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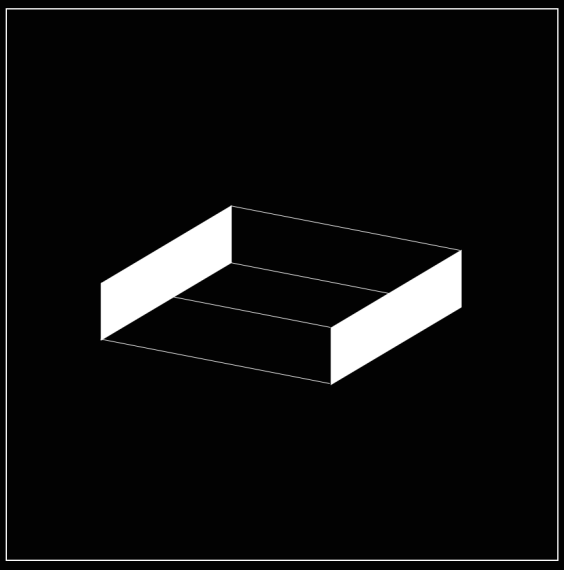

ARCHITECTURE , TO REMEMBER

TOWARDS UNDERSTANDING ***HOW ARCHITECTURE INFLUENCES***
THE NEUROCOGNITIVE MECHANISM OF SPATIAL ***MEMORY***

by

NICOLAJ Ø THUNBO

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READER'S GUIDE

The present study is the result of a long master thesis, which contains two interconnected parts; a theoretical part and a practical part. The present report represents the first part and establishes the theoretical foundation to the following practical part.

The theoretical part operates in the tension between two different disciplines; architecture and medicine, but it is primarily written for the interest of architects and architectural students. This view of perspective is both expressed in the choice of included literature and how the theoretical subject is communicated.

The theory is structured chronologically. The primary theory concerning the research question is presented in the main section, while the supplementing contents are found in the following appendices.

The full colored pages mark and present a new chapter, and furthermore conclude and summarize the conclusions from the previous chapter.

The Harvard Style of References is used as the standard referencing method throughout the report. *(Anglia Ruskin University 2008)*

Fig. 0.01: Understanding the Impact of Architecture. Painting by John Kørner.

ABSTRACT

Architecture has profoundly been influenced by the scientific evolution and includes especially studies of the analogy between the human body and its environment; from Vitruvius' admiration of the human anatomy to Kevin Lynch's psychological observations of the human mental image. It is reasonable to assume that the recent revolutionary conditions of neuroscience would affect architecture of tomorrow.

One of the most crucial brain regions in the perspective of both neuroscience as well as architecture is the hippocampal formation. The main region of the hippocampal formation, the hippocampus, is considered to maintain an essential cognitive mechanism for spatial memory. Especially, two fundamental discoveries underline this theory: the memory deficits of patients in consequence of neurosurgeries, and electrophysiological studies identifying a correlation between the neural activity of hippocampus and the spatial location of an animal.

Reviewed by the knowledge of the recent neurological studies of the hippocampal formation, it is suggested that the underlying neural mechanisms, a collection of spatial cells, establish a spatial representation of our physical environment, a cognitive map, in order to facilitate our spatial understanding and navigation.

The structure of the cognitive map is investigated as a result of both the environmental setting and the self-motion signals received by exploring the environment. The characteristics of the individual architectural features are clarified by neurological observations, and finally verified in an architectural context in order to provide sufficient insight into how our physical environment influences our ability to form new memories.

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PERSONAL MOTIVATION

I believe architecture exists in the balance between art and function. Without aesthetic considerations, only a building would appear, and in the absence of practical obligations, an artwork takes form. Architecture is a result of an artform with practical responsibilities.
The complexity of this balance involves a combination of both subjectivity and rational perspectives; the subjectivity as a response to taste and style reflectiving the reference of the individual, and the rational perspectives bound in empiricist methods and standards defined and confirmed by observations and scientific tests. The perspectives of both can be a challenge to maintain in equilibrium.
My personal motivation to this project is grounded in the aspects of this challenge, and my personal background has introduced me to the perspectives of both. My education as a carpenter revealed the rationalities of architecture. From the perspective of a young worker, I was mainly concentrated to the practical and tangible considerations of a project. As a technician, I translated the lines of the technical drawing to a spatial detail, not as a complete picture, but as fragments, due to the different phase of a building process.
In contrast, my time as an architectural student has accommodated the aspects of aesthetics, and introduced me to the elementary artistic exercises of an architectural education. This involves the processes that go prior the technical drawing and includes a more general point of view responding the elementary responsibilities of the building. This point of view has expanded my perspectives and influenced me from being a specialist to becoming a more generalist.
The multidisciplinarity of my experiences has shown me the importance of both professions in order to design architecture, expressed both by the rationality and the subjectivity. My experience futhermore taught me that the answer is not found as an expression of these perspectives, but rather as a reaction of them. Not found exclusive as the vision of the architect or the craftsmanship of the worker, but rather as a common understanding of the people for whom they build. The answer is rather found by a deeper understanding of our own needs - from the beauty of the facade to the height of the countertop.

APPROACH

The present theoretical part is grounded in the following approach initiated by the personal motivation. The theory is subdivided into five individual chapters illustrated on fig. 0.02. The chapters are presented in the rapport in following chronological order:

(i) Firstly, a prelude introduces the general point of interest in a historical perspective. The chapter investigates previous epistemological humanistic approaches to architecture in order to articulate the initial research question.

(ii) The initial research question is redefined on the basis of a systematic literature search. Scientific reviews concerning the initial research problem are included and establish the background context of the study. The context restricts the interest of attention and articulates a specified research questions.

(iii) The neurological aspects of the research question are investigated in this chapter. The neurological theory is gounded in a specified literature search including both original studies and recent reviews in order to establish a sufficient evidential state. The neurological investigation is rephrased and concluded in four general principles, which summarize the essential aspects of the included literature.

