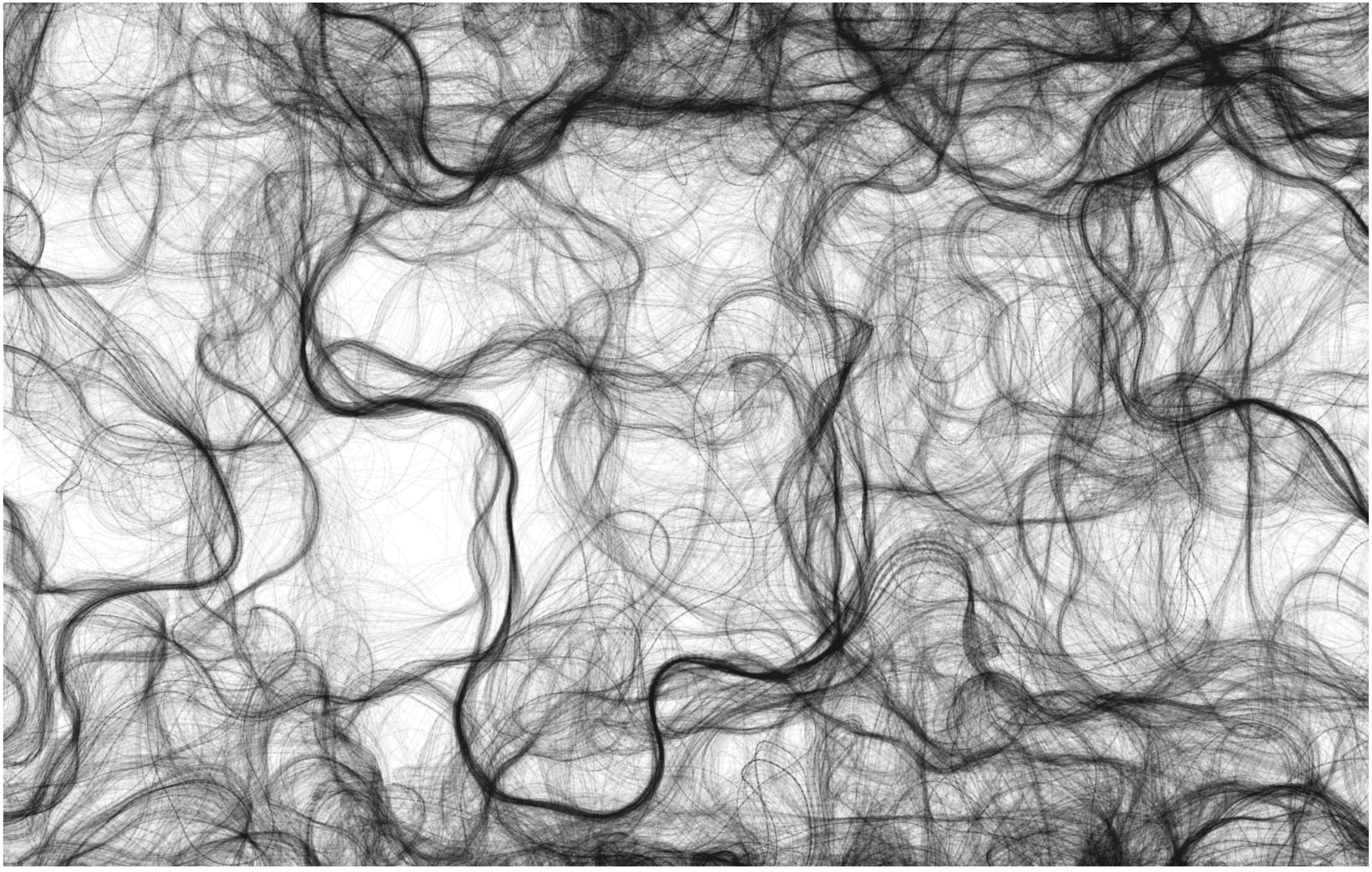


Figure 12: Creative representation of the entangled, intertwined and at times unnoticed relations between human and its environment (own figure)

Literature review

This section will encompass the theoretical framework for the paper. It will essentially decompose aspects inherent to what was previously treated as neuropragmatism. Herforth this section will at large be a philosophical one that will examine some of the most influential thoughts on sense perception as well as pragmatic experience. While much of what will be presented here is inherent to philosophy, other aspects are not developed as such but entail rich insights into its context. While neuropragmatism is not only composed simply of philosophy, this section will also encompass some remarks on neuroscience and cognitive science. Although, since the philosophical thread is the fulcrum of a later debate in this paper, this will be the most extensive part in this section, paying a less dominant role to the notions on neuroscience and cognitive science. The neuroscientific thread will thuse restrict itself to notions that can help understand the later EEG analysis

The philosophical thread

As this study is inspired by a fundamental curiosity towards human relations to phenomena, many questions, and highly relevant themes come to mind. Many of these surrounding our perception and experience and the merely existential matters of these. In order to inhabit these while not getting too detached from the context in which this paper is concerned it is worth to empathize that much of the literature presented here is not strictly dealing with lighting, but much of what we shall see is highly relevant to the topic. Before coupling its relevance for lighting, it remains worthwhile for the reader to allow for a moment of de-conception of our usual established understandings.

The sensory body
In the philosophical thread

While writing this paper in the context of lighting design and lighting research, it is important to recognize that lighting, even though mostly perceived in our visual domain, can not merely be treated detached from other senses. This is precisely what the Finnish professor and architect Juhani Pallasmaa is defending in his acknowledged book *The Eyes of the Skin: Architecture and the Senses* (Pallasmaa, 2005). Here Pallasmaa is advocating for an awareness of our senses as being a multi-sensory aspect of our experiences. Through a dedicated treatment of the senses, Pallasmaa is highlighting the sense of vision that historically has been the most privileged one, especially in a western philosophical tradition dating back to Plato and Aristotle. In criticizing this problematic tendency, Pallasmaa is unfolding his taxonomy and primal argument based on tactility as the most fundamental of the senses. He sees the tactile sense as the "mother sense" to which other senses gives rise. He states that:

> *All the senses, including vision, are extensions of the tactile sense; the senses are specialisations of skin tissue, and all sensory experiences are modes of touching and thus related to tactility. Our contact with the world takes place at the boundary line of the self through specialised parts of our enveloping membrane. (Pallasmaa, 2005, pp. 10-11)*

While making this bold claim - although with substantial confirmation form Ashley Montagu in his *Touching: The Human Significance of the Skin* (Montagu, 1986) - Pallasmaa is not as much diverging the debate on which sense should be a privileged one, but merely directs attention to all of our senses and their qualities that must remain equally noticed as instruments for bodily experience. His project in doing so is to open up our awareness of the immense capabilities of the senses and their needed interplay. Vision, he states, if treated alone or without equal respect to the other senses, will only cause problems to arise.

It is to this point that Pallasmaa sees the importance of taking the human organism as a holistic creature that is multi-sensory created. This calls not for singular attention towards a sense at a time but as a continuous and unified relation and thus "(...) qualities of space, matter and scale are measured equally by the eye, ear, nose, skin, tongue, skeleton and muscle." (Pallasmaa, 2005, p.41). It is in such a manner that our sensory engagement and the environment come to redefine one another, as our senses mature and acts based on its stimuli from the environment, the environment gains significance through our body. Hence it is through a multi-sensory engagements that we come to know the world and our self (Pallasmaa, 2005).

These thoughts presented by Pallasmaa mark an important take on our perceptual system, which we will see gain significance in later sections. In his most influential texts, Pallasmaa was clearly informed and inspired by a phenomenological tradition and especially by the French philosopher Maurice Merleau-Ponty, one of the most influential contributors to the philosophical projects of existentialism and phenomenology (Carman, 2008). In his 1942 seminal book - T*he Phenomenology of Perception* - Merleau-Ponty advocates for what came to be some of his major themes

within phenomenology. With his project of phenomenology, he describes it as

> *(...) a transcendental philosophy which places in abeyance the assertions arising out of the natural attitude, the better to understand them; but it is also a philosophy for which the world is always 'already there' before reflection begins—as an inalienable presence; and all its efforts are concentrated upon re-achieving a direct and primitive contact with the world, and endowing that contact with a philosophical status. (Merleau-Ponty, 2002, p. VII)*

Furthermore, phenomenology is to Merleau-Ponty a study of essences and a constant search for a definition of our essence of perception and consciousness. However, as much as it strives to understand these fundamentals, it does "(...) not expect to arrive at an understanding of man and the world from any starting point other than that of their 'facticity.'" (Merleau-Ponty, 2002, p. VII). Henceforth, what comes before any other engagement with any question that may be relevant to humanity, is the one of how life is in the first place facilitated for us.

All of Merleau-Ponty's serious arguments for his philosophy seems to spring from an attack and dissatisfaction with other philosophical traditions. While it is not the intent to examine this context in full extension, a glimpse of what is at stake is of high relevance in order to understand his philosophical undergoing. Merleau-Ponty, especially in his *The Phenomenology of Perception*, launches an attack on the philosophical traditions of '*empiricism*' (realism) and '*intellectualism*' (idealism) and comes to form a third possibility or a third worldview. Empiricism and intellectualism, while having radically opposed views, still have one fundamental thing that is shared among them, "One fundamental thing they have in common is presupposing an initial, at least notional, separation between the physical and the mental." (Baldwin, 2007, p. 2). Empiricism and intellectualism each privilege opposed sides of this division. Empiricism (...) starts with objects in the world as given, and tries to understand the mental in terms of them." and differently "Intellectualism, or idealism, starts with the mental as what is given, and then tries to explicate the physical in terms of it (...)" (Baldwin, 2007, p. 2). These are particular and very opposing worldviews that may seem to carry a Cartesian dualism. To remind the reader, Cartesian dualism is the view that mind and body, are distinct and separate entities, a stance most advocated by the philosophy of Descartes (Crane, 2000).

Merleau-Ponty did not find any satisfaction in such a dualistic view that was the product of Empiricism and intellectualism, and on this basis he comes to propose a more holistic account, which we will see soon. However, on his way to do this, it seems that especially the intellectualist tradition triggered a counter-reaction in Merleau-Ponty. In opposing the much influential philosophies of Descartes and Kant who affirmed that consciousness is what comes before anything else "They presented consciousness, the absolute certainty of my existence for myself, as the condition of there being anything at all (...)"(Merleau-Ponty, 2002, p. X). In maintaining so Descartes and Kant detach the subject and consciousness from anything that may be. Merleau-Ponty, on the contrary, argues that perception precedes cognition. With such a stance, he is rejecting the notion of pure reason and instead affirms that rationality is a product of intertwining perspectives that relate one another in a world that is phenomenologically founded. Herforth perception precedes cognition as the world is brought for us by our perception. Therefore it is through our perception that we form meaning, through and reason. As Merleau-Ponty states

> *The real is a closely woven fabric. It does not await our judgment before incorporating the most surprising phenomena, or before rejecting the most plausible figments of our imagination. Perception is not a science of the world, it is not even an act, a deliberate taking up of position; it is the background from which all acts stand out, and is presupposed by them. (Merleau-Ponty, 2002, p. XI)*

With this, perception is not something that is a casual element in our experiences but moreover is a condition and the background from where we act and facilitate the essences of our lives. But what is also evident in his philosophy of perception is that this closely woven fabric as he describes it is a continuous relational process. To Merleau-Ponty things are only to be apprehended in the context of other things, and therefore it comes to form an immensely sophisticated fabric of our reality that is intertwined by its many relations. This complex of things and their relations that forms our reality (fabric) is to Merleau-Ponty essentially experienced by the body.

One of the most prominent and ever returning themes for Merleau-Ponty is namely the essence of the body. He sees it as the focal point in our very existence because it is our body that is the center of our perception. However, before elaborating on this, it is important to understand why and how this comes to be significant as a central philosophical argument.

Merleau-Ponty had a strong case against traditions of *objective thought* and *objective knowledge*, an attack that can be seen directed towards the philosophy of intellectualism as well as Empiricism. With objective thought, Merleau-Ponty refers to the fact that objects are known and occupy a cognitive and consciousness state. This is to Merleau-Ponty that we have a knowledge of their appearance and function. He states that

> *(...) the house itself is not the house seen from nowhere, but the house seen from everywhere. The completed object is translucent, being shot through from all sides by an infinite number of present scrutinies which intersect in its depths leaving nothing hidden. (Merleau-Ponty, 2002, p. 79)*

Hereby we know object due to our prior knowledge and idea of things. And this is whereby Merleau-Ponty sees that perception ends in objects and that this constitution of the object is a final

destination. What we have just described about *objective thought* is a philosophical tradition Merleau-Ponty attacks because if we reduce our existence and experience of things to the idea and pre-assumption of it.

> *Thus 'objective' thought (...) is formed—being that of common sense and of science—which finally causes us to lose contact with perceptual experience (...) (Merleau-Ponty, 2002, p. 82)*

Henceforth he sets forth a philosophy of perception that must be prior to cognition or as means to arrive at the cognitive states of things. If we do not engage in such a way, we will have no means of finding the essence of things as we will already know the potential and properties in them.
While much of this argues against intellectualism, Merleau-Ponty, on the contrary, affirms that just as consciousness cannot be prior, neither can Empiricism be satisfactory in affirming that objects are known and facilitated as a given. Merleau-Ponty liberates the very dualistic approach in affirming that perception is a prior and a facilitator to knowledge of things and a givenness of things. Such perception is to Merleau-Ponty manifested through our bodies. It is through our bodies that are located in the world, that we come to know and through which we come to give meaning to things in our existence. Henceforth it is not appropriate to think of a world in itself, and neither can we think of a body for itself, as these are only constituted in a holistic entanglement of one another. It is for this reason that we have to pay attention to our embodied sensibility, not simply in the world, but of the world. Fate is henceforth that the body and the world are born in unison. Merleau-Ponty sees the locus of our perceptual abilities to be ascribed to the body because the body is in a sense operating in a pre-personal and anonymous manner "(...) my organism, as a prepersonal cleaving to the general form of the world, as an anonymous and general existence, plays, beneath my personal life, the part of an inborn complex" (Merleau-Ponty, 2002, p. 97). It is with this inborn complex as a pre-personal existence, our actual being in and of the world or so to say, our existence, is grounded.

> *My personal existence must be the resumption of a prepersonal tradition. There is, therefore, another subject beneath me, for whom a world exists before I am here, and who marks out my place in it. This captive or natural spirit is my body (...). (Merleau-Ponty, 2002, p. 96)*

It is our body that while acting as a pre-personal and anonymous spirit is forming a perception of ours in the world. It is by these means Merleau-Ponty sees the body and all its senses and openness towards the world as the primal and first facilitator of anything that may be. This is indeed breaking with a cartesian dualism and a separation of mind and body, as these two are not mere entities but rather part of the same thing that is born in and of the world as a bodily consciousness (Merleau-Ponty, 2002).

The essentiality of Experience

In the philosophical thread

As the body and the senses gained significance in the previous section, what might be useful is an engagement with the notion of experience, as this, which we will see, can act as an enlightening principle for a greater understanding on what might be at stake in our existence. While this notion is hardly to be ascribed to any specific philosophical tradition, the philosophy of Pragmatism holds it as one of their central principles. The much influential thoughts developed by William James, John Dewey, Charles Peirce, George Mead, and C.I. Lewis, formed the basis upon which Pragmatism as a philosophical tradition was formed. To these novel thinkers, the notion of experience is the fundamental principle in the emergence of meaning, as nothing can be said to possess meaning prior to experience (Rosenthal & Bourgeois, 1980). While this might occur rather obvious and in line to that which we have just described in the previous section, the Pragmatists take on these matters, offer a different reconstructionist and novel thinking that is of essence to this paper.

While many scholars have examined the theoretical framework of Pragmatism and their centrality of experience, one can hardly overlook the thorough treatment of Pragmatism by the American philosopher John Stuhr. In his paper *Dewey's Notion of Qualitative Experience*, Stuhr presents some of the influential thoughts by Dewey. Dewey's deep engagement with the notion of experience (and aesthetic experience) as his essential principle in most of his philosophy has a fundamental and vital relation to the concept of activity (energeia). This concept he derives from the philosophy of Hegel and Aristotle. Activity to Aristotle is that:

> *Energeia, (...) is fully actualized functioning or being, as it is its own end, and thus complete at each moment; Aristotle writes that we have seen at each moment that we are seeing. It is in this most general or inclusive sense that what there is, [ousia], is activity, [energeia]. Being is a functioning which is its own end; 'Life,' Aristotle succinctly states, 'is an activity.' (Stuhr, 1979, p. 70)*

Activity (Energeia) as qualitatively unified and complete at all times, implies its continuous striving and achieving. Similarly, this would count for Hegel as activity is "(...) self -actualizing potentiality, a self -positing and mediating, 'the process of its own becoming' [and] must be unity in continuity". (Stuhr, 1979, p. 71).

While the matter of activity and Energeia, as described above, may appear difficult to really grasp, it has great importance for the way Dewey treats experience and the qualities that are

inherent to this notion[3]. He sees that what is inherent to activity is essentially what is inherent to experience and the qualitativeness of it.

> *(...) experience constitutes a continuum rather than separation of means and ends; experience is qualitatively immediate and complete; experience is a transactional whole or unity of organism and situation, of subject and object; and, experience is historical, continuous, and so qualitatively 'funded'."(Stuhr, 1979, p. 71)*

As such, the characteristics of activity as we have seen them are as well inherent to Dewey's treatment of experience. Furthermore, he emphasizes the immediate unity of organism and situation, the subject and object. Just as activity is unity in continuity, so is experience. While moreover, experience is "(...) immediately and unfailingly actualized; its qualitativeness is the (...) unity (experience) of striving (experiencing) and achievement (experienced)" (Stuhr, 1979, p. 72). Henceforth means and ends are forming this unity and its quality in the relation between subject and object.

Dewey emphasizes that the quality of experience, in the first place, is unified, unique and immediately present. By these qualities, it provides the basis for when we name situations as - 'that storm' and 'that gathering' - which implies a unique and unified character. The quality is unified and unique in the sense that it pervades the distinct parts and bits of the experience. In the second place, what remains highly important to Dewey is that qualities are neither to be found in the organism (subject) or the environment (object). If one looks for the quality in experience in either of these domains, quality is never to be found. Qualities are instead experienced in the transaction between organism and environment, as a unity. Henceforth it is wrong to look for the quality in experience in either the physical or the mental because this is simply to misunderstand what is at stake. As Dewey notes in his famous book *Experience and nature*

> *[quality] is not a miraculous ejection from the organism or soul into external things, nor an illusory attribution of psychical entities to physical things. The qualities never were "in" the organism; they always were qualities of interactions in which both extra-organic things and organisms partake. (Dewey, 1958, p. 184)*

Henceforth the quality is a pervasive character that is unified in a situation that inhabits the parts and the elements that exist between the organism and its environment. In such a situation, qualities are experienced, not only as sensory qualities but just as much pervasive and immediate qualities of pleasure and pain. Qualities are henceforth what renders our feelings apparent to us from the very situation in which we partake (Stuhr, 1979).

These notions on quality in experience (which he also refers to as aesthetic experience) will come of significant importance in later sections, but at present, it is worth noticing how these notions draw fine lines to other Pragmatist ideas. In his detailed account of William James' very influential thinking, philosopher Richard Shusterman in the paper *The Pragmatist Aesthetics of William James*, outlines some of the thinking that was central to James, highly represented in his masterpiece *The Principles of Psychology*. Here James (from the reading of Shusterman), develops a philosophy of mind that is integral to how we perceive and experience. The world we perceive and experience is to James not 'an immutable given' and fixed, but rather it is an outcome of a human selection process. In the first stance, our senses are selective organs in that they construct a world from a scope of stimuli they receive and puts this into a sensory sensation. Further, our attention then governs how we experience the world as it picks, those of the sensations to bring forth or amplify. Such a selective process James states is set in motion in that

> *(...) we notice only those sensations which are signs to us of things. But what are these things? Nothing, as we shall abundantly see, but special groups of sensible qualities, which happen practically or æsthetically to interest us, to which we therefore give substantive names, and which we exalt to this exclusive status of independence and dignity. (James, 1983, p. 274)*

This is to say, that, when our attention picks a selection of sensations of importance from this larger group of sensations, our mind will deliberately make once another selection as "It chooses certain of the sensations to represent the thing most truly, and considers the rest as its appearances, modified by the conditions of the moment" (James, 1983, 274). Henceforth it is to James that our mind is an orchestra of possibilities, that constantly selects, forms and details what to maintain and what to maintain as true and as possible explanations to things. This is to James how we come to construct the experience of the world. However, with this, James at the same time affirms that the world might then also be otherwise, as what we know and who we are is simply based on a narrow selection and choices that we have extricated and exercised out of it.

With this, James emphasizes that our knowledge and rational thinking is to a large degree based on an aesthetic and practical selective process that concerns sensations to perceptions. But within this procedure of ours, we also come to define the real character in things, as

> *(...) of each known object we have selected one as the REAL one to think of, and degraded all the others to serve as its signs. This 'real' magnitude is determined by æsthetic and practical interest. [and when] two sensorial space-impressions, believe to come from the same object, differ, then THE ONE MOST INTERESTING, practically or æsthetically, IS JUDGED TO BE*

3 It is worth to mention that although Dewey would find the treatment of activity by Hegel and Aristotle highly impor tant, he would hold just as much disagreement with other parts of their philosophy (Stuhr, 1979).

THE TRUE ONE. (James, 1983, pp. 817-818)

It is by these means that our selective organisms discriminate signs and impressions into finding what may be 'real' and what may fit the purpose that is suitable and aesthetically pleasing at a given moment. To this point it is worth noticing that James occupies a view of democratic pluralism and meliorism, that is to say, he believed that we need to liberate ourselves from a blindness to the potentiality in things. With this - a meliorism - he found that the joys and goods that are there before us in human life have become invisible. As he himself states

> *We are stuffed with abstract conceptions, and glib with verbalities and verbosities; and in the culture of these higher functions the peculiar sources of joy connected with our simpler functions often dry up, and we grow stone-blind and insensible to life's more elementary and general goods and joys. (James, 1899, p. 38)*

In this our way sensible potential has been lost in this very habitualizing blindness that which we suffer from daily. And it is precisely to this point that, James finds a need that we act upon this, that we remind our perceptual qualities of their existence, giving back agency to our more simple satisfactions of "(...) seeing, smelling, tasting, sleeping, and daring and doing with one's body" (James, 1899, p. 38).

While James develops many different and important thoughts on human existence, psychology, philosophy, and experience in general, he can easily be seen as a great inspiration to Dewey's thoughts. One of the central aspects of the quality in experience is to James (as well as to Dewey) that there is a continuity that embraces, as Shusterman would say, "(...) the centrality of aesthetic experience and its unifying power of nameless quality. (Shusterman, 2011, p. 358). When naming it an aesthetic experience one will have to bear in mind that this is not merely talking about art and a pleasure it may evoke, but rather the richness that is inherent to the concept of experience. To James experience and stream of thought is continuous in the sense that it does not have any abrupt breaks and maintains a continuous quality. Here it is a stream or a river rather than a chain of thinking. James explains by referring to "(...) the breaks that are produced by sudden contrasts in the quality of the successive segments of the stream of thought." (James, 1983, p. 233). This is, for example, seen when a moment of silence is broken by a loud thunder. To James, these are not just two separate things as silence in itself and thunder in itself, but rather thunder after silence. In this respect, there is a relational character in every "instant" in our experience that makes it continuous and related. Shusterman puts it will, as he refers to James

> *We overlook the continuity because we typically focus on the 'perchings' (the salient, distinctive resting places) in the stream of consciousness, while not noticing the many things that connect them in our consciousness, including the contextual transitions and relations between them that form the background of our experience. (Shusterman, 2011, p. 359)*

Thus our experiences are not merely 'perchings', but carry with them transitional states, and feelings of relations and nameless qualities normally unaware by us. It is exactly these nameless and unobserved constructions of our experiences that provide a felt quality. As James states, "The significance, the value, (...) is all in this halo or penumbra that surrounds and escorts it." (James, 1983, p. 246). These relations and felt halos, are to James what renders our acts, sensations, selections and cognitive states unified into one whole qualitative continuous process. As such, this 'halo of felt relations' as he would put it, has a psychic overtone that performs an instant quality, and guides the experience itself (Shusterman, 2011).

These notions from James in close interplay with Dewey will become of high relevance in later sections. At the present moment, it is time for some final remarks regarding the philosophical thread that has been laid out. Although not an American Pragmatist, the thinking of Russian philosopher Mikhail Bakhtin is a fruitful acquaintance in the present section.

In the book *Technology as Experience*, the authors John McCarthy and Peter Wright, unfold some of the central thoughts by Bakhtin. In order to follow Bakhtin, one will have to devote to a certain worldview. This is that, to Bakhtin, we have to envision the world as an unfinalized 'thing', as if nothing can be assumed to be finalized and already-known but rather manifests as an open and continuous stream of constant change and hereby that everything is in a dynamic state of becoming. In this way, Bakhtin holds that it is of essence that we remain vivid and open to a potentiality which can only be achieved if we surrender ourselves to the world as an unfinalized thing. For Bakhtin, he sees that we in our minds, habitually conclude and define the reality and existence of things and in this respect finalize them but with this also comes that we lose the ability to see the potentiality that life might have. As McCarthy and Wright stresses

> *We tend to close our minds to the potentiality of the physical, biological, and social world, having already decided what everything is. Because of this, we fail to notice the essential creativity of our relationship with every "thing" that is. (McCarthy & Wright, 2004, p. 70).*

To this point, Bakhtin argues for an unfinalized worldview that is based on a dialogical felt life. In being a dialogical worldview, Bakhtin emphasizes the quality of experiences and that which makes experience meaningful is happening in the relation between the self and the other. This is to Bakhtin an answerable engagement or answerability as he stresses it. The fate is that "I only make sense of my self in terms of how I relate to others and to my own history of selves (...)" (McCarthy & Wright, 2004, p. 73). It is exactly this sort of answerability that comes to form the quality that experience might hold, or as an aesthetic experience as he would like to call it. But

the salient point is that in this dialogical worldview it is the tension and answerable act between the self and the other that both parties are consummated and authored. At his moment, it is that both the self as well as the other are fated by a unique 'excess of seeing' that is fundamental to how a shaping off or a consummation is possible. If a consummation of the self or the other has to be understood correctly, it is worth to notice that to Bakhtin the other can be a person as well as an object or a thing. To Bakhtin, a paradox exists in that we need the other in order to finalize and consummate ourselves. In this way, by our unique existence that is different to the other, the self is in a position to finalize the other, but the self is bound by the other to finalize and author the self.

> *The excess or surplus of the other is required to make up for the self's lack and to consummate the self. The aesthetic experience for the self requires the other but also a return to self. [...] In this moment, the self is authored. Consummation of self entails a dialogue with the other - a meeting of two consciousnesses - that confirms the unique perspective and value of the self, allowing the self for a moment to experience unity and completeness. (McCarthy & Wright, 2004, p. 75)*

Here we see with Bakhtin a process that is continuous and in a constant state of becoming and only reaches its destination as interactivity and answerability occurs between self and the other (McCarthy & Wright, 2004). These notions of dialogue by Bakhtin carry many similarities expressed with Dewey's transaction, James relational halos, Merleau-Ponty's body-in-the-world. This can eventually help us better contemplate the relevance of experience in relation to lighting. While these notions from Dewey, Merleau-Ponty, Pallasmaa, James and Bakhtin all revolve around the matter of experience, they can also be seen to be integral to what the German philosopher Gernot Böhme calls atmosphere. In his *The Aesthetics of Atmospheres*, Böhmes take on atmosphere resonates what we have dealt with in this section

> *The elements of the environment are not only causal factors which affect human beings as organisms but they produce an impression on their feeling (Befindlichkeit). And what mediates objective factors of the environment with aesthetic feelings of a human being is what we call atmosphere. The atmosphere of a certain environment is responsible for the way we feel about ourselves in that environment. (Böhme, 2017, p. 25).*

To Böhme, atmosphere is then what mediates our state in a certain context our situation as it is this that is in-between that comes to define the subject and the object at that moment (Böhme, 2017). In this respect, Böhmes atmosphere, along with the other notions we have seen in this brief philosophical section, will form a basis upon some of the discussions that are to come.

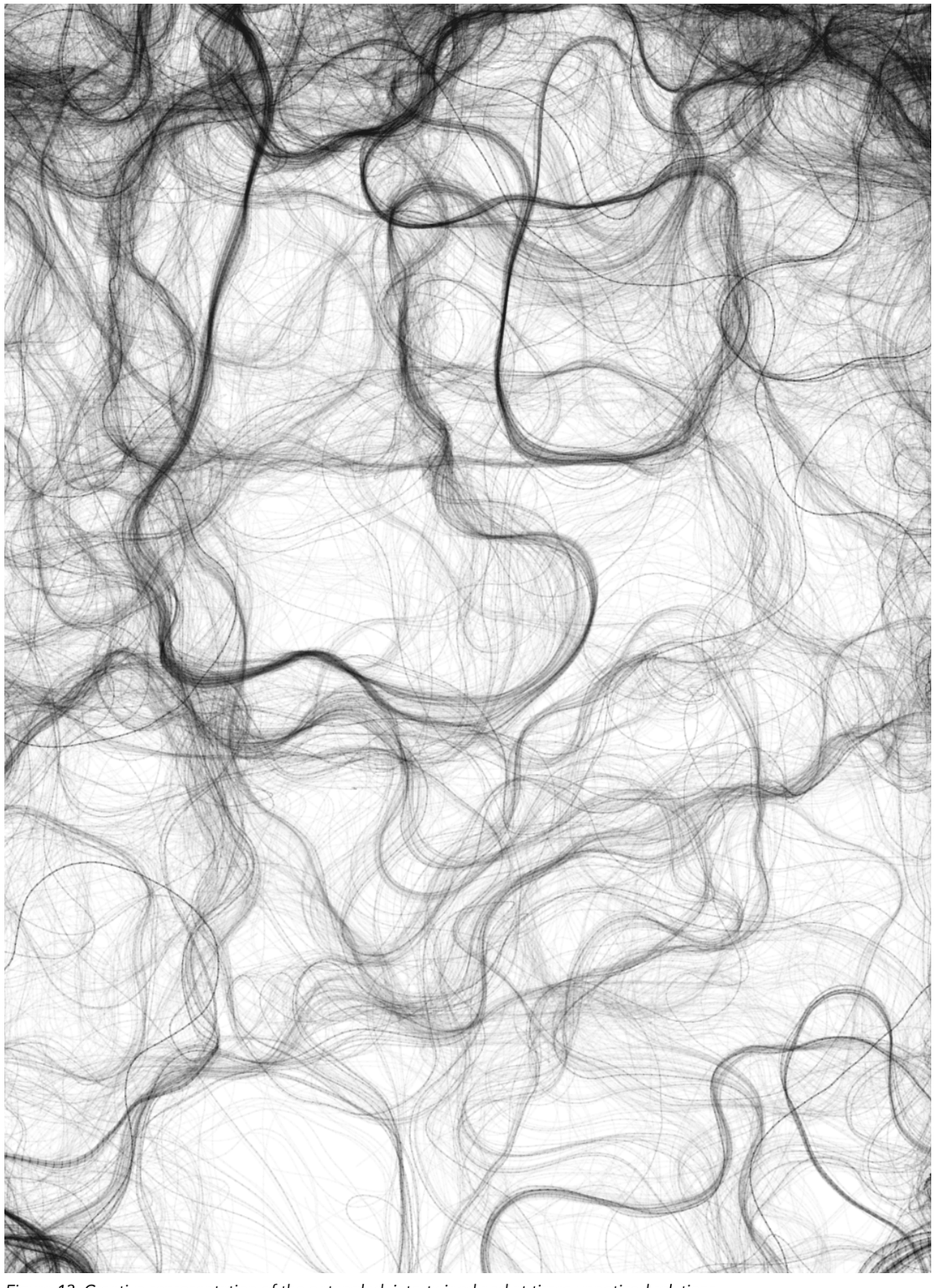


Figure 13: Creative representation of the entangled, intertwined and at times unnoticed relations between human and its environment (own figure)

The neurological thread

In this section, it is not the intention to unfold a theoretical framework for a neurological as well as cognitive science, and neither is it the intention to cover the vast aspects that are inherent to these disciplines. Instead, this section will provide some fundamental low-level aspects of our cognitive and neurological affairs that can act to support and better understand the EEG related findings and procedures that are presented later. Therefore it will be stressed that this section by no means can cover all the fundamentals but only the necessary aspects for understanding the later EEG analysis.

To start with, when talking about our usual processing of information and cognitive states, the brain have an autonomy constituting various areas that has different function and which come to make all this possible. A brief description of some of the central features will serve as a good starting point. In his much-appreciated book - *The Biology of Thought: A Neuronal Mechanism in the Generation of Thought - A New Molecular Model* - Krishnagopal Dharani helps us on some of these matters. The brain is the central and most important coordination organ in human as it receives stimuli and response based on this. Central to these functions is the nervous system. This can generally be divided into two groups, the Central nervous system (CNS) and the Peripheral nervous system (PNS). As the Central nervous system amounts to the brain and the spinal cord, the Peripheral nervous system constitutes all other nerves in the body that is outside the Central nervous system. There is a back and forth communication between PNS and CNS, as the PNS detects information from the surrounding environment (through the body) it communicates back to CNS, and similarly, CNS responds back to PNS to determine how to react to the environmental condition (Dharani, 2015). One could go into many of the details that is inherent to these structures but this would be too exhausting and beyond the scope of the paper.

Instead, it proves of good value to zoom out and look at some of the regions in the brain, as they in different ways obtain functional characteristics that may come of importance in a later section in this paper.

Among different structures in the brain one will find the four lobes, that are the Frontal lobe, Parietal lobe, Occipital lobe and Temporal lobe.

Each of these carries different functionalities. In this review, we will direct focus towards the Parietal lobe. This lobe is located above the occipital lobe and behind the frontal lobe. While the parietal lobe has many functions, what makes it differ from the other lobes is that it is highly responsible for sensorial stimuli as it is part of the somatosensory cortex (and working with the somatic nervous system).

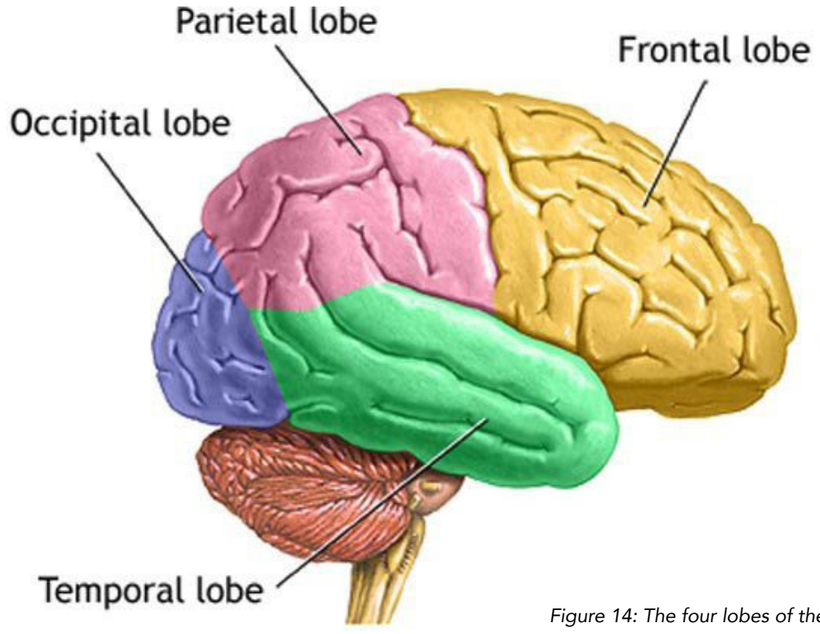


Figure 14: The four lobes of the brain (Kellie, n.d.)

This is evident with the Postcentral Gyrus, the areas concerned with somatosensation. The Parietal lobe is the area where information from our senses is perceived and processed. This region represents information on touch, limb position, temperature and pain. In general, this lobe has five major functions

> *(...) the primary analysis of somatic sensation (touch, the position of the limbs, temperature); the analysis of space using all sensory modalities; the specification of spatial targets for the motorsystem; the generation of attention; and the analysis of visual motion. (Goldberg, 2001, p. 11051)*

Moreover, it allows for the detection of variations in textures and perception of small changes that affect the sensory system and also compares various qualities in the sensations. Furthermore the Parietal lobe is also important in the processing of language (Augustine, 2008; Ruf.rice.edu, 2000). These distinctions on the Parietal lobe will show their importance in later sections.

To this point, a shift of focus is needed because to be able to engage with the findings and EEG analysis in general, we need to clarify some basic concepts about the brain waves that occur in us at all times. However these brain waves are of different characters. When neurons fire, they produce electrical signals that combine to form brain waves that oscillate at different frequencies (Ham, 2019). Our brain waves differ dependent on what we are doing. It can be said that the slower brain waves, those of a low frequency, in general, are dominant when we are sleeping,

meditating, feel tired and are not overly active. Differently, the faster brain waves, those of a high frequency, in general, are present when we are alert, feel active and attendant to process information quickly etc. Brain waves are categorized and measured in Hertz (Hz), that are the amount of cycles per second. Often they are categorized into the following (Baars, 2013; Brainworksneurotherapy, 2019; Ham, 2019).

Delta: 0.5 - 3 HZ
In this category, the brain waves are of a prolonged character, with a low frequency and a high amplitude. These are most often seen and dominant in deep dreamless and unconscious sleep and deep meditation. Most often, delta waves increase when awareness of the physical world increases.

Theta: 3 - 8 HZ
Theta waves are often seen in sleep and quiet meditation but has also been seen in relation to memory tasks. Hereby theta waves are often associated with learning and intuition in which we are detached from stimuli from the environment. In this state, we usually only experience vaguely in that we fall asleep or we become awake. In theta, we are imagining, in a state that normally occurs out of conscious awareness in dreams.

Alpha: 8 - 12 HZ
Alpha waves are most often occurring in relaxation and thoughts that remain of a quiet stream. Alpha waves are normally more present with eyes closed but this while being awake.