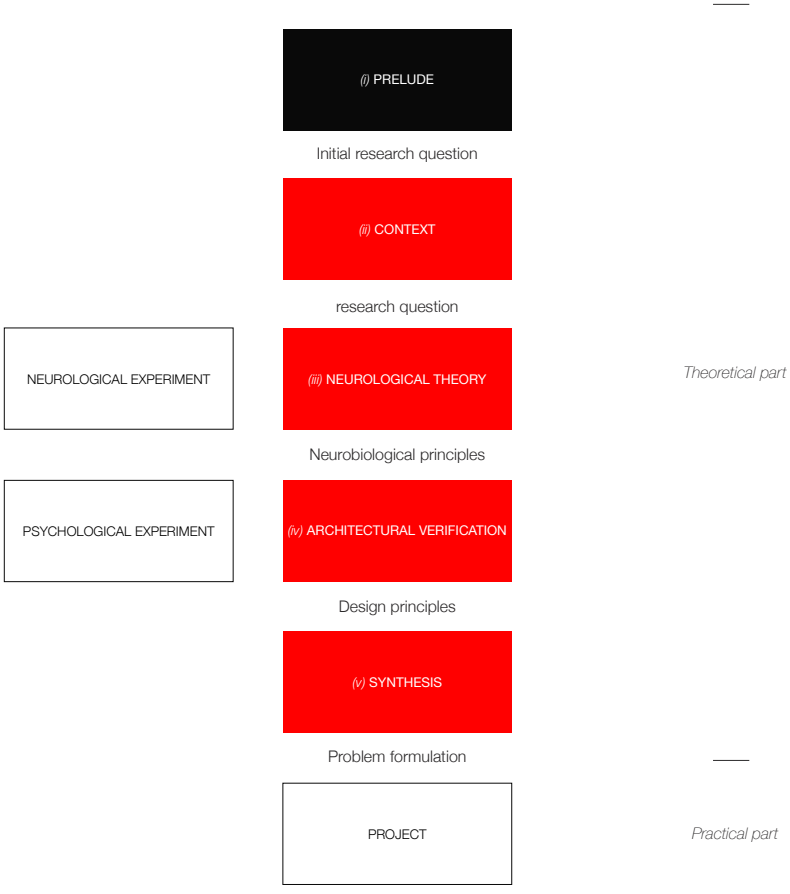
(iv) The principles derived from the neurological theory are verified in an architectural context in this chapter. This includes analysis of several architectural cases in order to validate the utility of the respective neurological principles in a human perspective.

(v) Finally, a synthesis concludes the present research by emphasizing and summarizing the essential findings. Furthermore, the general process and the further potentials of present study are evaluated.

Both the neurological theory could in further investigations be supplemented by specified supportive neurological and psychological observation and experiments in order to justify and verify the included theory.

The present study establishes the theoretical foundation to the following
project. The concluded design principles support the preliminary processes of the practical part and establish the basis for the following integrated design process. *(Knudstrup 2004)*

Fig. 0.02: Process flow diagram. The five filled boxes represent the individual phases of the theoretical part assigned from top to bottom in a chronological order. The three unfilled boxes illustrate the phases that might be supportive to the theory, but not fulfilled by this theoretical part.



The first chapter investigates how architecture has been inspired by human nature through history; from the ancient Greeks to the modernists of today.

Initiated by the personal motivation, the historical review seeks to illuminate, how architecture has been adapting to the knowledge of its time.

”Each generation must rework the definitions of the old symbols which it inherits from the generation before; it must reformulate the old concepts in terms of its own age”

(Bacon 1967, p. 27)

(i) PRELUDE

BODY & BUILDING ANALOGY

Studies of the human being have influenced and composed our way of thinking architecture for generations. The architectural theorist Marc-Antoine Laugier *(1713-1769)* sees architecture as a response to human nature. Accordingly to Laugier, architecture was naturally born as a reaction between the human and the environment. *(Laugier 1953/1977, p. 11)*

"On the banks of a quietly flowing brook he notices a stretch of grass; its fresh greenness is pleasing to his eyes, its tender down invites him; he is drawn there and, stretched out at leisure on this sparkling carpet...."
(Laugier 1953/1977, p. 11)

Thus begins the story about the Primitive Hut by Laugier in his book An Essay of Architecture. His story reflects the Primitive Man, who, controlled by his pure in stincts, builds a shelter to himself as reaction to his own human needs. The behavior of the Primitive Man visualizes how the human needs led to the creation of art, and how a relationship between human and architecture naturally was founded. *(Laugier 1953/1977, p. 11-13)*
One of the first men to put this relationship into words, long before Laugier's philosophies, was the roman architect Marcus Vitruvius Pollio *(80-70 BC - 15 BC)*, better known as Vitruvius. In his treatise De Architectura, written before BC for the service of emperor Caesar Augustus *(63 BC - 14 AD)*, Vitruvius presents the principles of art based of his own observations relative to the human body. The treatise includes ten books and is recognized as a manifesto concerning almost every aspect of architecture from critics of education system to design solutions of military camps. *(Vitruvius 30-15BC/1914)*
In the treatise, Vitruvius emphasizes some of the same aspect as Laugier demonstrated about 1800 years later that a building must correspond to the human body as nature designed it. He describes architecture as a metaphor for the human body in terms of proportions and symmetry. In the third book of the treatise, he highlights this crucial relationship as a essential part of design:

"Without symmetry and proportion there can be no principles in the design of any temple; that is, if there is no precise relation between its members, as in the case of those of a well shaped man."
(Vitruvius 30-15BC/1914, p. 72)

Furthermore, he emphasizes this aspect by describing individual measurements of body parts, their relation in scale to each other, and their relation to simple geometry. *(Vitruvius 30-15BC/1914, p. 69-76)*
Vitruvius' De Architectura stands today as a literary masterpiece in the field of architecture. His theories have inspired architects up to today, and especially his ideas concerning the body-environment analogy became an essential reference for the renaissance in Central Europe from the 15th to 18th century. Multiple professions as architect, artists, and philologists found inspiration in the work of Vitruvius, which fostered numerous of translations, analysis, and illustrated interpretations on the principles of his philosophies. This involves among others well-known treatises as De Pictura, De statua, and De re aedificatoria by Leon Battista Alberti *(1404-1472)*, and the famous drawing The Vitruvius Man by Leonardo Da Vinci *(1452-1519).* aDditional, Works from architects and artists as Francesco di Giorgio Martini *(1439-1501)*, Michelangelo di Lodovico Buonarroti Simoni *(1475-1564)*, and Cesare di Lo renzo Cesariano *(1475-1543)* are also highly inspired by Vitruvius' ideas.

The theories from the renaissance encouraged to a humanistic and multidisciplinary approach to architecture and a more literally analogical relationship between the human body and the building. The building should not only constitute principles derived from the human anatomy, but rather act and appear as a more or less directly recreation of the human body. The columns should act as the bones, the walls as muscles, and the finish as the skin. *(Mallgrave 2010, p. 13)*
The answer to architectural order and beauty were considered found in the nature of the human body, which required knowledge within elementary subjects as mathematics, medicine, and history. Especially, substudies in medicine concerning the human anatomy were considered necessary in order to work as an architect. Michelangelo claimed that the limbs of architecture derived from the human figure and postulated that a master in anatomy was a master in architecture as well. *(Mallgrave 2010, p. 24-35)*
Both Vitruvius' and the architects of the renaissance urged to characterize a universal system for measurement based on the proportions of the human body. Vitruvius wrote these measurements in his third book, while Da Vinci visualized it in his drawings.

The effort to translate the proportions of the human body to a universal measurement has also inspired architects of the last century. This includes the French swiss architect Charles Edouard Jeanneret *(1887-1965)*, well-known as Le Corbusier. He published his book The Modular in the 1940's, as a manifesto describing his humanistic system. Le Corbusier was motivated to develop a poetic universal architectural system to replace the general used metric and the decimal system, which he found abstract and bloodless.

Le Courbusier found his inspiration in music, which he considered equally to the art of architecture. Inspired by the languages of music notes, he suggested an adjusted system of measurement for standardization of architectural members. *(Corbusier 1948, p. 15-21)*
This system should stand the general globalization in the time of industrialization with serial production. By combining rules elucidated from The Golden Section and the proportions of a grown man - an English policeman, Le Corbusier invented the description and measuring tool named The Modulor. *(Zollner 2014)*

"*A man-with-arm-upraised provides, at the determining points of his occupation of space - foot, solar plexus, head, tips of fingers of the raised arm - three intervals which give rise to a series of golden sections"*

(Corbusier 1948, p. 55)

Le Corbusier claimed, where the metric system was a result of the decimal system without any concrete origin, the numbers of The Modulor were a product of human nature with an anthropometric scale. The system of The Modulor was despite it recognition from several different branches, never implemented as a national or global system. Nevertheless, The Modulor became Le Corbusier's elegant method of legitimizing a certain rationality in his architecture. *(Zollner 2014)*

Objective to Le Corbusier's more poetic approach towards a general system of measurement, Ernst Neufert *(1900-1986)* conducted a theory of proportions based on the metric system. The system was rationally related to the human body through experiments and previous projects. Neuferts book Architect's Data published first time in 1936 stands as a rational collection of guidelines that serves as a lexicon of standards for the use of architects and designers of today. Neufert agreed in the observation by Le Corbusier, that the metric scale complicates the translation from the human body to the units of measurement, but emphasized that this translation was a task for the architect. The architect was responsible to mentally picturing and familiarizing the dimensions of the building relative to the human scale in order to design comfortable environments without waste of space. *(Neufert & Neufert 2012, p. 30)*
In his more or less exclusive factual and objective based theory of proportions, Neufert shortly references to a more psychological approach of designing, by designating the importance of aspects beyond the physics of the human as feelings and emotions. *(Neufert & Neufert 2012, p. 1)*
With this short notice Neufert references to another perspective of interest, that has been supporting and expanded our understanding of the human being relative to our environment for the last decades - environmental psychology.

ENVIRONMENTAL PSYCHOLOGY

Psychological theories concerning the relationship between the human and the environment have been described since the middle of the twentieth century.
This includes a high variation of complex and divers perspectives, which all address the environmental impact to human behavior. Studies not only restricted to the interest of the psychologists, but involves several other fields as sociology, planning, design, architecture, human ecology, medicine, geography, and etc. *(Craik 1973, p. 255)*
This multidisciplinary character has fostered numerous of different designations to this relationship. This includes several different labels that represent different branches of the same area, behavior geography, architectural psychology, and ecological psychology to mention some of them. In order to generalize across subfields and establish a theoretically neutral term, the term Environmental psychology was adopted and outlined by Kenneth H. Craik *(1936-2012)* in in the 1970's. *(Craik 1973, p. 253)*
The studies in Environmental psychology position itself as a subdivision of psychology. The primarily focus of Environmental psychology concerns the individual reaction to a molar environment, by disentangling factors as behavior, perception, emotion, and intellection. The research stands as a methodological and theoretical tool used in the field of design by industrial designers and architects, and especially by urban planners as Jane Jacobs *(1916-2006)* and Jan Gehl *(1936)*. *(Gärling 2001)*
The approach includes systematic observations and registrations of the human behavior that occur in relation to the environmental setting and endeavors in order to answer questions as:

"What characteristics of an environment make a person with certain characteristics choose the environment?"

(Gärling 2001)

One of the first designers to address and investigate psychological question as abovementioned was the American urban planner and theorist Kevin Lynch *(1918-1984)*. Lynch analyzed the aspects of Environmental Psychology in the scale of the city. His book The Image of the City from 1960 investigates the relationship between the observer and the observed, in the search of a general mental understanding of the given environment. Through interviews and observations of both general residents and trained observers, Lynch establishes a number of principles based on our abi-

lity to organize and use definite sensory cues from the physical environment - our mental image. *(Lynch 1960, p. 1-13)*

"The environment suggests distinctions and relation, and the observer... selects, organizes, and endows with meaning what he sees."

(Lynch 1960, p. 6)

Similar mental image was just decades before Lynch observations also demonstrated in studies conducted in the laboratory. Psychologist Edward C. Tolman *(1886-1959)* performed in the 1940's some of the first laboratory experiments on rodents examining the relationship between the environment and the behavior of animals. He systematic and repeatedly studied the movement of rats navigating in mazes. These studies indicated that the behavior of the rat was related to complicated and patterned cognitive processes. Tolman suggested that the animal establishes a kind of cognitive field map based on the explored environment. *(Tolman 1948)*

The studies of both Tolman and Lynch indicated that cognitive processes establish a spatial representation of our environment. This cognitive reaction was termed as a cognitive map by Tolman, and as a mental image by Lynch. Both psychological theories suggest that underlying neurological mechanisms map our understanding of the physical environment.