Beta: 12 -38 HZ
Beta waves are mostly present at moments where cognitive tasks require attention, and therefore, it is a rather fast and irregular activity in the awake state. Areas of problem-solving, focused activity, busy and to time anxious thoughts and engagement to things trigger beta waves. Beta waves, as they cover a large frequency band are often divided into three, sub-bands in which the level of its characteristics grow more and more intense from its lower band to its highest band.

Gamma: 38 - 42 HZ
In Gamma waves, information is processed rapidly and is considered to be the fastest of the brain waves. Normally gamma waves are best obtained when the mind is quiet. (Baars, 2013; Brainworksneurotherapy, 2019)

These divisions of frequencies are worth to consider when the findings of the EEG experiments are presented. In order to be able to make something out of the data that is presented later, we have to note some basic concepts related to EEG. Here we have to see what Event-Related Synchronization (ERS) and Event-Related Desynchronisation (ERD) means. Pfurtscheller and Lopes da Silva, through various contributions, shed light on the matter of these concepts (Pfurtscheller, 1992; Pfurtscheller & Lopes da Silva, 1999; Pfurtscheller, 2001). Both concepts are concerned with how neurons behave and all dependent on their behavior it can reveal some of the cognitive states in the human brain. That the brain is in the state of a desynchronisation (ERD), means that "(...) in the underlying neural network or neuronal circuitry, small patches of neurons or neuronal assemblies work in a relative independent or desynchronized manner" (Pfurtscheller, 2001, p. 1259). This (ERD) is here in the form of a synchrony decrease of the neural populations and its rhythmic activity is of a decreasing amplitude. Pfurtscheller and Lopes da Silva affirm that this sort of neural desynchronization represents states of extreme readiness and high load of information processing. Hereby a desynchronisation represents that neurons in the brain are in an active state in the form of increased cortical area of activity/excitability. Furthermore, desynchronisation is a correlate of active processing of stimulus but is also characterised by neural formations preparing to deal with sensory information.
On the contrary, event-related synchronization (ERS) is characterized by a cooperative and synchronised behavior of neurons where a rhythmic potential leads to an amplitude increase. ERS is then characterized in states of reduced processing of information and deactivated brain network.

It is vital to stress that such event-related desynchronisations (ERD) and event-related synchronizations (ERS) are very frequency-band specific. This mean that what ERD and ERS means in one frequency-band, (let us take the Alpha band), might be different for the Gamma band. The above characteristics of ERS and ERD are inherent to Alpha and Beta frequency-bands. Pfurtscheller and Lopes da Silva affirm that in the gamma-band when neurons occupy resonant behavior (like in ERS), the characteristics carry out as an active state of information processing. In this respect, ERS and ERD are rather frequency-band specific (Pfurtscheller, 1992; Pfurtscheller & Lopes da Silva, 1999; Pfurtscheller, 2001).
This brief terminology will take us far in the analysis of the experiments that we will explore soon.

In this literature review, it is evident that a substantial focus has been given to the philosophical aspects, while the neurological thread has been given less focus, as this latter part is mostly provided to be able to analyze and understand the EEG recordings. Both of which are provided to form an understanding of the coming sections.

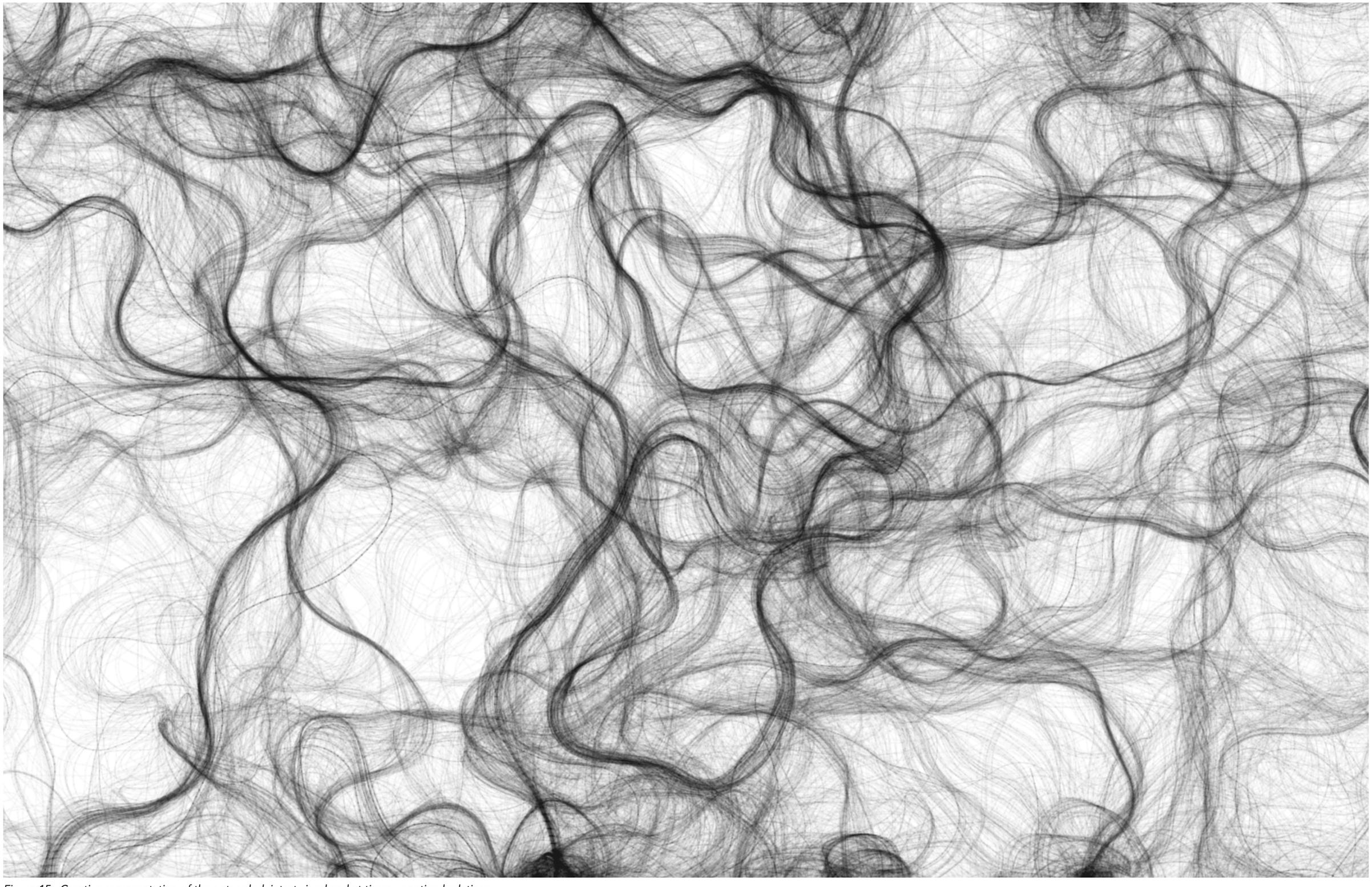


Figure 15: Creative representation of the entangled, intertwined and at times unnoticed relations between human and its environment (own figure)

Problem statement

Up until now, the paper has provided a contextual field of lighting and colored illuminations as well as a background of its inspiration, making grounds for an unfolding of a neuropragmatist approach that has inspired to form a theoretical section. Following this, the paper has so far set a framework from which the forthcoming can be considered. In order to proceed, a problem statement has been formed. The problem statement sounds as follows:

Is there a relation between lighting and our non-ocular-body and if so, what does this mean for light and color illuminations in relation to our cognitive states? In this respect, what might the implications then be for human relations to the world?

The problem statement is companioned by a curious interest in human relations to the phenomena of lighting. This interest is at large maintained from an intertwining of science and humanities, that suppose a neuropragmatist approach to help in this quest. While the scientific thread is seen to be the tool in this undertaking, a more thorough emphasis is devoted to a philosophical treatment of lighting and colored illumination as to explore the essential qualities it might provide for our experiences.

Design approach and experiments

This section will focus on the design of experiments and procedure that has come to shape the final test. In this respect, it will be divided into four sections, that is; *the experimental setup*, *the experimental preparation*, *the final experiment* and lastly *the post-processing*. These sections will both provide insight into how the process has evolved as well as the reasoning for the choices that have been made. Further, this section will also feature the hypothesis for the experiments. However one will have to keep in mind that not many EEG experiments, has featured tests of color illuminations when being blinded, therefore some aspects are of experimental characters. Further, it is of utmost importance to bear in mind the methodology we have described earlier in which both neuroscience as well as the philosophical thread inform one another, both in decision making and in evaluation on the design and its procedure.

Experimental setup

In Design approach and experiments

All the experiments took place in a room at Aalborg University, Copenhagen. Below, one can see the room and a gray space that indicate the experiment space (gray space size: 240cm * 280cm). This is the space where the participant would sit in a chair, wearing the EEG cap that would read the electrical activity from the participant's brain (this will be unfolded soon).

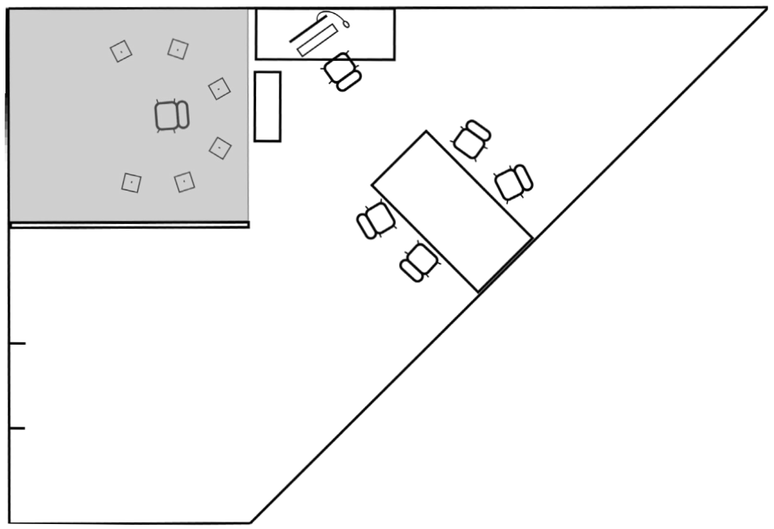


Figure 16: Experiment space (own figure)

The reason for closing off and limiting the experiment space to such a small area was so that the light would be somewhat controlled and intense in a small area. The surfaces of the experiment space were covered with white smooth wooden plates, so that light was not absorbed in any materials and made sure no color bleeding was possible. The lighting fixtures are marked in the picture as six boxes (in the gray space and placed approximately 70 cm from the chair) that would surround the participant. The light fixtures used for this experiment were 6 x two-meter long LED-fixtures. The fixtures had an acrylic diffuser on top of an LED strip in the fixture, that would ensure a good spread and distribution of the light. The fixtures were borrowed from Vertigo Obscura (Vertigo, 2019). The LED strips in the fixture are of the model number SK6812 that has an RGBWW ability. This means that they are programmable LEDs that can range between Red, Green and Blue and warm white. Along with the light fixtures, a box with hardware (Teensy, power unit etc.) was used to program the lights to do as wanted. The protocol used was DMX over ArtNet. In terms of EEG equipment, a flexible cap with 16 electrodes was used. The placement of the electrodes follow a general distribution over the brain, following the standard 10-20 array system (Northrop, 2017). These are the electrodes of F3, Fz, F4, T7, T8, C3, Cz, C4, P7, P3, Pz, P4, P8, O1, Oz and O2. Their placement on the head can be seen in figure 17.

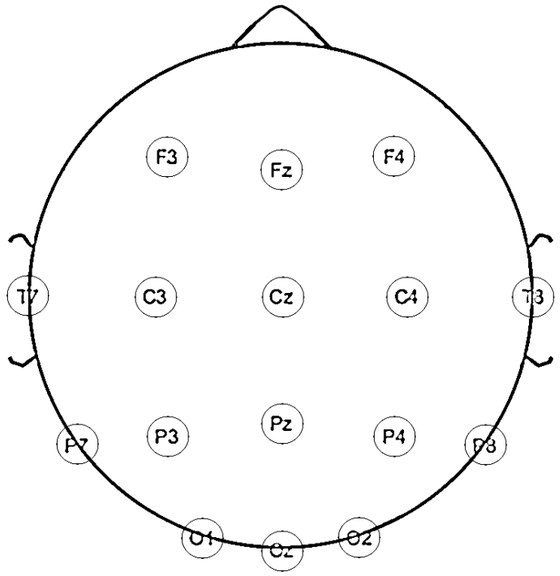


Figure 17: Electrode array (own figure)

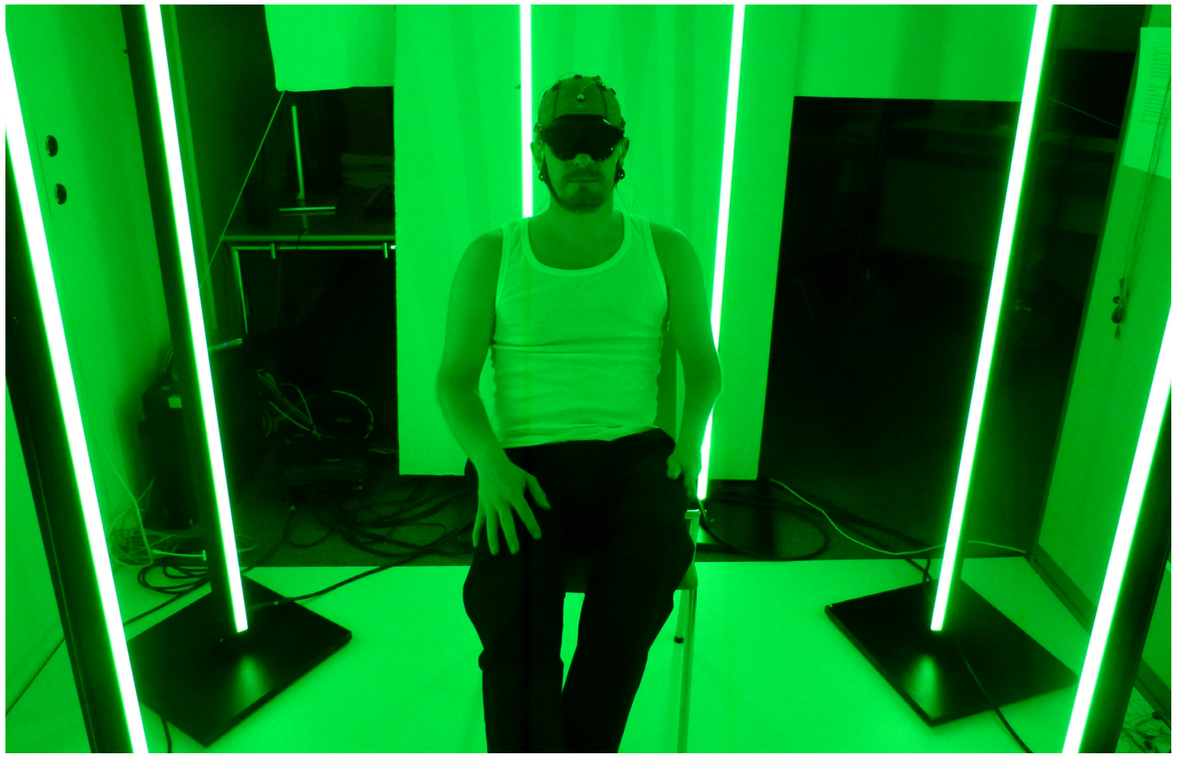


Figure 41, 42, 43 & 44: Experiment space and color illuminations (own figures)

Aside from the hardware-side of the setup, the experiment carried some essential software combinations. Below one can see the structure of these. Everything starts and is connected to a Max MSP script. In this respect, a Max Msp application was developed in order to be able to communicate with both the triggering of events that has to do with a shift in light and as well triggers for the EEG recording. This Max Msp script would sent out OSC messages (Open Sound Control -protocol) at certain moments in order to perform a possible shift in scenarios (this will soon be explored further). A trigger sent to MadMapper would then be able to communicate with the light fixtures, accordingly to what the Max Msp patch would tell it to do. At the same time of communicating to MadMapper, it would talk to Simulink, so that an EEG recording would start and put 'events' when the Max patch told it to.

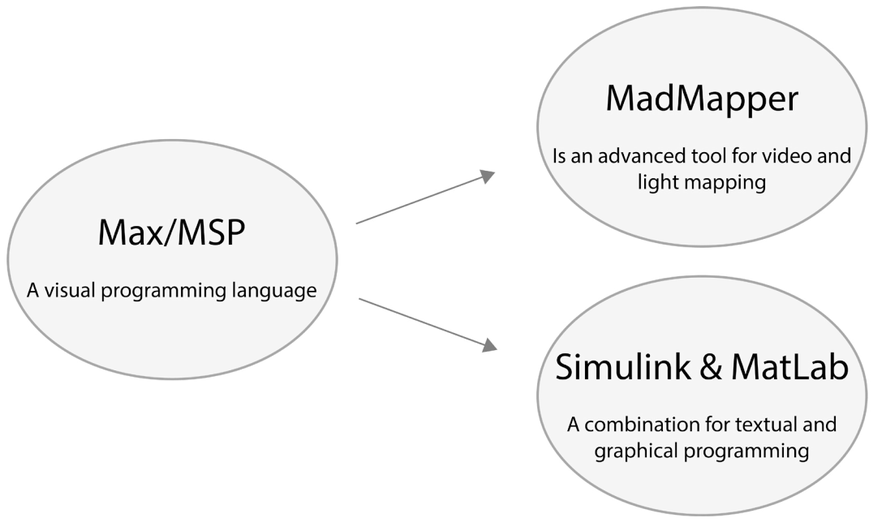


Figure 18: Communication system(own figure)

One could ask if all these complications in computational communication are necessary? The reason is that our brain is extremely quick in processing information, even faster than 100 milliseconds (Trafton, 2019). Therefore the triggering of EEG events and light scenarios had to be precisely correlated, in order not to start the EEG reading or light scenario at the wrong time. With this brief overview of the setup, one can better engage in the specifics we are about to dig into.

Experimental preparation - a learning process

In Design approach and experiments

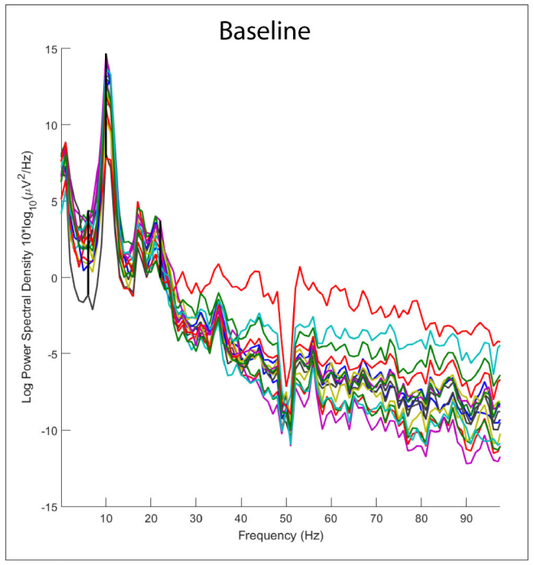
In order to get started with EEG recordings and learning the procedures to do so, a preliminary hypothesis was made: - *light and possibly color in light has some effect on the body when the sense of vision is disabled* - and this was the initial departure for the experiments and preliminary testings. In order to undertake an experiment that could examine this, a blindfold was used. This was a flexible multi-layered fabric cloth, that would fit neatly on and around the eyes. It was tested in the experiment space with light fully turned on and off and it was not possible to detect any light change.

Initial testings examined the functioning of the technical setup (Max/Msp, OSC, MadMapper, Simulink) and furthermore determined if such a type of experiment could indicate something interesting for the initial hypothesis.

In the first pre-test, a test subject would be exposed to red light for three minutes. As stated earlier, some of the aspects were experimental in these first tests, because there were no real comparable EEG experiments. However, in relation to the duration, it is known that some of the slowest neural messages occurring in the body can be up to two seconds in signal speed (Myers, 2014). This may indicate that the exposure time should be at least two seconds, however, not much evidence has been shown on the transmission rate of neural sensations occurring under exposure to light when blindfolded. Therefore, it was decided to keep an exposure for three minutes, making sure that if the body could sense light, there would be enough time to detect this. The selection of red light in this pre-test remains an experimental choice and part of a learning process.

The test was performed on a male professor (teaching at Lighting Design), and he was provided a tank-top, in order to enlarge the skin surface that the light could shed on. A normal procedure for EEG based experiments is to have a baseline period before stimuli so that one can have a reference. Therefore the first pre-test had a baseline of 1 minute - reading the brain activity without any light turned on - followed by three minutes of red light.

This first pre-test indicated that there was a slight difference between darkness (baseline) and the red color exposure in some of the frequency bands (see figure 19 & 20). Here a simple analysis was performed to determine the power of the signal (from each electrode) distributed over frequency bands.



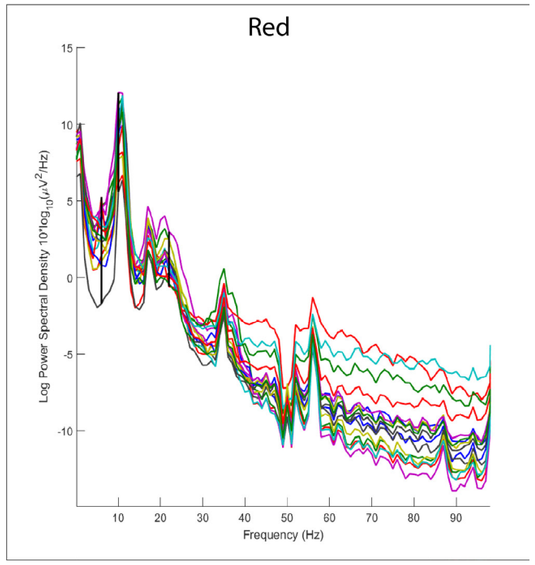
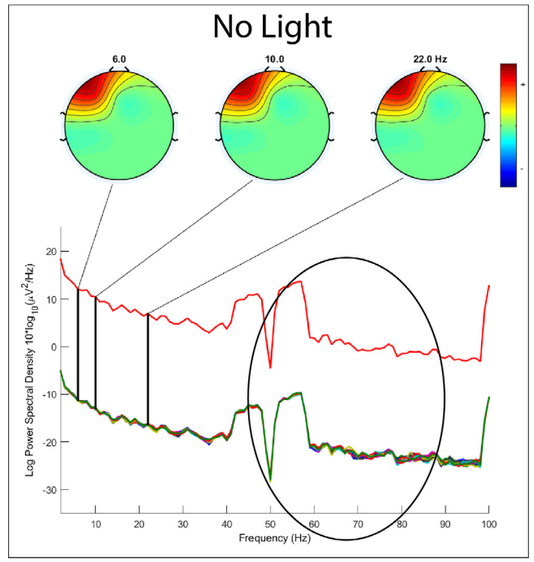


Figure 19 & 20 first pre-test (own figure)

From this comparison between the baseline and red color exposure, it was seen that the low frequencies in the alpha band (8-12 Hz) as well as some beta frequencies (12-38 Hz), differed among the baseline scenario and the red light scenario. While this could at no means come to conclude anything, as it was only performed on one person, it was treated as an indication and a thrive to carry on more experiments within this area of focus. Furthermore, it was seen in the raw data, that a change could be seen in the very instant that the light was turned on (red color), and therefore it was also decided that the duration of three minutes could possibly be lowered.

Of equal importance, it was seen that around 50 HZ and upwards, there seemed to be some noise artifacts. It was hypothesized that this could possibly have to do with an electrical field that was evoked as the light was turned on, which possibly could affect the readings.
Another pre-test was therefore initiated to determine this potential electricity interference[4].
This showed that at around 50 HZ and above, there would be interference from the electricity, as seen from the comparison between no light and light on (See figure 21 & 22). Therefore, for the next experiments, it was decided only to look at the frequencies below 50 Hz and cut off the ones going over 50 Hz.

4 The EEG cap (with all the electrodes) was placed in the experiment-space and by putting a finger on the reference electrode it was possible to detect if any electrical interference would occur when the light was turned on.



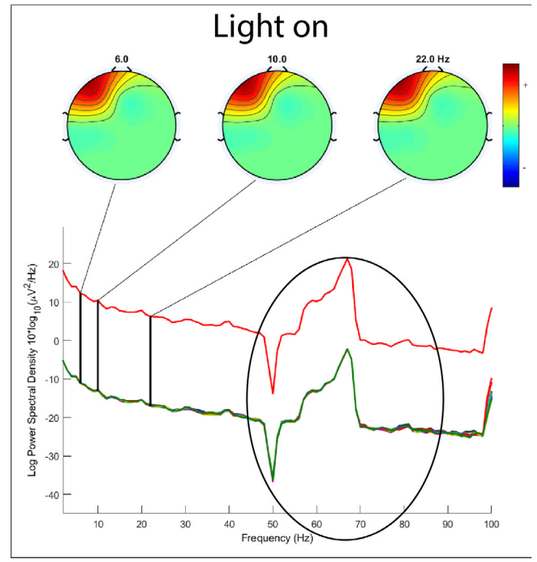


Figure 21 & 22: first pre-test (own figure)

In order to proceed to the final experiments that could feature more colors than just red, multiple pre-test and evaluations were initiated. These tried to combine different colors of light into one EEG experiment. At this point, it also became apparent that only exposing one color one time, would not be enough as the validity of the data would then not be sufficiently strong. Therefore it was decided that each color should be repeated more times. This is also known to be a standard procedure in EEG experiments, that exposure to a stimulus has to be repeated, in order to get proper and valid EEG measurements (Bos, 2007).

At this point, three parameters became important:

Which colors to use.
Duration of exposure to each color.
Number of repetitions of each color.

As no predefined formula was at hand for this, multiple tests and examinations were initiated, in order to determine the three aspects listed above.
In terms of the first aspect, of which colors to use, it was not as much the scientific testing but rather the humanistic concern that defined this. Since we on a normal basis are surrounded by natural and artificial lighting in which some wavelengths are visible to the human eye, it came clear that the EEG experimentation should try to feature as much of the visible spectrum as possible, as this is often the spectrum that the lighting designer utilizes. Henceforth it is commonly

known that the human eyes have three cone types, each with photopigment differences that are sensitive to specific wavelengths of light, that is the short (blue), medium (green) and long (red) wavelengths (Purves et al., 2001). In this respect, it illustrates the sensitivity of the human eye but this may not be applicable to the skin as this organ is of a different architecture. But if the skin is at all sensitive to light and various wavelengths, one could hypothesize the potential that it would act as a supporting leg for our visual system. In this respect, the three colors of red, green and blue were chosen for the EEG experimentation. For each color illumination, the MadMapper settings were set to a 100% opacity, making the color 'intensity' as vivid a possible[5]. The specific wavelength of each of the three colors were measured using a spectrometer (Asensetek, 2018). Here the red light had a spectral peak at 627 nm, the green a peak at 517 nm, and the blue a spectral peak at 464 nm (the full spectrum maps for each color can be seen in the appendix).
As for the second aspect, duration of exposure to each color, the duration was set to 30 seconds for each color. This was estimated to be a fair amount of time, as previous pre-tests showed stimulus detection almost at the outset of light exposure. The reason for extending the duration to 30 seconds was simply to explore if stimuli (lighting) detected by the skin would differ over time.
The last aspect, number of repetitions of each color, was closely estimated in relation to the second aspect seen above. Here a number of five repetitions was chosen, as this would make the results more valid. The reason for not increasing the number of repetitions was due to the fact that people were almost falling asleep when the total time was too high. For these reasons, the five repetitions of each color were chosen.

At this point, the steps that form the final experiment have been clarified. A final aspect of the test was decided. A dark scenario in between each of the colored scenarios could act as a cool-down period. In this sense, if there were anything to report from light and color stimuli through the skin, the cool-down period would allow these indications to stand more clear. With this cool-down period, it would also allow seeing if there would be any "aftermath" or sudden differences, or adaption period between going from a light scenario to a dark one. Therefore the experiment would look something like this, as it is seen in figure 23.

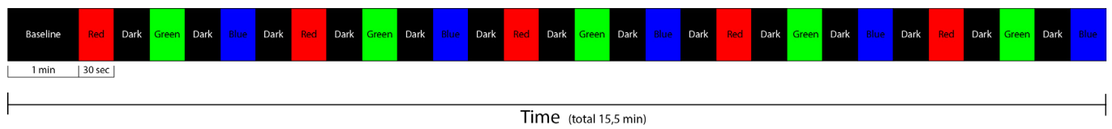


Figure 23: experiment structure, without randomizer (own figure)

5 The reason for stating the 'intensity' as a 100% setting of each color in the MadMapper software, and not stressing the luminance or illuminance levels, is that these photometric units are only relative to the sensitivity of the eye. They only describe relative luminosity, that means that all such units are measures of the eye, that is most sensitive to green light of 555 nm. Hence, when measuring green light a luminance will be higher than that of blue or red light. Therefore, as not concerned with the sensitivity of the eye, the units of luminance and illuminance are not applicable when dealing with the skin, that does not have the same architecture as the eye. Therefore such units would be misleading in this respect.

However, as this shows a structured order of the colors, a randomization algorithm was made in the Max patch. Hereby there would never be a logic of which color that would come after one another, making it less biased. However, it preserved the dark states in between each color.

Since the experiment would aim to solely look at the body/skin response to light and eliminate vision, a completely blinding blindfold was ensured. The blindfold was optimized to some swimming-goggles that was made blindfold proof as well as would make a vacuum on the face, letting no light in. The blindfold potential of these goggles was tested with a light sensor that has the sensitivity as the human eye (Adafruit n.d.). This sensor was placed inside the goggles while a test person would wear them. Exposed to light and shifting between the scenarios seen above, showed that no light was entering into the goggles. This revealed the proof of the googles being completely blinding when they made a vacuum on the participants face. The light sensor was therefore removed again and the final experiments were ready to be initiated.

Final experiment - hypothesis and procedure

In Design approach and experiments

Up until now, the steps and reasonings for the final experiment are clarified. Now we know details on the experimental setup, the colors of light and their durations. For this full experiment, two hypotheses were made.
The first one illustrates a general curiosity towards light and how it might implicate for us other than the visual domain of the eye. This sounds as follows.

> *Lighting can affect us through our skin when the sense of ocular vision is disabled!*

This raises questions towards a general potential of light and moreover the cortical reactions and activity that light may be inherent in modulating.
The second hypothesis is different as it taps into the specifics of lighting. It states that

> *Human skin can differentiate between different colors of light, rendering a modulation in cortical reactions.*

This second hypothesis is looking for a potential that is more specific in lighting, namely how colors possibly can change our brain activity. While these two hypotheses are fundamentally odd and may seem questionable, they are inherent in the present study and has been the statements that have guided a view on lighting as a potentially rich phenomenon. The final experiment was, therefore, aiming to clarify the two statements.

The final test included 22 test subjects. These people were healthy students in the age between 23 and 33 years old, equally covering both genders. A brief walkthrough of the final experiment will render more clearly the various steps.

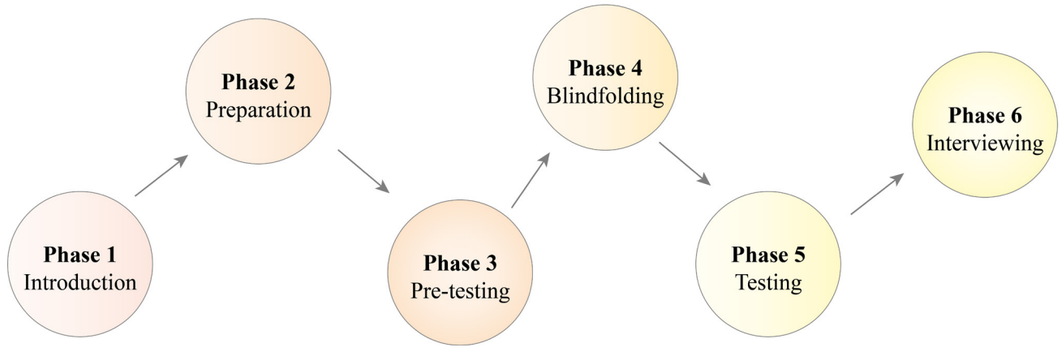


Figure 24: Final experiment phases (own figure)

- Phase 1 - Introduction: One test subject could participate at a time and each participant would at the outset get an introduction to the purpose, the duration, and instructions related to the test. Only a sufficient introduction was given, as not to make the participant biased. The total duration was stated to be approximately 30 minutes. Here the first 10 min would cover phase 1, 2, 3 and 4. Phase 5 would cover the actual EEG test of 15,5 min and in the last phase an interview was given a maximum of 5 min. The participant was provided instructions on what to do throughout the test such as: remain calm, do not speak and do not move when the EEG is recording.

- Phase 2 - Preparation: Here test the subject was provided a tank-top to wear (as to allow more exposure of skin surface) and asked to hand over mobile phones and other digital devices. The test subject was instructed to sit on a chair in the experiment space and the EEG cap would be put on.

- Phase 3 - Calibration: Test subject, while sitting, would go through two pre-tests as to ensure a clear signal and well-working equipment. This included clenching the teeth and blinking with the eyes.

- Phase 4 - Blindfold: The blindfold would be put on the test subject, ensuring a vacuum between the googles and the face. The test subject was asked to report if he/she could see anything and if not, the experiment could proceed. Before the actual test would begin, the test subject was asked to close their eyes, sit still and keep quiet during the test.

- Phase 5 - Testing: The test would run for 15,5 minutes shifting between the different color illumination scenarios.

- Phase 6 - Interviewing: It was decided to include an interview after the EEG experiment. This would ask two questions: How was the experience of participating in the experiment? Followed by: Was any of your senses triggered, and if so, can you explain this sensation?

This was the procedure for the final experiment, however, before unfolding the findings, a last step was needed in the process. This has to do with the Post-processing.

Post-processing

In Design approach and experiments

In order to express the results of the EEG experiments, various steps of postprocessing were needed. The following list shows in chronological order the required steps.

Pre-processing:

- Each set of EEG recordings were given a high pass filter (0,5 Hz) in order to remove signal drift.
- Then a low pass filter (48 Hz) was used to remove everything exceeding 50 Hz. As found in the pre-tests an electrical field interfered in frequencies above 50 Hz, therefore everything above was removed.
- A notch filter (48-52 Hz) removed power noise.
- Following these filters, the data was manually scrolling through to look for possible artifacts. This included an interpretation method (if an electrode channel would have too many artifacts, it would be interpolated to look like its neighbor channels).
- A re-referencing method (moving the reference to other locations) would enable an average signal for all electrodes.
- Independent Component Analysis (ICA) - was used to detect noise, eye movements, muscle movements etc. that was not EEG related, and hence removed.

At this point, the data was clean. Two different methods were then used to evaluate the data, that is a *Power Spectrum Density* (PSD) analysis and a *Temporal Spectral Evolution* (TSE) analysis. For both techniques, the 'event signal' triggered by Max Msp was put into the clean EEG data, to determine when scenarios were shifting.

- For the PSD analysis, spectrograms for various conditions and persons were extracted and divided into the different frequencies (Delta, Theta, Alpha, Beta and Gamma). Then a sum of the different frequency areas from each test person was found and an average was made. A rank-sum test could then determine the significant differences between scenarios, as well an effect size could determine the strength of the significant difference.

- For the TSE analysis, a Fast Fourier Transform (FFT) algorithm, could help determine how the frequency bands would evolve over time. At first, this would determine FFT for each test person, electrode channel and condition/scenario. An average FFT was then made for each channel and condition/scenario. To compare scenarios, a Wilcoxon rank test was used to compare conditions against one another and with this, the significant event-related desynchronization (ERD) and event-related synchronisations (ERS) were found.

In the findings section, the results of the TSE analysis will be explored as this revealed more interesting patterns compared to the PSD analysis. The Temporal spectral evolution (TSE) determine the event-related changes that occur in the frequency over time (Salmelin & Har, 1994). This is what remains interesting to explore in the next section.

Figure 25: Light and skin (own figure)

Analysis and findings

In this section, the findings will be presented and analyzed. The reader will be presented with some of the rough results from the tests and afterwards, some interpretations and possible correlations will be proposed. It is important to keep in mind that all the findings cannot be presented here, as there are many details to dig into, so therefore this section will be restricted to look at the most indicative and prominent results that can provide an answer to the two hypotheses that we have previously seen.

To start with, and in order to follow the coming analysis, it is important to keep in mind the order and placement of the electrodes that were used in this study, this was previously shown in figure 17.

The following section will refer to the method of Temporal Spectrum Evolution (TSE) that has been used to arrive at the results. Here it is worth to give an example of how this will be presented. When looking at the results from the electrode F3 (marked in figure 27), the findings from this electrode will present it like it is shown in figure 26. This represents the average of F3 measures of all test subjects. In this specific figure, it sums up the average of the F3 results in the blue scenario. Here it is seen, first, on the left-hand side the different frequencies (remember the aforementioned division of the frequency bands: theta, delta, alpha, beta and gamma). Second, at the bottom of the figure is shown the time duration, which is from 0-30 seconds (the duration of blue exposure). The slot placed before the dotted line is the average of the baseline (no light). Third, on the right-hand side, is a color gradient that is a measure of microvolts (μV) from the electrode. When the microvolts are measured to be low, it will have a blue color and this is resembling an event-related desynchronisation (ERS). On the contrary, when the microvolts are higher (closer to 3 microvolts), it will have a red color and hereby indicates an event-related synchronisation (ERS). When the microvolts are closer to 0, it resembles that not much deviation is occurring relative to baseline. It is important not to confuse the fact that the test included red, green and blue colors of light and these graphs are shown with red and blue colors, this has no correlation. Hereby with this graph, the ERS and ERD can be determined, that occur over time in specific frequency bands.