These neuropsychological aspects was difficult to investigate in details in the time of both Tolman and Lynch, but are later, with the development in the field of neuroscience, been investigating massively the last 40 years.

ARCHITECTURE OF THE MIND

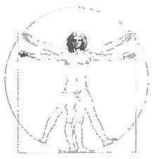
The fascination of the human body has continuing up to today, where especially another branch of scientific research has been distributing significant the last decades - cognitive neuroscience. Studies in the human brain have in recent years achieved an outstanding attention and revolutionary conditions. Scientists have discovered more information about the thinking brain the last two decades than in all human history. As a natural reaction of the development of knowledge, numerous amounts of professions have adjusted and adapted in order to optimize and improve their business. Even new interdisciplines have been established as a response to the increased information. Professions as neuroeconomic, neurobusiness, neuropedagogy, and etc..

Cognitive neuroscience has just recently been introduces in the field of architecture, where terms as neuroarchitecture or neuroaesthetic just have been formally defined as terms in the beginning of the 21st century. These new sub-disciplines represent an empirical aesthetic that combine studies in neuroscience with the experience of art and architecture. The position of cognitive neuroscience has to be considered as a different methodological approach to the field of architecture grounded in quantified measurement of the human brain. A methodology that offers the ability to verify and support already existing knowledge in details, but also gives the opportunity to test psychological and neurological phenomena, that never has been possible. Neuroscience do not act as an alternative to the humanistic approach, but rather as a supplementing epistemological approach in order to clarify how we think and design architecture in regard to the behave of the human being. *(Robinson & Pallasmaa 2015, p. 162)*

"I believe neuroscience already has a range of insights that are new to architecture and can stimulate its future development"

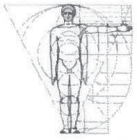
(Robinson & Pallasmaa 2015, p. 95)

Fig. 1.01: The Mind of the Architect. Different human figures drawn by different architects The drawings illustrate how the architect thinks and sees the human being.



Leonardo Da Vinci

Le Corbusier



Ernst Neufert

Gian Lorenzo Bernini

Frank Gehry

SANAA

C. F. Møller

Theo van Doesburg

Santiago Calatrava

Renzo Piano

Norman Foster

Walter Gropius

As Laugier described the process of simple nature, architecture has historically been influenced by the scientific evolution of human understanding and naturally altered by the human nature.
Architecture has adapted to how we look and how we act. It is reasonable to think, in the light of the revolutionary condition of neuroscience, that architecture is going to adapt to how we think.
Neuroscience might potential act as a source to the nature of architecture, similar to the reaction of the primitive man - and establish a reaction to renewed knowledge.
The presented historical review demonstrates how architecture parallel with the scientific evolution, has adjusted to the newest information of their time. *(Hamilton 2009)*

The following chapter seeks to identify the context of the present study in order to limit and define the final research question. Aspects presented in the prelude are used as basic for the further examination. This includes theories from both the field of architecture and neurology.
The chapter is grounded in the following initial research question:

”Why do we love and vividly remember certain places and not other?”
(Robinson & Pallasmaa 2015, p. 144)

(ii) CONTEXT

SPATIAL MEANING

We perceive space differently and we understand our physical surroundings in various ways. An environment would for one be memorable, for another totally out of matter.

From a psychological perspective, our environmental image is constructed as a three facet relationship between the environment, the person, and the activities the person is engaged in. *(Gärling 2001, p. 4652)*
In order to understand the environment, one must understand the individual who perceives the environment - the observer.
Lynch was profoundly aware of the complexity of this task, and emphasized the subjectivity of the individual.

"Each individual creates and bears his own image."
(Lynch 7960, p. 7)

Lynch categorizes the perspective of subjectivity as the meaning of the environment. He describes the meaning as an emotional value associated with the memories attached to the given environment. *(Lynch 1960, p. 8-9)*
The emotional meaning influences our mental image of the environment, whether it is a joyful memory of our childhood home or a terrible impression associated with a prison. It can be difficult to visualize how the meaning of a space affects our spatial perception. Lynch even excludes this aspect from his studies, because of its inconsistency and complexity.
Nevertheless, the aspect of meaning is relevant in a spatial context, and our memories profoundly affect our perception of space. The well known French-American artist Louise Bourgeois *(1919-2010)* addresses and visualizes the complexity of this emotional phenomenon in her sculptural artworks. In her artworks titled Cells, Bourgeois explores how memories materialized in objects and sculptural forms influence the architectural space - the cell. Her cells substrate itself from the space they are positioned in and establish several individual smaller spaces enclosed by a variety of architectural features. Each cell represents an individual emotional character mainly defined by the memories it is soaked in. Two respective cells would, despite its similarity in terms of dimension and architectural enclosure, reflect radical different characters, due to the manipulated environmental meaning. For instance, her installation called the Red Room includes two cells both defined by old hotel doors and approximately the same size. The architectural properties are more or less equally, but the memories tied to the space, visualized by colored objects, reflect different characters. One of the spaces reflects the memories of her childhood space, while the other her parent's room.
Bourgeois visualizes the memories of the pain, fear,

Fig. 2.01. The Red Rooms. Two cells from Louise Bourgeois exhibions titled Cells. Both cells include similar architectural enclosure, old holel doors, but express radical different interior spaces.

and sexual release by using physical objects tied to a general associations. By the use of architectural features, she manipulates the character of the interior space and illuminates the importance of the spatial meaning. *(Furtado 2015)*

Our spatial memory is definitely important in terms of our spatial meaning, but the status of the physical environment represented in our memories, can be difficult to deduce. Indications suggest that our environment acts as an essential part of our memory. For instance, if you recall a specific memory, you will in most cases be able to recognize the environmental setting; despite it did not affect the essence of the memory. For instance, the tragedy of the 9/11 attacks, when the twin towers in New York were attacked and collapsed. You will most likely remember what happened in New York, but you might also remember where you were at that particular moment, despite it had nothing with the actual incident - in your living room, at the shopping mall, etc..
This situation articulates the question, whether our memories are attached to our environmental surroundings somehow, one of the oldest memory techniques addresses this question. This imagine technique used be the ancient Greeks to memorize a number of discrete information, loci, is termed as The Methods of Loci by the Greeks, but generally known as The Memory Palace. This method emphasizes the importance of a spatial context relative to our memory and imagination and illustrates how the meaning of space can actively be used as a tool for memorizing.
The method is characterized by mentally walking through a familiar environment, the childhood home, the nearby park, or any familiar geographical entity. The subject establishes an imaginary route within the familiar environment and combine the loci, the information to memorize, to recognizable spaces or features within this environment. This composes a spatial relationship between the environment and the loci, and helps to order and recollect the memorized content. The information can be retrieved by mentally walking the imaginary route through the memory pal ace and activating the individual elements. This technique was not only used be the Greeks, but is even today used as an effective method of memorizing by the world champions in memory. *(O'Keefe & Nadal 1978, p. 389-390)*

"The house is one of the greatest powers of integration for the thoughts, memories and dreams of mankind"

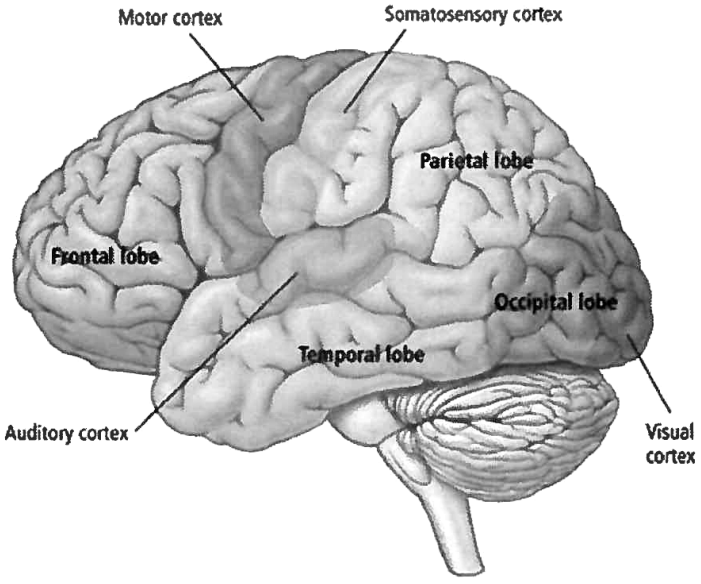
(Bachelard 1958/1964, p. 6)

Louise Bourgeois' installation Cells and The Methods of Loci demonstrate how the spatial meaning can be reached as an expression of art or as a technique of memory. But how can architecture articulate the spatial meaning, and how can architectural features provide emotional meaning?

The American architect and urban planner Edmund N. Bacon *(1910-2005)* addresses these questions in his book Design of Cities from 1967 and describes the spatial meaning as the spirit of the space - a spirit that activates our senses and enhance our emotions, similar to the Greek designation of Genius Loci. He stresses the complexity of infusing this aspect in an architectural context, and emphasizes, corresponding to both Gärling and Lynch, that this can only be achieved in compliance with the observer and the activities the observer is engaged in. Nevertheless, Bacon stresses that architectural features as geometry, materials, textures, light, and color can accommodate the emotional quality and add a sense of meaning to the space. Furthermore, he emhasizes that this quality can be received by the skilled architect *(Bacon 1967, p. 18-19)*
To summarize, accordingly to the statement of Bacon, the spatial meaning can be received by the architect, and is present in the complex relationship between the environmental setting and the observer accordingly to Lynch. To comprehend both, and to address the initial research question, one must analyze the subject in relation to its environment prior the personal evaluation. In order to go beyond the complex state of subjective understanding, one must analyze the underlying cognitive processes of spatial meaning by investigating how the environmental features facilitate our ability to form both meaning and new memories. The recent findings of neuroscience and the studies of the human brain might offer the answer to this question.
The psychological studies of Kevin Lynch pursued the mental image by asking the observer, this study based in neuroscience has to investigate the tools the observer used to create the mental image - the human brain.

Fig. 2.02: Reflection. Painting by Jean Alphonse Roehn (1799–1864). What represents our mental image; the painting, the reflections, or the tools the painting are create by?

Fig. 2.03: The human brain - subregions. The cerebrum includes four different subregion; frontal lobe, parietal lobe, temporal lobe, and occipital lobe. Each anatomical area controls different functions



THE THINKING PERSON

To address the neuroarchitectural aspects of the cognitive mechanisms, a more systematic focus of the neurological aspects is required. The following section provides a general overview of the human anatomy structured chronological, zooming from macroscopic to microscopic.

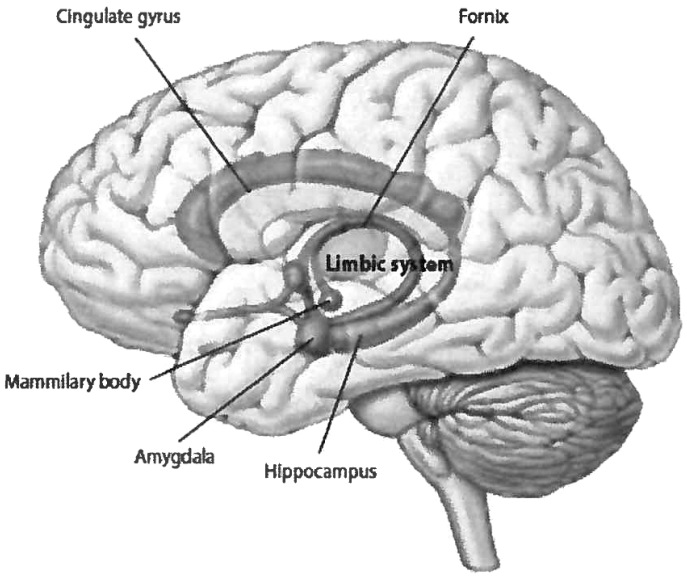
The nervous system is one of the most complex systems in the human body consisting of approximately 100 billion microscopic building blocks, termed as neurons. The nervous system works as a biological center for communication transfer ring information by electric impulses between every organs and tissues of the body, coordinating and controlling the physiological processes, and gathering informa tion received from the outer environment. *(Hall & Guyton 2006, p. 543)*

The nervous system is divided into two parts: the peripheral nervous system (PNS) and the central nervous system (CNS). PNS includes the outer nerves to the organs and extremities of the body, and transmits information received from our outer sensory receptors. CNS includes the brain and the spiral cord, and is responsible of the majority of the human functions. *(Cluck et al. 2014, p. 41-42)*