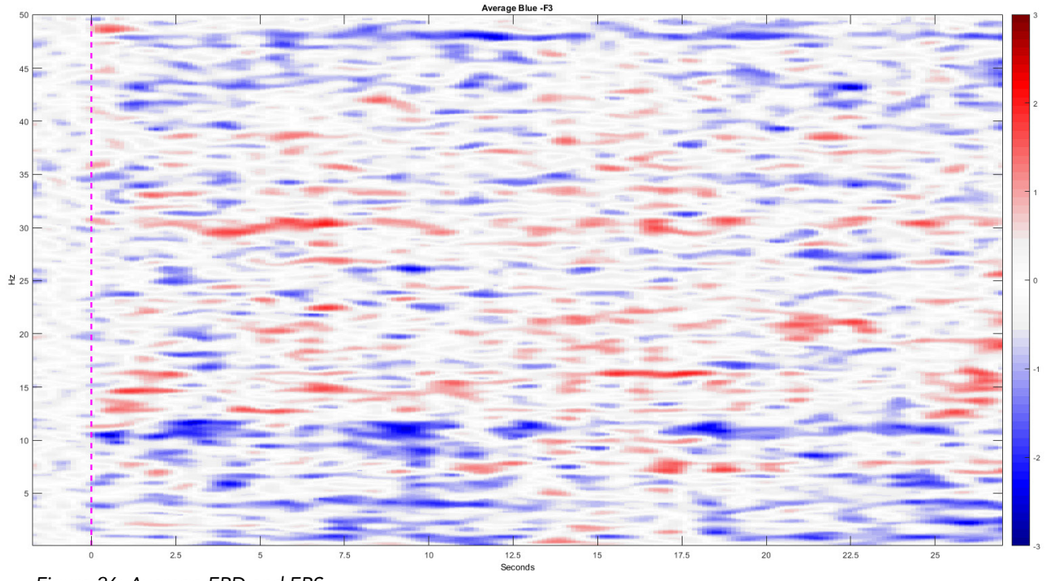


Figure 26: Average ERD and ERS over time for electrode F3 in the blue illumination. (own figure)

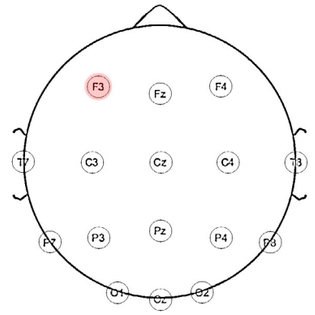


Figure 27: Electrode F3 (own figure)

Now that groundwork is established a for how to understand the data, one can look at the findings that have occurred. First, the average results from the dark scenarios are presented in figure 28. Second, the average results from the red scenarios are provided in figure 29. Third, the average results from the green scenarios in figure 30. And lastly, the results from the blue scenarios in figure 31. The figures are placed as to match the correct placement of the electrodes (each result and more data can be found in the appendix). Below the figures just mentioned, some of the rough correlations and findings will be presented.

Darkness

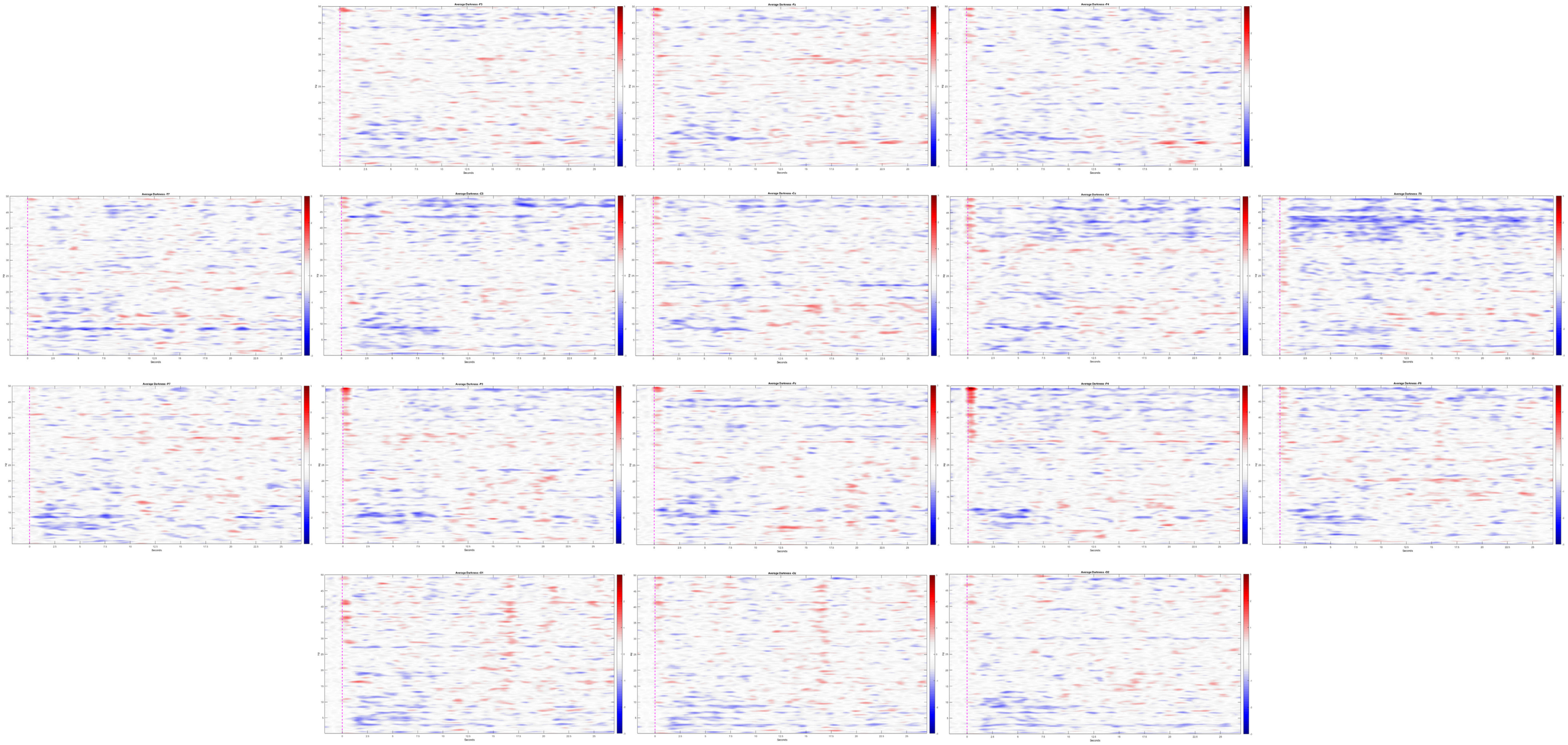


Figure 28: Average TSE maps for all the electrodes under the dark states (own figure)

Red illumination

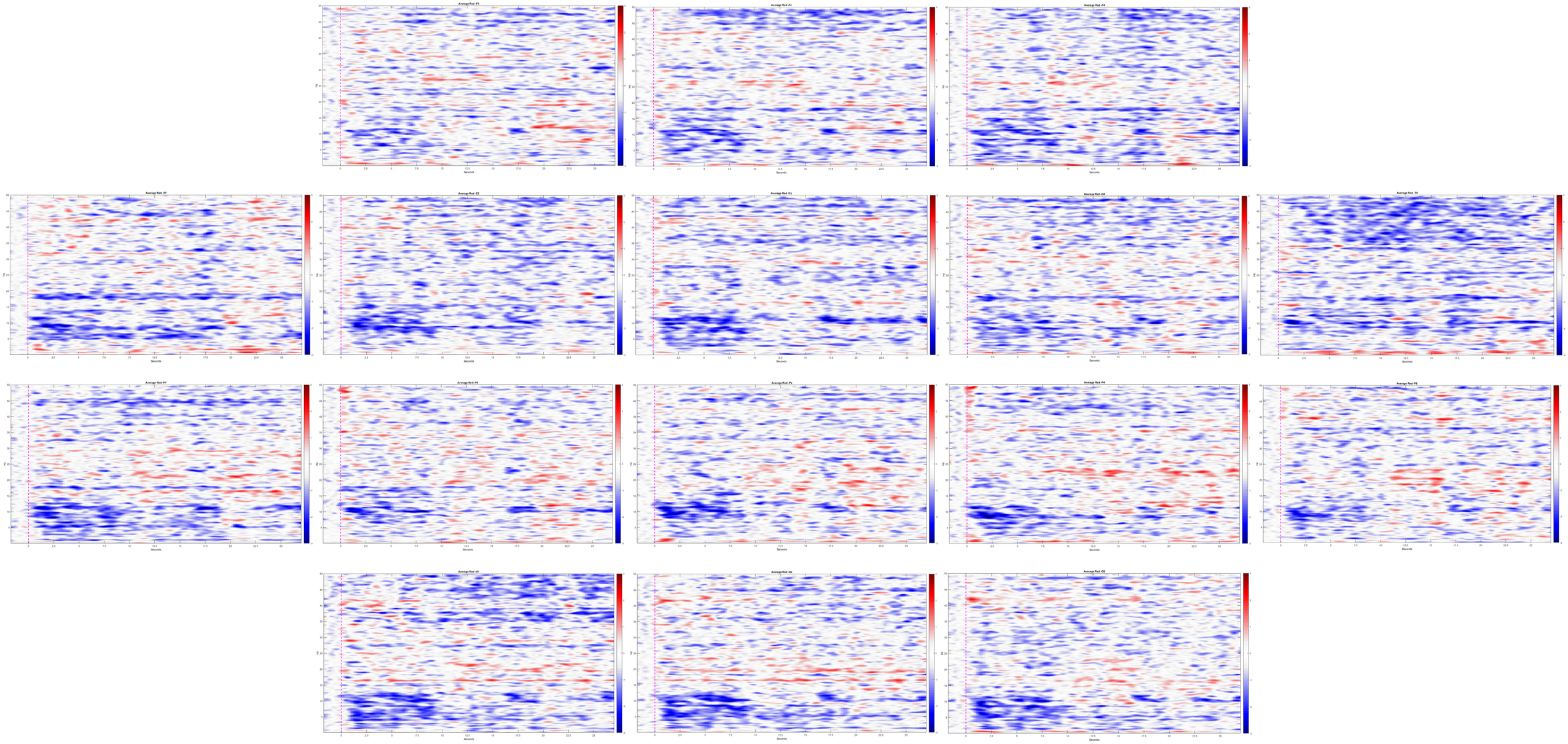


Figure 29: Average TSE maps for all the electrodes under the red illumination states (own figure)

Green illumination

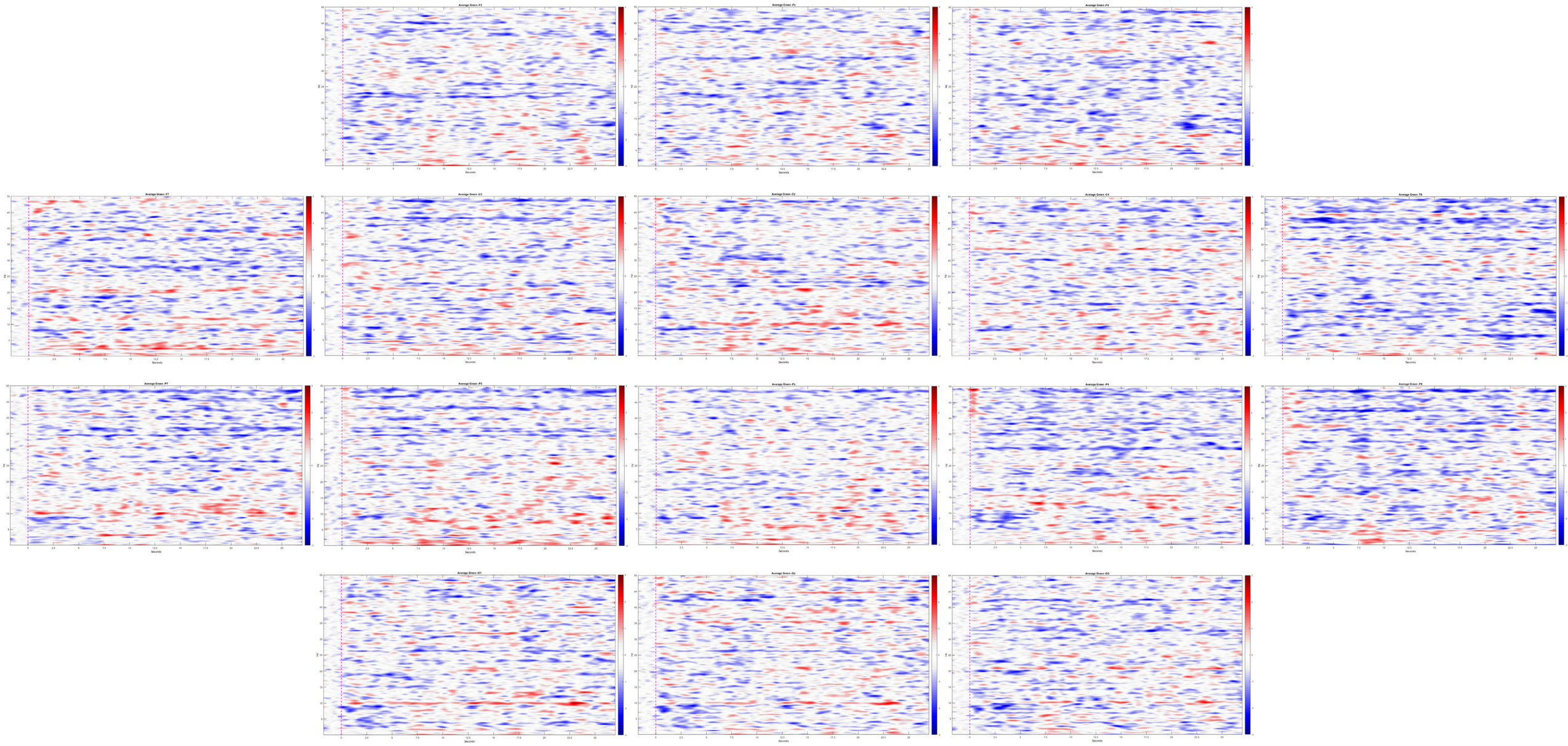


Figure 30: Average TSE maps for all the electrodes under the green illumination states (own figure)

Blue illumination

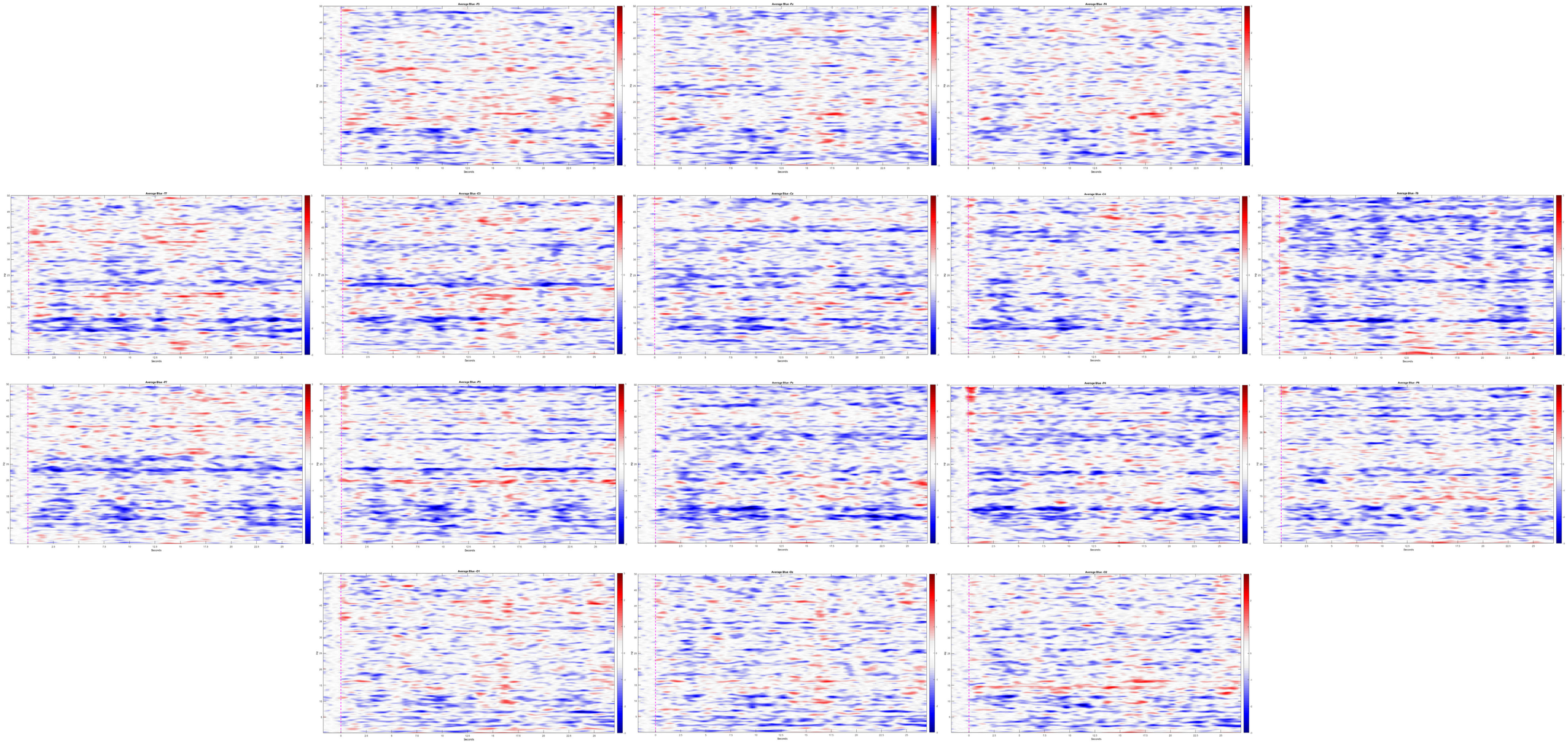


Figure 31: Average TSE maps for all the electrodes under the blue illumination states (own figure)

When looking at the figures above, they present the average activity in the brain that has occurred over the 22 test subjects when presented to the different lighting scenarios.

An overall pattern is shown in that the dark scenarios are different from the other scenarios. It differs in the sense that it has less ERS and especially much less ERD compared to the other lighting scenarios. With such a dramatic difference, it proves that the brain reacts differently when there is no light compared to when there is light. An interesting aspect to notice in this respect is that there was observed a gamma synchronisation (ERS) burst in the first second in P3, P4 and a bit in Pz electrodes. This makes good sense as it was learned from Pfurtscheller & Lopes da Silva that gamma synchronisation is related to an activated cortical area and furthermore are seen as

> *(...) a binding of sensory information and sensorimotor integration [and] oscillations in the gamma band appear appropriate to establish rapid coupling or synchronizing between spatially separated cell assemblies (Pfurtscheller & Lopes da Silva, 1999, p.1853).*

This means that the gamma burst occurring in the first second when the dark scenario is put on, indicates that the body is reacting to a change in stimuli, but only very shortly. This sounds reasonable taking into account that a lighting scenario has just occurred before the dark scenario, and therefore as sharp shift from light to darkness might demand an activated cortical reaction to adjust to this new and very different setting. We also have to remember that gamma waves are those that operate with information quickest, and therefore it makes sense that the burst is seen in gamma outset. This is further supported as Pfurtscheller & Lopes da Silva also affirms that a prerequisite for a development of a burst in gamma-band might be the desynchronisation of alpha rhythms and this is as well seen in our experiment in especially electrode T7 and to some degree in Pz and P4 (Pfurtscheller & Lopes da Silva, 1999).
Furthermore, the thesis that light is sensed through the skin and can cause a cortical reaction is further indicated in the fact that these ERS bursts occurred at the parietal lobe, which previously was shown to be the area processing sensory information (here among touch and stimuli to the skin). This is further supported as the interview following the EEG experiment revealed some interesting patterns. Over half of the participants noticed a change in stimuli from time to time, and many stated that it felt like a change in light level, as people felt they could sense with their eyes a light turning on or off (Lind, 2019). While it was ensured that the blindfold was completely blinding, it indicates that the photoreceptors in the skin sending information to the brain is able to cause a type of synapse between neural pathways. How our brain is able to do this remain an unknown factor for the present study. However, it supports that light can be sensed through the body to cause an aware cortical reaction.