The brain represents the center of the CNS, processing impulses received by our sensory receptors located in the PNS. The received stimuli, when you feel, see, hear, taste, or smell, are converted into outgoing impulses triggerni g a response and activating muscles and glands. These sensory experiences involve cognitive processes as memory, learning, navigation, personality, feeling, problem solving, motoric outputs, etc.. *(Gage 2003)*

The brain structure is subdivided into three main parts: brainstem, cerebellum, and cerebrum. The brainstem, truncus encephalicus, located beneath the cerebrum, establishes the connection between the brain and the spiral cord. Every impulse from higher neural centers travels through this region. Abilities as eye movement and respiration are controlled by the neural activity in the brainstem. *(Hall & Guyton 2006, p. 505)*

Fig. 2.04: The human brain - the limbic system. The limbic system is located in the center of the brain and includes several essential cortical areas relative to the function of memory



The cerebellum, generally also known as the little brain, is located at the back of the head. This region controls functions as coordination of movements and balance, which makes it essential for learning physical action and motion. *(Hall & Guyton 2006, p. 681)*
Located just above both the brainstem and the cerebellum, representing the uttermost region of the CNS, is the cerebrum. The cerebrum constitutes the majority of the brain structure and includes the four subregions termed; frontal lobe, parietal lobe, temporal lobe, and occipital lobe. Each lobe is anatomical districted and related to different variation of perceptual and cognitive processes with each individual specialization. *(Cluck et al. 2014, p. 42)*
"The frontal lobes help you to plan and perform actions, the occipital lobes allow you to see and recognize the world, the parietal lobes enable you to feel the differences between silk and sandpaper, and the temporal lobes make it possible for you to hear and to remember what you're done."
(Cluck et al. 2014, p. 42)

In the center of the brain, immediately under the cerebrum, involving parts from both, the frontal lobe, the parietal lobe, and the temporal lobe, is the limbic system located. The limbic system consists of several cortical structures as hippocampus, hypothalamus, amygdala, fornix, etc.. These cortical structures are considered as the center for emotional behavior, motivational drives, and memory.
The specific function and communication between the collective parts of the limbic system is still partly a mystery and especially the complexity, the location, and the fundamental cognitive importance make it difficult to conduct experiments in order to identify the respective function of the individual parts. *(Cluck et al. 2014, p. 42)*

The knowledge concerning the limbic system is mainly founded in studies of animals, but several prominent brain operations conducted on human from the 1950's have identified the basic understanding of the limbic system concerning learning and memory.

REMEMBER THE STORY

One of the most revolutionary neurosurgeons within this field was William Beecher Scoville *(1906-1984)* - a surgeon at Hartford Hospital, USA. Scoville managed to conduct several radical surgeries within the limbic system of humans. Surgeries that later in history became essential for understanding the cognitive mechanism of the limbic system. Scoville performed several surgeries on patients with intractable seizures, also known as epilepsy, as a response to failed medical treatment. The surgeries were concentrated about operations in the limbic system and involved resection of several parts in this area. Several of these operations managed to reduce the uncontrolled seizures, but resulted in an unexpected and persistent memory deficit. Especially, a surgery conducted on the patient named Henry Molaison *(H.M.) (1929-2008)* led to groundbreaking discoveries concerning the human memory. *(Scoville & Milner 1957)*

H.M suffered from intractable seizures after an accident on a bicycle at the age of seven. The medicine did not had any significant positive effect, so Scoville conducted a surgery of H.M involving a bilateral resection including two thirds of the hippocampus and the amygdala. The operation seemed to be successful at the first glance. H.M. suffered no deterioration in general intelligence or personality, and his intractable seizures were almost eliminated. But to the surprise of the doctors, something was totally wrong, he had unexpected grave loss of recent memory.

H.M was capable of recalling early memories from before the operation, but he had basically no capability of constructing new long-term memories or establishing intermediate memory lasting more than few minutes. H.M. couldn't even recognize the hospital staff, remember his way to the toilet or recall his day-to-day events. No improvement of memory was registered ten months after the operation, where H.M. was able to read the same magazine and collect the same puzzle over and over again without realizing any familiar contents. H.M.'s ability to both perform motoric skills and formulate complete sentences indicated a functioning working memory, and his ability to remember facts, persons, and events prior the surgery suggests a certain form of storage of permanent memories. *(Squire & Wixted 2010)*

Scoville's studies with H.M and further studies conducted by Scoville and his colleges indicated a certain relationship between the level of memory loss and the extent of destruction of the hippocampal complex. Furthermore, the studies clearly specified the importance of hippocampus in terms of forming new memories. But the scientists could not absolutte conclude that the function of memory is exclusive isolated to the hippocampal complex. Especially, areas as entorhinal cortex, uncus and amygdala were up for further discussion. Bilateral removal of only the uncus and amygdala did not result in any persistent imp airment of recent memory. *(Scoville & Milner 1957)*

Nevertheless, the surgeries demonstrated the importance of hippocampus and nearby sub regions in terms of memory, particular concerning spatial memory and navigation. They fostered numerous of specific research focusing on the mechanism of this cortical area, and especially electrophysiological studies, focusing on individual neurons, have expanded our understanding of the memory mechanism for the last few decades. An evolution that positions the hippocampal formation as one of the most studied areas of the brain of today. *(Bird & Burgess 2008)*

THE MECHANISM OF MEMORY

The hippocampal formation is recognized by its main region - the hippocampus. The hippocampus is formed and named by the shape of a seahorse and located deep in the medial temporal lobe. The hippocampus contributes to the function of memory, and is especially involved in spatial memory. Getting lost or forgetting

where objects are placed is a frequent implication after a damaged hippocampus. *(Bird & Burgess 2008)*

The anatomical layout of the hippocampal formation includes besides the hippocampus several adjacent cortical region; the entorhinal cortex, dentate gyrus, CA1, CA2, CA3, subiculum, and etc.. The individual cortical regions communicate collective by neural pathways. *(Hartley et al. 2014)*

The complexity of the hippocampal formation has fostered several different theories concerning the memory function, but especailly investigations concerning neural activity within the hippocampal area have identified and documented some of the underlying spatial processes. This involves microscopic studies of the activity within the neural pathways between the cortical areas. Especially, by recording the transmissions between the received sensory information and the cognitive processes have been rewarding and accumulated a deeper understanding of spatial memory. The individual neural connections and respective functions are mainly identified by studies of the animal brain.

A neural activity can be generated by a sensory experience received from our sensory receptors, - when your eyes catch a stream of light, when your fingers touch a rough surface, or other kind of perceptions. Our sensory mechanism receives stimuli and activates our neural system constantly, which results in an over load of perceived sensory information. Our brain discards more than 99% of the perceived information, because the information is either irrelevant or unimportant.

Fig. 2.05: Schematic overview of the hippocampal formation of a rat. The neural pathways of the hippocampal formation of rat and the human are similiar. The areas of the hippocampal formation are divided into separate subareas connected by neural pathways. The illustration shows the major anatomical pathways.

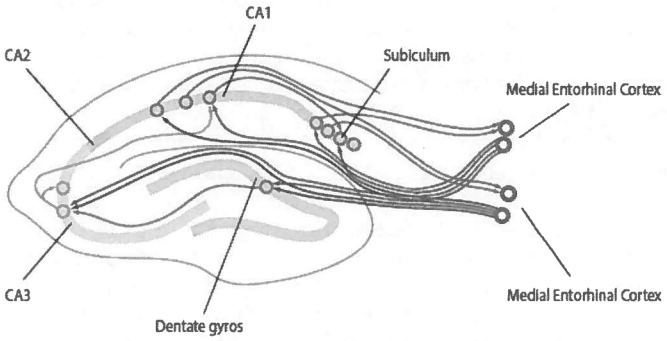


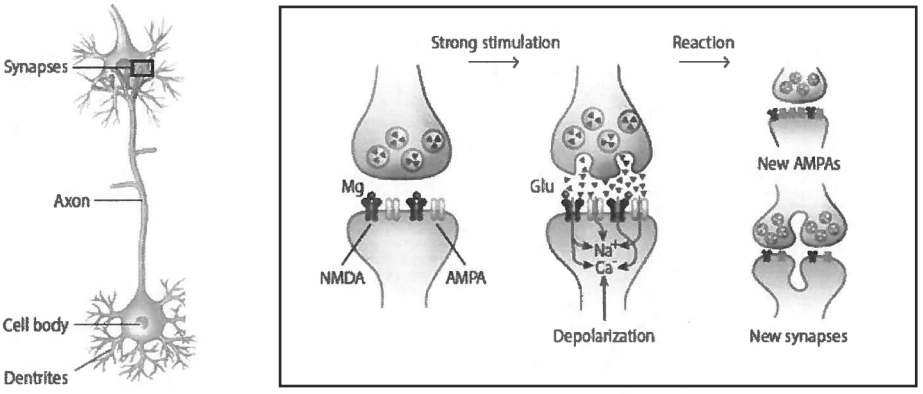
Fig. 2 06: Long-term potentiation. Long-term potentiation happens in the synapses between two neuron, where the axon from one neuron meets the dentrites from another. A high frequency of stimulus, a strong stimulation, depolarizes the post-synapses and increase the influx of sodiumand calcium ion. This intensify the connection between the neurons and leads to either new APMA receptors or new formations of synapses.

For instance, the sensory stimuli received by wearing cloth or the smell of our own breathe is often unregistered. On the other hand, a sensory experience can also be so intense, that it accumulates as a memory. This memory can be stable for only a few minutes, several weeks or a whole lifetime. *(Hall & Guyton 2006, p. 543-545)*

The neurons process the sensory information by transmitting communicating signals by electrical impulses. A prototypical neuron consists of three functional parts: axon, cell body, and dendrites. The communication signals are received from neuron to neuron by the junctionpoint between the axon of one neuron to the dendrites of another. This connection is termed as synapse. Memory is suggested to be a function of neural activities transmitted within these synapses - a neural mechanism termed as long-term potentiation (LTP).

Microscopic studies conducted by the Norwegian doctor Terje Lømo *(1935)* in the 1960 have demonstrated this mechanism as a result of synaptic plasticity. He conducted electroencephalogram (EEG, see appendix A) studies with electrodes implanted in the hippocampal formation of a rabbit. Multiply electrodes were implanted in a perforated pathway and the dentate area, performing electroshocks, imitating external stimulations, and monitoring signals. *(Bliss & Lømo 1973)*

This constellation made it possible to record the aftereffects of neural activity in response to manually provoked sequence of stimuli, and by repetitively stimulat ing the neurons, Lømo observed a mechanism responsible for LTP, as a potential substance for memory. LTP happens as a reaction to a sufficient amount of repetitively transmitted signals between the pre- and post-synapses. Normally, when a electrical impulse is transmitted through the axon of the neurons to the synapses, a chemical substance named glutamate (Glu) is released. Receptors positioned at the post-synapses, termed as APMA and NMDA receptors, react



to the binding of the glutamate. The APMA allows an influx of sodium to pass, while the NMDA channel stay blocked by magnesium ion (Mg). But when a high frequency of electrical impulses are transmitted to the synapses, the post-synases will depolarizes, as a result of an increased influx of sodium ion into the cell through the APMA receptors. This action expels the magnesium from the NMDA channel and allows an influx of both sodium and calcium ions. The influx of both sodium and calcium into the cell strengthens the relation between the neuron by either insertion of new APMA receptors in the membrane or increase the formation of new synapses. This biochemical change activates the process of LTP. This phenomena is often referenced as the reaction to memory acquisition. *(Cooke & Bliss 2006)*

There is a general consensus among neuroscientists, that LTP or modifications of LTP represent the primary mechanism of memory, but the biological confirmation of the cognitive mechanism of memory still remains unsolved. But the studies in LTP indicate a profoundly link between the neural activity and memory-associated behaviors and emphasizes the importance of the neural mechanisms. *(Poo et al. 2016)*

This inculdes especially the status of the individual neurons, which has been investigated intensely in experiments concerning spatial memory. *(Shapiro et al. 1997)*

The subjectivity of our spatial understanding is reflected in the adjectives of the initial research question: *"Why do we **love** and **vividly** remember certain places and not other?" (Robinson & Pallasmaa 2015, p. 144)*

The subjectivity of the initial research question can be difficult to determinate. Nevertheless, the recent neurobiological studies let us understand the cognitive mechanisms behind spatial memory, and can potentially explain why we remember certain places and not other.