At this moment both considering - the general difference that manifests between darkness and the other scenarios, in that darkness has way less ERS and ERD and that also the more specific gamma bursts right after darkness onset - reveals that the skin/body is sensitive to light and that this can be seen in the brain activity. Seen from the experiments, this cannot be questioned and therefore, we will have to accept the first hypothesis that we set forth.

While this first analysis relating to the first hypothesis was rather straightforward to show, it reveals new insights that are highly relevant for further discussions that we will engage with later. The second part of the analysis that has to do with the second hypothesis of whether our skin can differentiate between colors of light rendering different cortical reactions is just as striking but evidently more complicated to tackle. This is because much more data and possible correlations are in play here. In this paper, we will stick to the main findings.
Here it is not of much use to compare the red, green and blue scenarios against the dark scenario, but rather compare the color illuminations against each other. In this respect, it is worth to focus mostly on the alpha frequency band, as it shows some rather interesting patterns. In this frequency-band some remarkable results occur. When looking at the TSE -maps presented above for the different colored lighting scenarios, it is evident that there are some differences, in fact, there are many differences. One particular is that both the blue scenarios and the red scenarios exhibit significantly more desynchronisation (ERD) compared to the green scenario that has an increase of synchronisation (ERS). This is also evident when zooming in on the alpha specifics (see figure 32). Here we are not directing attention to the difference between the red and the blue scenarios, as this is not that significant. Instead, the figure emphasises the differences between green vs. red and blue. It is also shown that both the red and the blue scenario has a smaller amplitude than the green (in the figure: Blue < Green = blue has a smaller amplitude then green).

Alpha Blue < Green ERD	8 - 12 Hz
1- 5 Sec	T7, Cz, P4
5 - 10 Sec	T7, C3, Cz, C4, P7, P3, Pz, P4
10 - 15 Sec	T7, Cz, C4, P7, P3, Pz, P4
15 - 20 sec	Cz, T8, P7, Pz
20 - 25 Sec	Cz, C4, T8, P7, Pz
25 - 27 Sec	Pz

Alpha Red < Green ERD	8-12 Hz
1- 5 Sec	C3, Cz, C4, P3, Pz, O1, Oz, O2
5 - 10 Sec	Fz, F4, C3, Cz, C4, Pz, O1, Oz, O2
10 - 15 Sec	F4, C3, Cz, C4, Oz
15 - 20 sec	F4, C3, Cz, C4, T8, P7, Oz
20- 25 Sec	Cz, T8, P7
25 - 30 Sec	Cz, P7

Alpha Green > Red ERS	8 - 12 Hz
1- 5 Sec	Cz, P7, O1
5 - 10 Sec	Cz, P7, O1, Oz
10 - 15 Sec	Cz, P7, O1, Oz
15 - 20 sec	Cz, P7, P3, O1, Oz
20 - 25 Sec	Cz, P7, O1, Oz
25 - 27 Sec	P7

Alpha Green > Blue ERS	8 - 12 Hz
1- 5 Sec	Cz, O1
5 - 10 Sec	Cz, P7, O1
10 - 15 Sec	Cz, P3, O1, Oz
15 - 20 sec	Cz, Oz
20 - 25 Sec	Cz, C4, P3, O1, Oz
25 - 27 Sec	

Figure 32: Comparisons between alpha in red and blue vs. green illuminations (own figure)

Therefore a desynchronisation is carried out for blue and red scenarios and a synchronisation for green scenarios. This evidently provides us with information stating that under green lighting, our cortical neural networking has a rhythmic potential that leads to an amplitude increase. And this is carried out as a deactivated and less information processing state of the neurons in our brain. Pfurtscheller refers to this state as an 'idling' mode of the brain as it reflects a "(...) large amplitude oscillations over cortical areas which-at this moment of time - 'have nothing to do'." (Pfurtscheller, 2001, p. 1259). Hence, green light triggers an in-active or less aware state. Differently, the blue and red lighting scenarios exhibit desynchronisation in the sense of a synchrony decrease of the neural populations and its rhythmic activity is of a decreasing amplitude, that hereby resembles a neural network of already high information processing and/or extreme readiness to cope with stimuli. Hence with red and blue light, an aware and active state is initiated. This off cause has to be understood in relation to the alpha frequency band.

While the difference between red and blue against the green is not to overlook, a slight difference is also manifested between the red and blue. Here it is seen that red is in fact showing more desynchronisation compared to blue.

Alpha Red < Blue ERD	8-12 Hz
1- 5 Sec	C3, Pz, O1, O2
5 - 10 Sec	C3, Oz
10 - 15 Sec	T7, C3
15 - 20 sec	F4, T7, C3,P8, O1
20- 25 Sec	
25 - 30 Sec	

Figure 33: Comparisons between alpha in red and blue illuminations (own figure)

This means that under red illumination, the brain is further activated in a sort of information processing or readiness to perform some sensory processing compared to exposure of blue illumination.

Another interesting aspect that occurred was an asymmetry between the left and right hemispheres of the brain. This was especially seen in that the left hemisphere under red light showed a profound desynchronisation in the alpha band, while under green light this cortical regions showed a synchronized tendency. These processes were especially evident in the parietal lobe region and were almost only apparent in the left hemisphere. This might indicate that light and the color of it when blindfolded is to a larger degree noticed and processed as a sensory phenomenon in the left side of the brain.
From the interviews, there was no clear indication that participants sensed the exact colors used in this test. Although some identified that they felt some colors, but this was of an inconsistent character, as different colors were mentioned than those used in the test. The concept of phosphenes could moreover explain this, that is the phenomenon of light flashes, shapes and colors occurring at our eyes at certain times when lighting is not entering the eye (Weitering, 2014). Hence it can be hypothesized if light illuminations can cause such phosphenes. While this is not within the scope of this paper, it must be a future study.

However, the findings presented here mostly resides around the impact of color illuminations on alpha waves, we have seen that different colors evoke different processes in the brain. This has most notably been seen in the red and blue colors that differ with respect to green. Hereby we can conclude upon the second hypothesis. Based on the different patterns in ERD and ERS as well as the cortical areas involved with these, it can be concluded that color in light from these experiments confirm that the non-ocular-body can differentiate between colors rendering different cortical reactions to this.

While these findings provide some strong indications, more research is needed to shed light on the complicated matters this field entails. With the current research that this paper is illustrating, it has not been the focus to account for the all the exact neurological explanations, but rather this study has provided focus for a discussion on the potentiality that lighting might have. This has been the focus in this research and then it is up to further studies to look at the specific complications this holds.

However it is not the aim to stop here, because this would not remain sufficient. With the present findings we have to look at the potential meaning this has for mankind. Remember that the neuropragmatic approach starts from the humanities and go to the scientific domain. This is what we have done so far but we need to bring these findings back to the humanistic domain in order to finalize the circle that potentially can enrich us. This is what we will undertake in the next sections while also building further on the analysis of the findings.

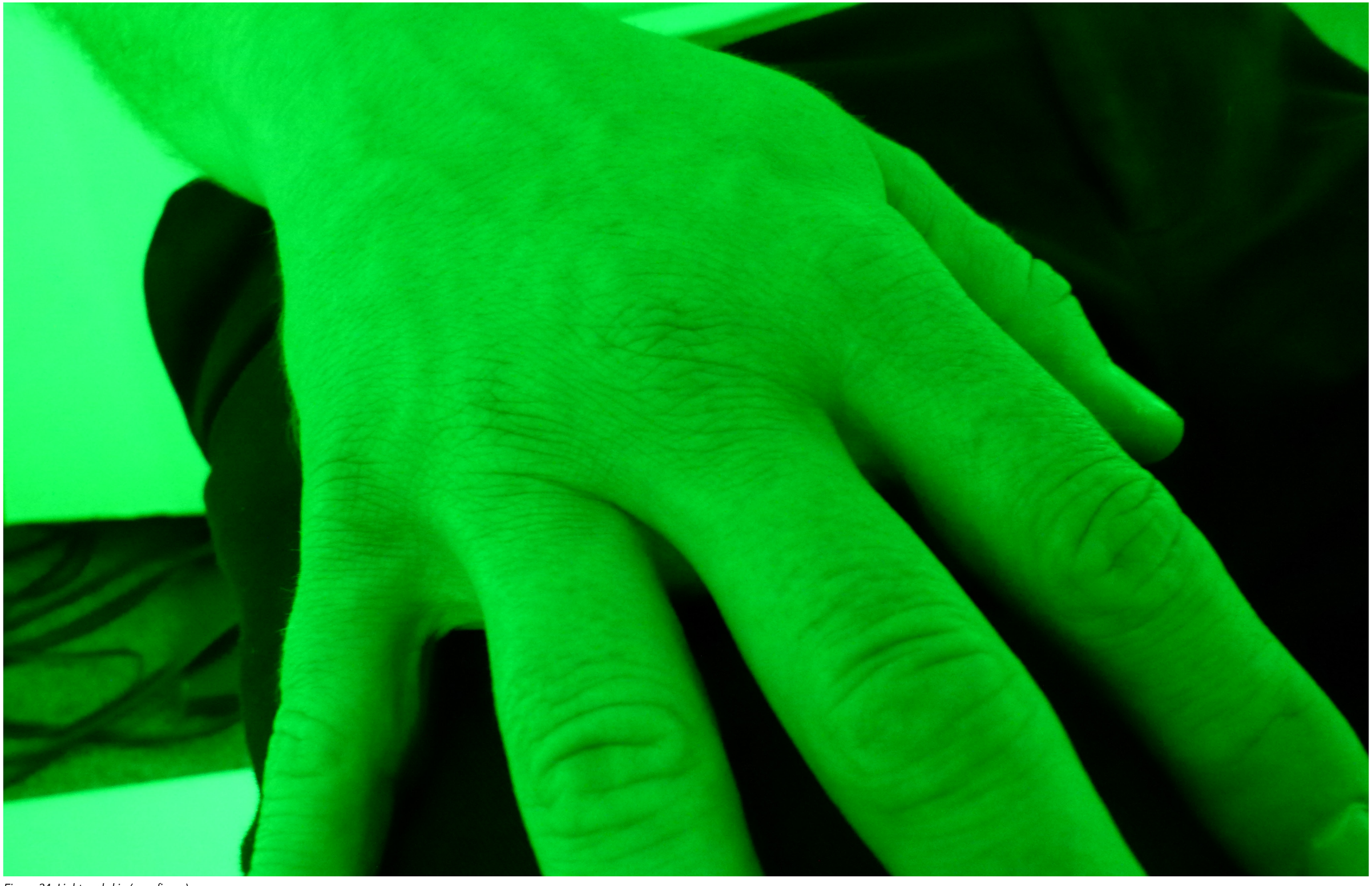


Figure 34: Light and skin (own figure)

Discussion

In this section, the implications of the present findings will be discussed and further analyzed. This will at large draw on the philosophical thread, as a means to arrive at a taxonomy on lighting that touches all areas of our lives. The aim in doing this will be to illuminate some of the complexity in our experience as a means discuss the potentials and challenges that might be in play. This section will further include supportive literature that can help put the current matters into its right perspective. Moreover, the section will take up the relevance of the findings in relation to lighting design as a discipline.

So far, it has been evident how the neuropragmatic approach has informed the development of this paper. Starting from a humanistic account on a certain interest and curiosity towards lighting and how it might be affecting us in our daily lives, has lead to a scientific undertaking of EEG experiments and lighting analysis, but then how can we bring these findings back to the humanistic domain to complete the circle.

Questioning limitations of sense modalities

In discussion section

In previous sections, it has been clarified how Pallasmaa outlines how the ocular sense has dominated among the sense throughout history. He further adds that the sense of sight not only has been the privileged one of the senses but came to form how knowledge, truth and 'the real' was established. Henceforth such an ocularcentric paradigm has at large defined our relation to the world and our experiences of it. Pallasmaa stresses that such a paradigm is the downfall of humanity, as

> *The dominance of the eye and the suppression of the other senses tend to push us into detachment, isolation and exteriority. The art of the eye has certainly produced imposing and thought-provoking structures, but it has not facilitated human rootedness in the world. (Pallasmaa, 2005, p. 22)*

It is precisely this longing for rootedness in the world that strives Pallasmaa to advocate for his multi-sensory paradigm (Pallasmaa, 2005). These thoughts have been an important motivation for the current paper, as the dominance of the visual sense still thrive and obtains the paradigmatic position in many fields, as well in lighting design. The paper will now try to sketch a position that is reminiscent of what we see with Pallasmaa but obtains a crucial extension to this.

By targeting and confronting the dominant modality of vision, an emphasis on a multi-sensory paradigm can take us away from the dominance of the eye. A multi-sensory paradigm tries to explain our experiences in the world from its entanglement of our sense modalities. If the sense modalities are qualified into various groups like (...) visual system, auditory system, the taste–smell system, the basic-orienting system and the haptic system (Pallasmaa, 2005, p. 45), one can question if these modalities have to be like this, and whether they can not overlap, substitute and help one another in various ways? With the current neurological study conducted in this paper, we are not only to speak of separated sense modalities/systems, as we have seen that the skin, which must belong to the haptic system, is in fact performing actions that must be said to belong to the visual system. As such a complicated image occurs, as functions of one sense modalities overlap with another's functions. One could say that an emphasis on the division of sense systems might reveal a conflict over which sense stimuli that one modality "owns". If this is the case, one can question if we once again are not just returning to the problem of knowledge and truth? Is the visual system only a knowledge of the eye?

The point that is argued here is that if a strict division of sense modalities is maintained, one can question if we utilize and realize the resources of human experience and the immense potential it might possess. It seems that a critical view towards boundaries of sense modalities might be of preference. Might one bodily sense be able to compensate and assist another sense in the hope to perceive and experience?

On this matter, Merleau-Ponty, as we have seen in a previous section, maintains a profound interest in our perceptual experience. When emphasizing that perception precedes cognition, he directs a serious attack towards philosophical traditions of Empiricism and Intellectualism. With the problematique seen with such traditions that maintain a separation of mental states and physical phenomena, as either a view of 'a mental life that precedes everything else' or that 'physical things that come prior to that of the mental', Merleau-Ponty holds a holistic account of being-in-the-world.

In the present findings, it has been illustrated that light is sensed by the skin, as such challenging similar notions as Merleau-Ponty. Hence, objective knowledge as he puts it (that we know the nature of things) is questionable as we have indicated in the findings. As such, lighting can not only be seen as an objective knowledge of the visual sense. It seems that the stance, when Merleau-Ponty concerns the body, might be able to reveal more to us than simple reasoning can do. Remember Merleau-Ponty's notion of a pre-personality as a bodily knowledge or a body

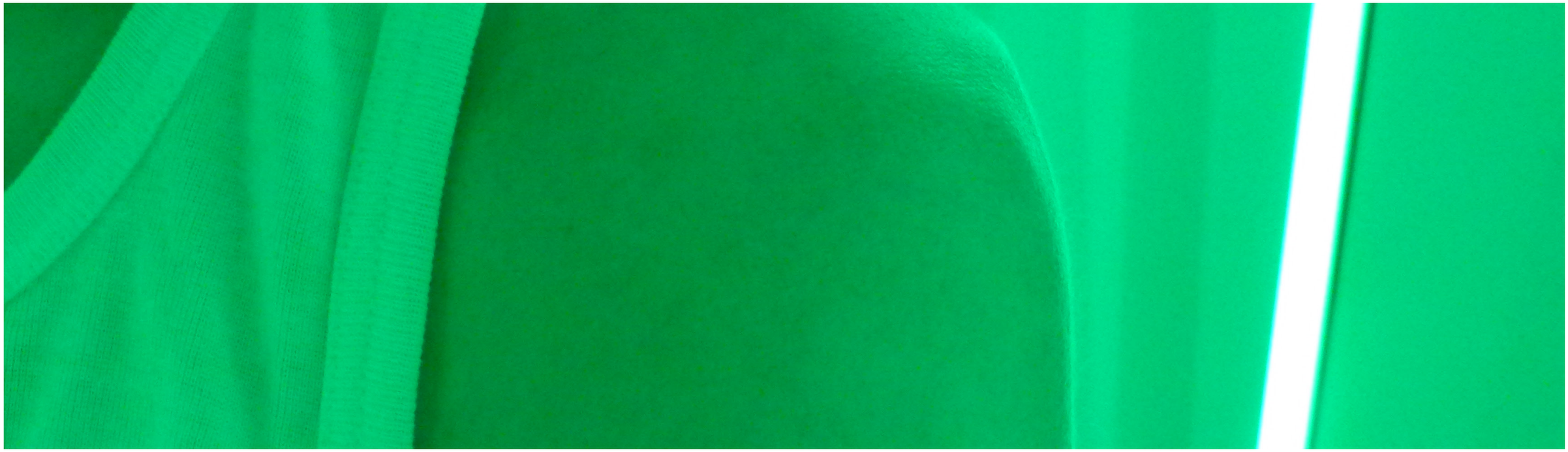


Figure 35: Light and skin (own figure)

consciousness. He expresses this as

> *Each time I experience a sensation, I feel that it concerns not my own being, the one for which I am responsible and for which I make decisions, but another self which has already sided with the world, which is already open to certain of its aspects and synchronized with them. Between my sensation and myself there stands always the thickness of some primal acquisition which prevents my experience from being clear of itself. I experience the sensation as a modality of a general existence, one already destined for a physical world and which runs through me without my being the cause of it. (Merleau-Ponty, 2002, p. 251)*

In this sense, we have a world that is always 'already there' before reflection begins, that is experienced through our body in a pre-personal, subconscious character. This is Merleau-Ponty's strive to attack the notions of objective thought that manifest in the world of knowledge and already obtain cognition on things. By favoring Merleau-Ponty's stance, one can better discover the potential in our intricate relations between sense modalities and phenomena, not as solely known and predefined in cognition, but as a lived bodily consciousness.
In this way, when dealing with light, it might be of preference to take a step back from our established thinking on how we relate to lighting. Do we know and have a good enough establishment of these modalities to make definitions of their boundaries? One can say, in following Merleau-Ponty that we have a pre-consciousness that is our body, which is the primal facility to anything else such as cognition. Hereby we must pay respect to what the body tells us. In the present study, our body beyond the ocular domain tells our cognition that light is sensed by other modalities than the eye, hence exemplifying that a non-ocular-body- consciousness should be considered in relation to light.

It is in this respect that this paper proposes a critical view towards a dominance of the eye as a means for truth and predefined boundaries of the sense modalities. In the findings from the experiments conducted in this research, lighting and colored illumination is sensed by the body outside of the ocular domain and that colors of different kind activate different cortical reactions in the brain. This is advocating for a revisited perspective and awareness towards an intertwining of the sensory domains.

This aspect of our bodily consciousness informed by our perception is indeed relevant when not only looking from a philosophical angle but gains significance for the current research also in a neurological perspective, that which we will look into now.

Cognitive states and light

In discussion section

In debate over unconscious and conscious states that is relevant for the present study, we will apply the distinction used by neuroscientist Heather Berlin, here the unconscious mind refers to anything outside of awareness/consciousness (she also uses nonconscious and subliminal mind to describe this) and the conscious mind refers to that which is percent for mental awareness (Berlin, 2011).

From the reading of Merleau-Ponty it occurs that we have a distinct presence and an underlying consciousness in the world, that is our body, which is prior to that of our primary conscious cognition of the brain. A similar, although slightly different advocacy, can be found with the philosophy of William James, as outlined previously. As he stresses the continuity of relational acts, he calls attention to the psychic overtone that is manifested in felt relational halos that carry a certain quality into our experiences. These qualities of the psychic overtone are at large nameless characters that remain anonymous to our awareness but still manifests into our experiences. Some of the readings of James propose that these notions provided by James were a means to describe our unconscious mind[6] (Weinberger, 2000). Such readings emphasize the large impact and much-underestimated implications of the unconscious and subliminal region of the mind.

> *It was by far the largest most important region of the mind for James. [This] subliminal region of the mind accumulates experiences, whether attentively or inattentively registered. There, completely outside of awareness, they are processed and elaborated upon. The results of this subconscious 'incubation' or 'cerebration' can then emerge into consciousness with mundane or dramatic results. (Weinberger, 2000 pp. 443-444)*

Hereby the unconscious and subliminal mind is a large mental box, affecting our experiences and consciousness, that which has probably been more commonly recognized with Freud's notions on these matters (Wollheim, 2003).

The relationship between the conscious and unconscious states of the mind is also an aspect explored through the EEG experiments of the current paper. Most surprisingly, we are not only sensing light and colored illumination with the skin, but this is also rendered into cognitive activity. As such, it is not merely a localized stimulation of cells in the skin but a neurological communication to the brain. With this, it was seen, as presented in the findings, that a conscious state was found at some point of the stimuli, at least if we speak of consciousness in terms of awareness.

6 However, rather prefered to use subconscious and subliminal mental states to describe the unconscious mind (Weinberger, 2000).

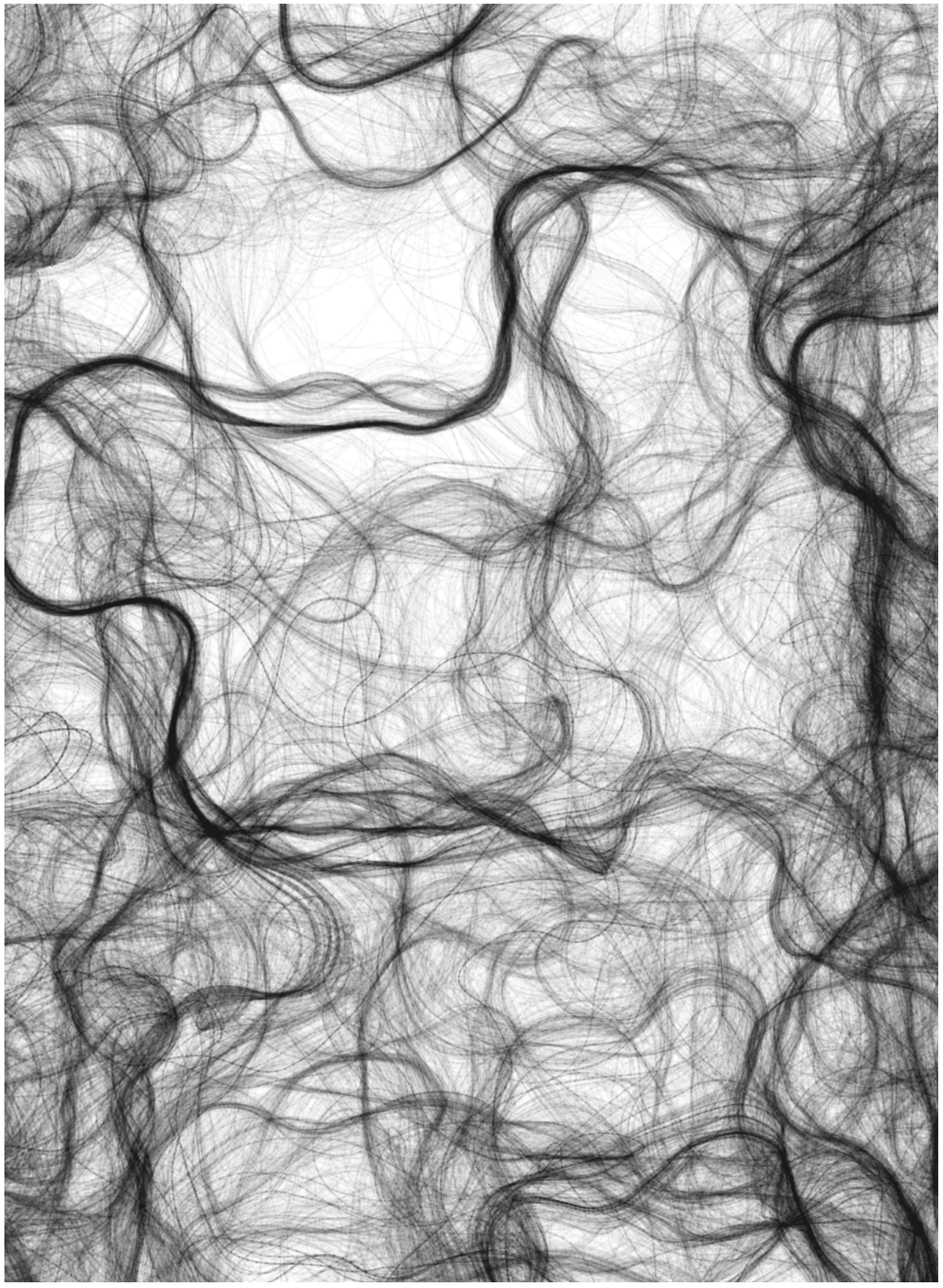


Figure 36: Creative representation of the entangled, intertwined and at times unnoticed relations between human and its environment (own figure)

From the interviews following the experiments, many participants felt a change in illumination, as if a lightbulb was turned on or off in front of them, even though they were blindfolded. Although this at large was an unexpected finding, it makes sense as the lighting scenario would shift between colorful illumination states to dark states. Furthermore, as it was seen in the analysis section, a quick peek of gamma synchronisation waves was triggered at the outset of shifting between light and dark, which is known to be an indication for conscious awareness, reported in studies on the cortical activity of gamma (Jamieson, 2007).

However, the interviews also revealed that the sudden conscious awareness produced at shifts between dark and light was not maintained in between these shifts, as people had a hard time describing other than the sudden effect of the shifts. But as it was seen in the EEG recordings, the brain did still undergo certain cortical processes under color illumination, that were different from the dark states. This indicates that there has been some kind of unconscious or subliminal activity. But how can one better understand the fine line between conscious and unconscious mental activity?

Studies on neurological behavior have proposed that cortical desynchronisation in the alpha band is associated with 'supraliminal stimuli'; consciousness processing, while a synchronisation in the alpha band is associated with 'subliminal stimuli'; unconscious processing (Bareither et al., 2014; Bazan, A. 2017). This is highly interesting when seeing that red and blue illumination in the experiments elicit a desynchronized alpha activity, and green illumination elicits a synchronization in alpha activity. This is to say that the red and blue illuminations are therefore more integrated with conscious processing while green illumination remains more at an unconscious state.

However, one can advocate that these indications of conscious and unconscious states in relation to our findings, still largely remain within an umbrella of an unconscious/subliminal character. Hence the interviews do not provide consensus on how people have experienced the situations. Further, in everyday life, we are still experiencing light mainly from our visual system and therefore, the bodily sensing of light might be pushed to the background of our awareness. If it is the case that the stimuli overall balance between conscious and unconscious/subliminal neurological reactions in the brain, it seems that there still is some way, for the cortical activity to render such stimuli fully aware and conscious to us. Neuroscientist Heather Berlin, explains some of these phenomena as subliminal perception:

> *Subliminal perception (aka perception without awareness) occurs when stimuli are processed by our sensory systems, but do not reach the "threshold" of entering into C [consciousness] because they are presented below the limen for conscious perception. (Berlin, 2011, p. 6)*

Hereby Berlin talks about the unconscious effect of stimuli that have been found to be able to penetrate into the brain, but that is unable to reach the threshold of conscious perception (Berlin, 2011). This seems to be the case for much of the findings in the experiments conducted in this paper. Some reach the threshold and enter into consciousness, as seen when scenarios shift between light and dark, but within the color illuminations themselves, a more subtle subliminal perception seems to rule, as it might not reach the threshold. Although as we have seen with the red and blue illumination, it seems to locate closer to the threshold due to the previously mentioned studies advocating for ERD in alpha to be more suitable for conscious process. Berlin further states from her neuroscientific perspective that "A great deal of complex cognitive processing occurs at the unconscious level and affects how humans behave, think, and feel." (Berlin, 2011, p. 5). This is indeed talking into the notions of a psychic overtone and the subliminal/unconscious -mind described by James but moreover the dominant thinking of Freud had a special concern for the unconscious of the mental states, as he found that the conscious only represented a small amount of our mental life (Oschman, & Pressman, 2014).

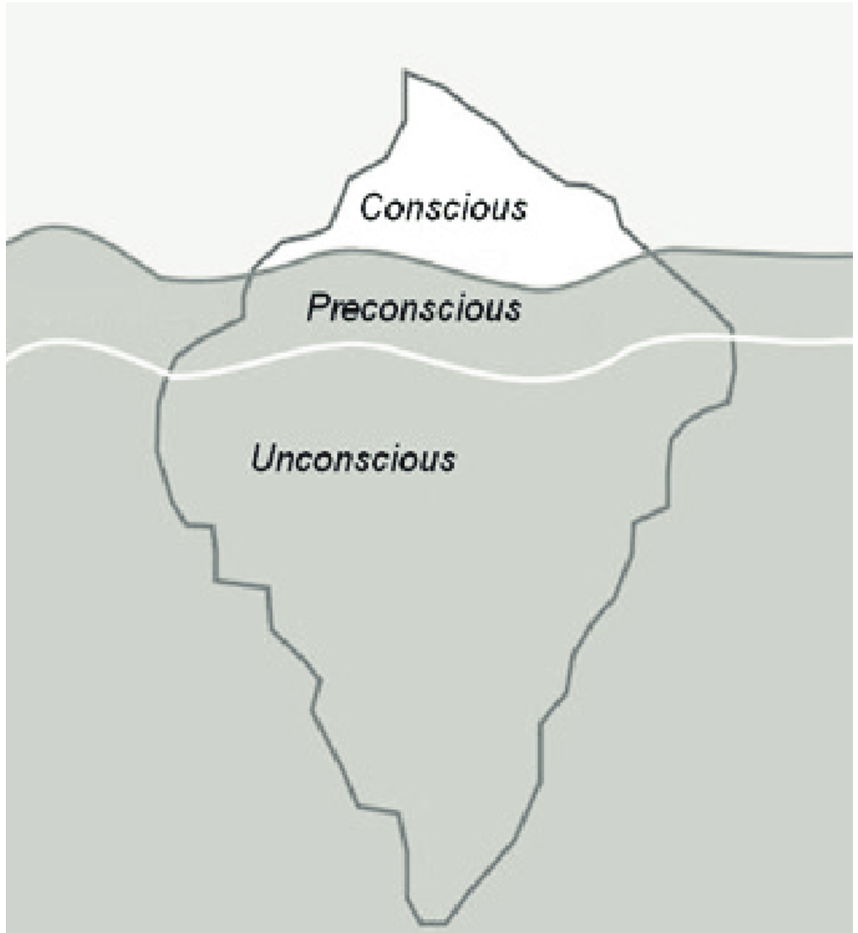
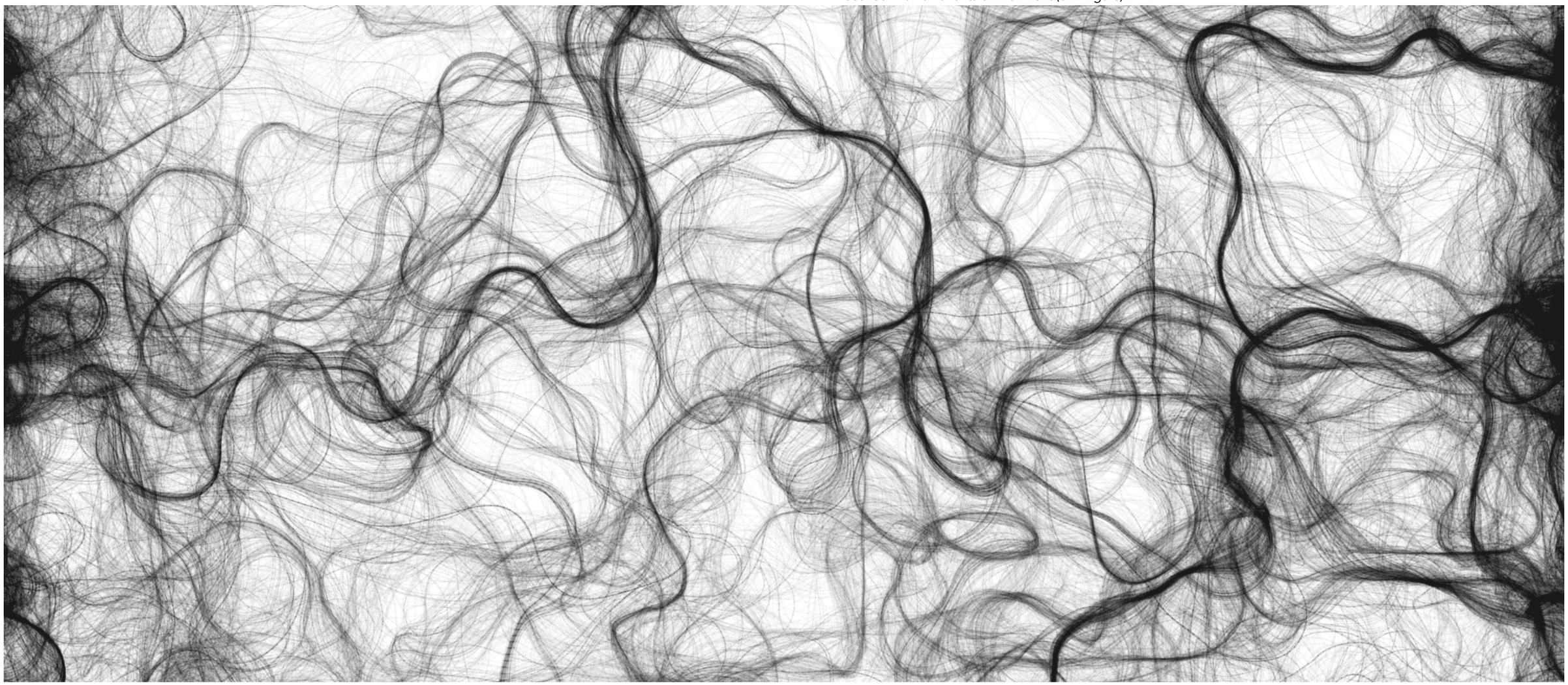


Figure 37: An iceberg is often used to represent Freud's theory that most of the human mind operates unconsciously. (Oschman & Pressman, 2014)

At this moment, both philosophical and scientific fields contribute to the attempt in uncovering the conscious and unconscious mental states. In this paper, it is not the quest to uncover these matters but it remains important to notice how lighting and colored illumination might have implications for these mental structures. When we say that the findings indicate some characteristics as conscious and some as subliminal/unconscious, it is the means to set forth the importance of noticing the body (skin) as a catalyst for the experience of light, hence not only stressing the qualities of the eye. Therefore with the capabilities of our bodies as a catalyst for conscious and not least unconscious/subliminal -states, the importance of the bodily relation to its environment gains significance in relation to lighting and its colored illumination, especially when these phenomena can obtain brain reactions through the body beyond the eye.
The importance of recognizing these 'hidden' matters are now explored as a means to discuss our experience and relation to lighting.

Figure 38: Creative representation of the entangled, intertwined and at times unnoticed relations between human and its environment (own figure)



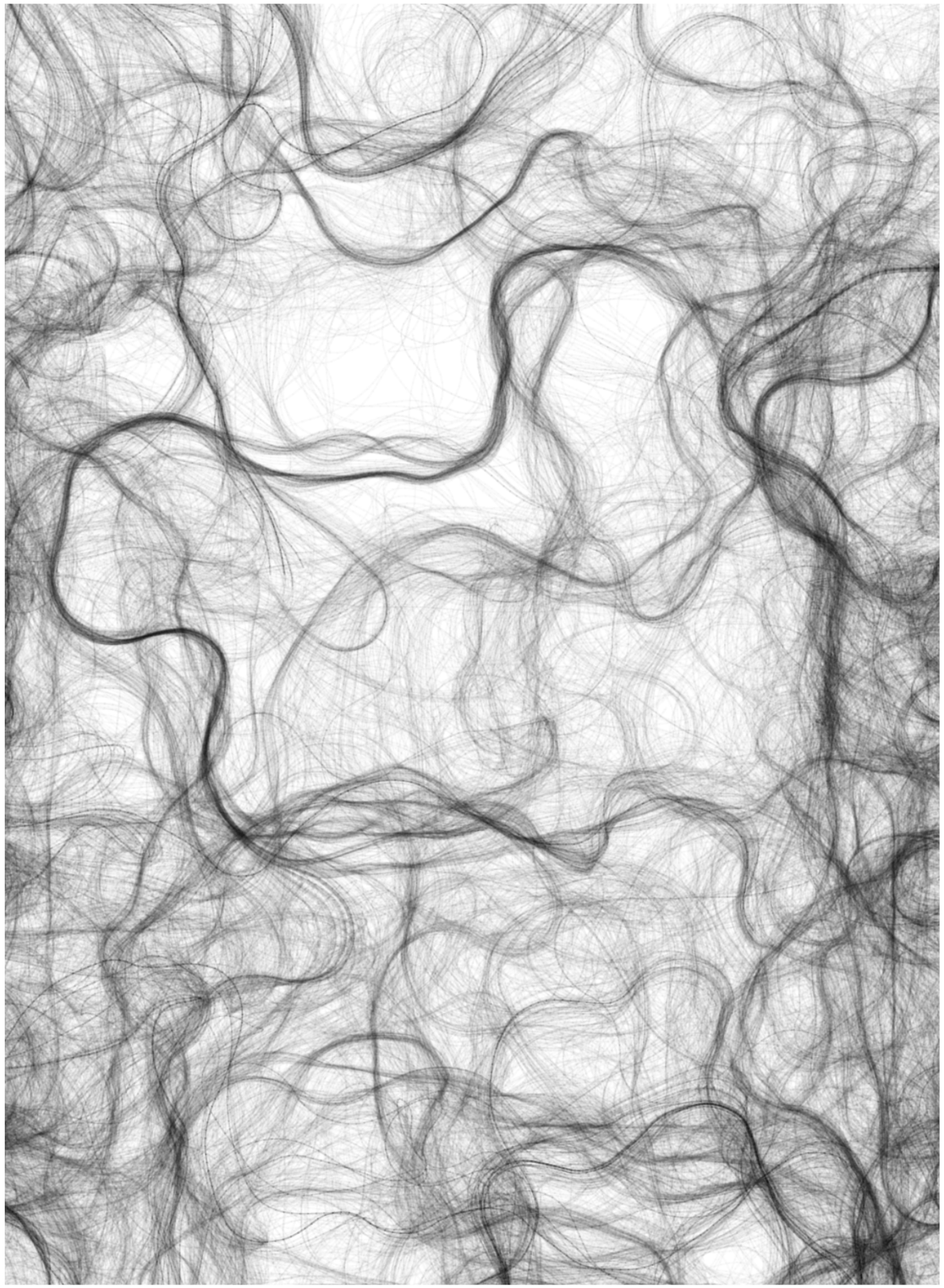


Figure 39: Creative representation of the entangled, intertwined and at times unnoticed relations between human and its environment (own figure)

In between me and it

In discussion section

One can question why the paper so far has stressed a critical view towards the eye, paying more attention to the body and its embodied cognition? One answer can be that since phenomena of light and colored illuminations is part of the human world, that which connects human and its world is the experience of it and this might be crucial to attend to. Essentially that of the 'in-between' is a profound interest for this paper. When stressing 'in-between' it is, in fact, a means to reexamine our presence in the world as to extend our understandings and relations of how we experience in the world. This is essentially the most important matter for this paper. In attending to the quality that might reside in such in-betweenness of human and its environment, the nature of the human attitude seems to challenge this quest.

We have seen with James that the human mode of being is at large structured in that we continually undergo selective processes (we selectively shape our reality). In this respect, our sense perceptions on a normal basis select which impressions occur most interesting to attend to and further chooses those aspects that "(...) represent the thing most truly, and considers the rest as its appearances, modified by the conditions of the moment" (James, 1983, 274). In this way, our selective mechanisms reach a point in which the selective shaping finds way to represent what must be considered as the real property of a thing. While we have already seen this in a previous section, it poses a problem at the present moment, because in this respect it is no wonder that we consider the phenomena of lighting and colored illumination as real properties of the eye, due to our selective mechanisms. In this respect, as the selective processes to James at large are affected by our habitual beings, we might be limiting our understandings of lighting and its vast potential to a limited scope.

However, with this selective mechanism of our human mode of being, James is also drawing attention to the fact that in this process we only account for and direct attention to a very little range of our lived experiences, hence emphasizing a vast potential that is out there for human. Furthermore, if we maintain that lighting and colored illumination has an established function and a defined existence, we forget that even though we are selective creatures, phenomena or things can never be understood in isolations, as they always contain a relational property. This is when James talks of the psychic overtone and fringe that entails a thing in relation to other things. In this light, if the aim is to better realize our presence and experience in and of the world, it seems that, although selectively founded, we have to allow for the 'unseen' and un-selected properties of lighting as relational if we are to benefit from its full potential.
Such a view talks into the notions we have seen with Bakhtin, as to explain a world that is unfinalized. By a suffering from the habitualized and the already known, we tend to miss the potential in life. In line with Bakhtin, we are unfinalized as long as we have not encountered a relational activity that is an answerable act of being. Hence one can only make sense of himself in terms of how

he relates to the other (a thing, person or phenomenon). Therefore the point is that in this dialogical worldview it is in the tension and answerable act between the self and the other that both parties are consummated and authored. In this respect, it remains important to consider lighting as a property of our experiences. In order to fully understand how lighting might facilitate a living for us, we have to engage fully with all its meanings for human, that which also include impacts on 'the body outside of the ocular domain' that this paper emphasizes. The reason for this is that Bakhtin sees a dialogue between the self and the other that is interactive in the sense that I can consummate and finalize the other, let us say the lighting phenomena in this respect, but I am fated to need the other in order to consummate myself. It is precisely this special bond that can render our experiences final or consummating for ourselves. "The excess or surplus of the other is required to make up for the self's lack and to consummate the self." (McCarthy & Wright, 2004, p. 75). It is in this respect we need lighting and colored illumination to confirm our existence, and to experience unity and completeness. Hereby we are talking about that lighting potentially can enrich our understanding of ourselves. In this way, it is the very dialogue between lighting (as well as other things) and ourselves that can confirm how we relate to the world, and offer us explanations. This kind of dialogue, as stressed with Bakhtin, is to Dewey that of a transaction that holds in it, the qualities of our experiences. In this way, Dewey calls attention to the very continuity of our experiences, as it is a constant transaction that can alter our relation to the world. Moreover, in realizing that the quality in experience is not in the subject nor the object but "() always were qualities of interactions in which both extra-organic things and organisms partake." (Dewey, 1958, p. 184) one is elevated from misconceptions to the actual matters at stake. Hence,

> *Experience is the result, the sign, and the reward of that interaction of organism and environment which, when it is carried to the full, is a transformation of interaction into participation and communication. (Dewey, 1980, p. 22)*

As such, when carried to its fullest, it can potentially not only shed light on our interaction with the world but moreover cause new forms of participation and engagement with it. Since it for Dewey is continuous, not only does it mean that the transaction is present at all times, but also that it might implicate for us at all times how we relate to the world. Hence, with lighting, it is this kind of continuous interaction between subject and object that potentially can enlighten our participation in the world, eventually exploring our own presence in it.

We have seen in the current experiments that lighting and colored illumination, is not only a sense for the eye, but also that light is a perceptual quality for the skin, that which furthermore result in cognitive reactions. Red and blue seem to cause different reactions compared to green, and in general terms is light compared to darkness causing cortical differences, all solely sensed by the body outside of the ocular domain. Hence we have to stress an emphasis on a certain

transaction or dialogue between the world and human when it comes to the phenomenon of light, that is not only to be seen with the eye but also the body that exists beyond the visual sense. Therefore lighting and colored illumination sensed by the skin, of a cognitive and bodily character, remain important with these concepts of felt haloes (James), dialogue (Bakhtin), transaction (Dewey), pre-personality (Merleau-Ponty) as all direct us towards our relationship with the world and the phenomena it presents us. All of which occupy a certain interest in that existing in-between us, that which can potentially occur with our engagement in the world. It has been with these concepts in mind that a heightened focus has been advocated towards a potential quality that might appear to us, as we encounter lighting and its colorful illuminations.

It is with this emphasis the current work illustrates that there is an 'in-between' or a transaction between light (and color) and our non-ocular-body (skin), not commonly recognized, that is part of our daily experience of things. In stressing such a tendency, making it common knowledge, one can, when further established, possibly better shape and understand the qualities of our experiences. These notions remain at large importance for the field of lighting design, as we shall see in the final chapter of this discussion.

A matter for the lighting design practice

In discussion section

In the 'state of the art' section, the paper aimed to illustrate how diverse and widespread lighting and its colorful illumination is in cultural and environmental fields. While there mostly focusing on architectural, artistic and entertainment values of colored illumination, it was nonetheless a means to exemplify the broad field of application. As we know, lighting is everywhere and colored illumination contribute in many aesthetic and functional uses, the findings and philosophical discourse presented in this paper render matters of lighting design all the more relevant. Assuming that both the findings from its neurological discourse as well as the philosophical debate, is considered here, we can talk of how these aspects matter for a lighting design practice.

From the findings, it has been shown that not only vision but also the skin senses light and can differentiate between different colors, rendering cognitive variations. This is not to stress that lighting designers should be preoccupied with the non-ocular-bodily sensing of light on the same level as visual sensing of light, as it is clear that lighting is mostly sensed through the eye. However, it is calling for attention towards qualities of light that is not only ocular. Henceforth, taken that the study presented here is elaborated in a multitude of fields and applications, fully confirmed and made accepted knowledge, this might pose a level of complications to the lighting design field, as more considerations have to be taken in the design process.
While such a statement might sound negative, it can just as well be put positive, because if it is the case that colored illumination can affect our cognitive modes through the skin, it can also be utilized to make atmospheres and sense impressions, if the effects of such colors are fully understood.

The role of lighting design might differ all dependent on the context it has to engage in and whether a treatment is of natural or artificial lighting and if this is an aesthetic or functional treatment. Treated as a qualitative and imposing medium lighting has sometimes been stressed in relation to the concept of atmosphere (Bille, 2007; Edensor, 2015; Nielsen et al. 2018). Atmosphere as a concept was also briefly brought up in the philosophical section when referring to Böhme who advocates for an awareness towards the atmosphere of the in-between. The concept of atmosphere carries many similar notions as the other terms presented, such as dialogue, transaction, relational halo etc.. The notion of atmosphere has been stressed in relation to lighting, that it:

> *(...) creates atmosphere, highlights and sculpts areas, and opens up spaces, influencing not just how you look at them but also how you feel about them. Light profoundly influences both ambience and mood (Sorrell, 2005, p. 58)*

As such, atmosphere occurs important in the establishment of what kind of experience one will have with lighting[7]. Hence, the findings presented in this paper might be rather important for the concept of atmosphere, because if it is the case that we experience light and colored illumination also non-ocular, then this might feed into how we perceive a given atmosphere, whether con-sciously or unconsciously. This might be one of the concerns for the lighting design discipline, as to explore how light in different ways, not only visually can contribute to a given atmosphere. Böhme calls attention to two approaches towards his notion of atmosphere, that is perception aesthetics and production aesthetics. While the first one at large has to do with the transaction, dialogue and in-between -notions, that we have already addressed, the second refers to the pro-duction of an atmosphere (Böhme, 2017). This production aesthetics, while often seen in stage design as scenography when combining media, materials and probes into a coherent setting for a certain mood/atmosphere, production aesthetics should also be an important keyword for lighting designers. If seeing lighting design as a production of atmospheres, it also implies that a perception aesthetics is concerned. This might be an overwhelming task for lighting designers, but it might be a crucial undertaking if the hope is to more extensively explore the relations be-tween lighting and human experience of it.

Solely extracted from the findings in this paper, lighting (experienced non-ocular), in general, stimulate cognitive activity of either an information processing state or a deactivated state, that differs from the state when there is no light. More precisely, it has been suggested that illumi-nations of red and blue indicated a heightened information processing or readiness to do so, suggesting a more conscious formation (although still of a subliminal character). Green, on the other hand, differs in that it sets a deactivated cortical mode that could indicate signs of an un-conscious/subliminal state. All of which, of cause still have to be respected in the alpha band. At this moment in time, it is hard to interpret further on these findings, but it could be questioned if such relations to light and colored illumination could also play a role in perception aesthetics of atmospheres. Nonetheless, it indicates that the concept of 'production aesthetics' that Böhme highlights, is of importance to the lighting designer, both for the visual appreciations but also for the non-ocular ones. In this respect, the present findings emphasize a broadened awareness towards how light and its color might affect us.

Throughout the sections in the discussion, it has been the purpose to complete the neuroprag-matic circle. Starting from a humanistic concern and exploring this in a scientific realm, the paper returned and explored the scientific implications in terms of a humanistic concern. However, this circle cannot be regarded as full, as the current investigation only has touched very little of what might be at stake. Future works and research can help illuminate, the curiosity outlined in this paper

7 It is off cause important to stress that atmosphere is not a concept focused on light but include all kind of sense impressions

Future works

As the research conducted so far has only taken infant steps and only tend to indicate rather than fully confirm tendencies between human and light, this section will touch upon some of the questions future research must attend to in order for a more grounded understanding of our multitude and intricate relations to lighting and colored illumination through our skin.

A wide variety of fields are needed to take further the current research, this could embrace neuroscience, neurobiology, cognitive science, but also include qualitative investment into artistic explorations, architectural applications and other human-centered practices. Since lighting and its colored illumination extend into widespread fields, future research is not simply a task only for the laboratory. Since no phenomena will ever be experienced in isolation (drawing on James and Pallasmaa), but is intertwined in human experience, the major job might be to explore how a cross-influence of lighting and other phenomena induce human cognition, behavior and motivation, that concern the eye but just as well the rest of the body. While this is a large undertaking that seems impossible to fully understand, one can start at the more foundational considerations. A list of some possible aspect for future work can be:

- Temporal qualities: In the experiments presented in this paper, the duration of colored illumination was only exploring stimuli over 30 seconds, although repeated multiple times. Even though it was shown that colored illumination differently affected cognitive activity in this short timespan, the findings do not define how such lighting might affect bodily and cognitive states over larger durations. How would it be to live, work or sleep in red illumination on a normal basis? Can lighting in such a way induce reactions different from short duration exposure, and what is the correlations in this respect?

- Spatial qualities: While only exploring the effects of color illumination in close approximation to a light source in an intimate and controlled spatial setup, how can colored illuminations in normal settings, such as architectural appreciations, affect our awareness of and relation to space? Is cognitive reactions of colored illuminations on the body, only a function of intimate and direct spacing or is it also expressed in normal spatial settings? If green illumination is tending more towards subconscious reactions in the brain, and red and blue towards conscious reactions, what does this implicate for spatial design?

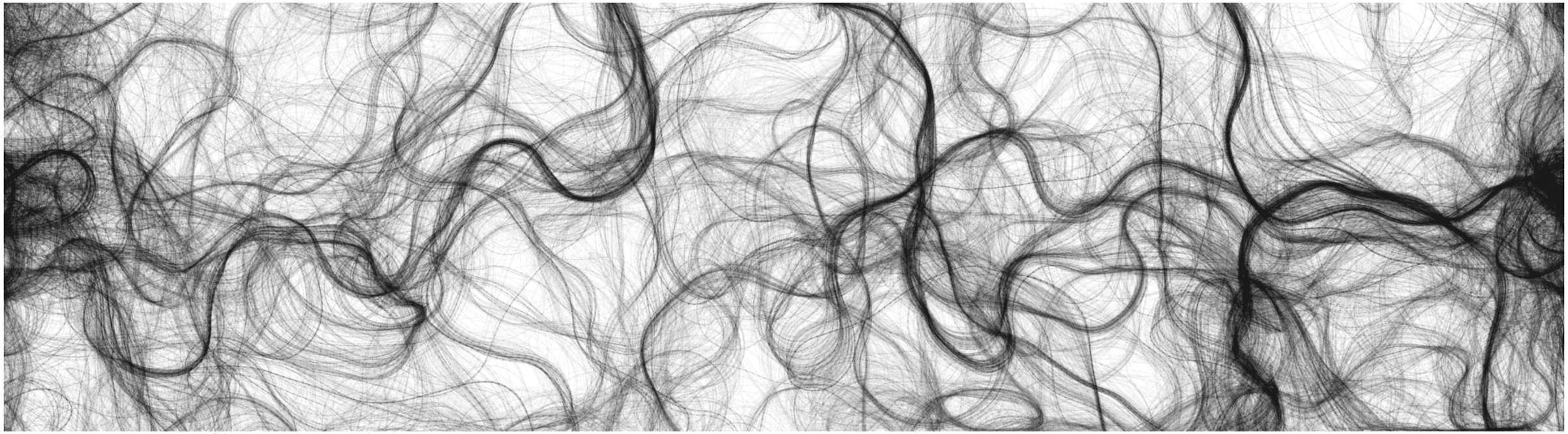


Figure 40: Creative representation of the entangled, intertwined and at times unnoticed relations between human and its environment (own figure)

- Emotional qualities: If it is the case that color illuminations can differentiate our mental activity, what does this mean for our emotional and affective beings? When witnessing the installations by James Turrell (presented in the 'state of the art' section), how does the color illuminations affect our emotional relations to the piece of art? When waiting in Chicago airport, at its stained glass windows, in order to reach a flight, how might this affect our emotional modes of the plane flight?

- Sensational qualities: One should question how the language of the non-ocular-body is compared to the ocular-body when it comes to the perception and interpretation of light. Is it the same "language" they speak? Do color illuminations from sight and non-sight -bodies mean the same to cognition or do the sensations understand light and color differently?

- Brain qualities: In the tests, we saw that our brain activity differed when there was darkness compared to when there was light, as well green illuminations triggered different cortical reactions than blue and red illuminations. How is it exactly that this is happening in the brain and which nervous pathways are those which makes our body connect with our brain in this way?

- Bodily qualities: In the experiments, the whole body was illuminated, how is the part and areas of the body sensitive in different ways? Do we have better abilities to sense and cognize color exposure on the arms than on the feet? What is the relationship between photoreceptors in the hair compared to those in the skin?

- Technological qualities: In the test participants were exposed to a fixed photometric brightness (lumen), but what is the correlations between photoreceptor sensitivity in the skin and luminance intensity, and moreover where is the threshold as to render this into a cognitive mode? What is the exact impact of brain activity from an interference of electrical fields in lighting equipment?

These questions are only preliminary and some of them might there likely already be good answers to, but the challenge must be to formulate such considerations into a language that becomes coherent, intertwining science and humanities, to inform our understanding of light, color and human relations. In such ways might we potentially gain better insights into our transactions with lighting as to explore the qualitative aspects of our experiences.

Conclusion

By questioning an ocularcentric paradigm, in which our experience and perception of light and its color illuminations at large dominate, a revisited relation between lighting and human has been proposed. Through a neuropragmatic approach, it has been the quest to undertake a transdisciplinary research on the potentiality and relation between human and lighting and color illuminations that exist beyond the human eye. In this respect it has been revealed that our relationship to phenomena of light can not only be limited to the visual perception of the eye. Moreover the study shows, with its neuroscientific findings, that we are able to sense and differentiate between various colors of light through our skin. This is not only affected in localized cell structures but reveals different brain activity under various color illuminations. Hence, indications stress that our reaction to green light differs with respect to blue and red light. Under green light an increase of ERS points towards a deactivated cortical state (with respect to the alpha band), that indicating a mode of less information and sensory processing, while the opposite is the case under blue and especially red light exposure. These findings are not only interesting in a scientific tradition but reveals many implications in our lived world.

In this respect we are confronted with a complicated and intertwined relation to our environment. Since light and color illuminations exist all around us, our relation to lighting phenomena reflects a transaction and dialogue that at large remain unnoticed, but nonetheless must be recognized, as its unconscious implications might be integrated into our experiences. It has been stressed that the transaction between human and its environment holds consummatory qualities in our experience, that is often 'invisible' and nameless qualities, but comes to signify how we experience a situation. In order to allow for these hidden qualities in our transactions with lighting, it is of uttermost importance to break with an ocularcentric 'knowledge of truth' and instead allow for a potentiality in phenomena of light. This engagement should be important for a lighting design discipline in order to design aesthetic and functional lighting, that accommodates a holistic concern for humanity, and not only the eye. Moreover, the real matters of quality in experience finds place in human engagements with the world, that calls for a revisited cultivation of the senses and an openness towards that existing in between us, that which can potentially occur in our engagement with lighting.

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Figures:

Figure 1:
Own figure, Creative representation of the entangled, intertwined and at times unnoticed relations between human and its environment.

Fig 2:
Elliott, J. (n.d.). Stained glass window in Notre Dame. [Online image] Available at: https://www.architecturaldigest.com/gallery/stained-glass-windows [Accessed 1 may. 2019].

Fig 3:
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Fig 5:
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Fig 6:
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Fig 7:
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Fig 8:
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