The following chapter seeks to investigate the recent research of spa tial memory in the perspective of initiated context.
The investigation is focused in a redefined research question articulated by the architectural and neurobiological considerations presented in previous chapter.

How is the cognitive neural mechanism processing our spatial perception of our physical environment? And how do architectural features influence our ability to form new memories?

(iii) NEUROLOGICAL THEORY

THE COGNITVE MAP

The following section investigates how our spatial memory operates as a cognitive map structured by the communicational neural activity of the hippocampal formation.

As introduced in the prelude, Edward Tolman suggested already in the mid of the twentieth century, that humans as well as animals navigate and orientate themself by using a mental representation of the environment - a kind of tentative cognitive map. Tolman proposed that the internal representation is constructed by stimuli received by our sensory receptor. The different stimuli are cognitively processed and organized in a spatial field map indicating routes, paths, and the environmental relationships of the physical world. This theory was established on the basis of extensive psychological studies in the behavior of rodents by tracking movement and navigation of the animals, while looking for food in different mazes. *(Tolman 1948)*
Tolman's suggestions fostered numerous of experiments investigating the cognitive map in vivo. In the early 1970's the neuroscientists John O'Keefe and Jonathan Dostrovsky succeeded to digitally record sequences of neural activity by microelectrodes implanted in the brain of rodents. The neural activity indicated a cognitive representation of the environment. *(O'Keefe & Dostrovsky 1971)*
These neurological investigations were described and elaborated in the book The Hippocampus as a Cognitive Map written John O'keefe and Lynn Nadal in 1978, and stand as the neurological instantiation of Tolmans pshychological studies concerning the cognitive map theory.
O'Keefe and Dostrovsky were able to systematic register neural activity in the hippocampal formation, while a rat was exploring a controlled environment. The initial experiment included a restricted environment denned by a 24 cm x 36 cm raised platform, enclosed to three sides with a white curtain and only open to one side, revealing a view to the laboratory. The rats were recorded with electrodes implanted in the hippocampal complex and analyzed while doing daily routines as eating, walking, drinking, sleeping, etc. *(O'Keefe & Dostrovsky 1971)*
The activity of the recorded cells was establishing a firing field, the cell firing, representing a certain direction and location of the animal, similar to a GPS tracking system. The discovered cells were only active when the animal was facing the side open to the laboratory, and relative inactive when the rat was facing other directions, totally independent of the daily routine of the rat. It did not make any significant difference, what the rat was doing or why it was doing it, but the position of the animal in the given situation was decisive for the firing of the cell. This discovery led to the idea about spatial cells that encode locational information based on the stimulation of the environment. These cells were later termed as place cells. *(O'Keefe & Dostrovsky 1971)*

(i) PLACE CELLS

The activity of place cells was exclusive location-specific and dependent of the properties of the environment. The place cells were firing at minimal rate, when the rat was exploring the environment, but at a particular region of the environment the firing rate was significant increased, identifying a place field or firing field. Different place cells monitored simultaneously reveal different place field, each representing a specific location of the rat. *(Hartley et al. 2014)*
O'Keefe and Dostrovsky suggested that the collection of these place fields established a spatial reference map - the cognitive map *(O'Keefe & Dostrovsky 1971)*
This remarkable discovery led to several other studies investigating the properties of place cells and the structure of the cognitive map.
O'Keefe and Nadal predicted, by logical reasoning, that the map was established by a spatial relationship between spaces. A relationship conducted by information about speed, distance, and direction. They suggested that the cognitive map of hippocampus was generated by information from nearby cortical areas of the hippocampal formation providing the necessary information about the location. *(O'Keefe & Nadal 1978, p. 102-103)*

"Hippocampal place cells support spatial memory using sensory information from the environment and self-motion information to localize their firing fields."
(Spiers et al. 2015)

This prediction fostered comprehensive studies of the subcortical areas of the hippocampal formation in order to localize and identify the input information, and led to numerous of groundbreaking discoveries in order to identify how spatial memory is constructed.

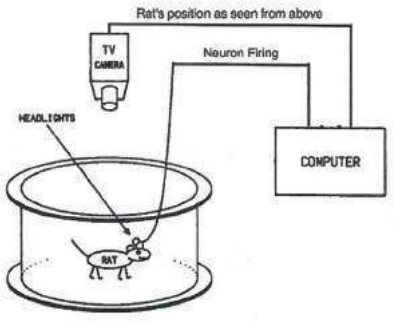


Fig. 3.01 The initial testsetting

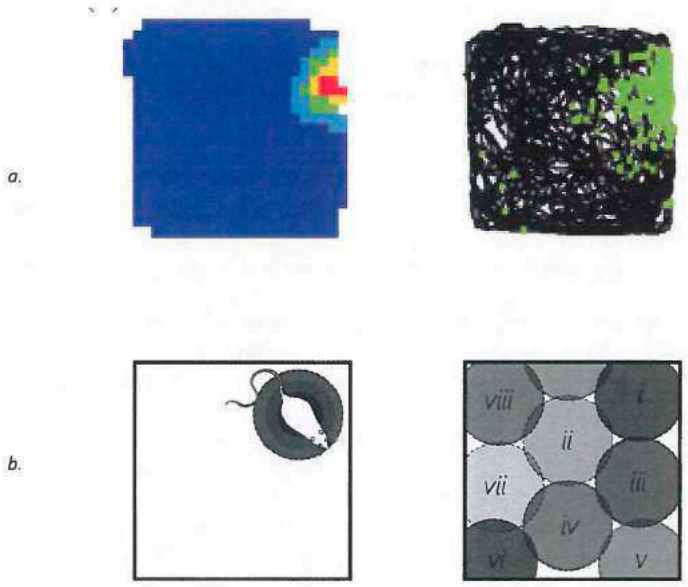


Fig. 3.02: The place cells. a.· The activity of place cells is illustrated to the left in a heat map - a locational firing ratemap. The red color illustrate high firing rate, while blue illustrate low firing rate. The illustration to the right shows the route of the animal the black line. The green dots illustrate when the neurons are active. b: The place cell is active when the rat enters a particular location of the environment - establishinga firing field The population of place cells acts as a representation of the environment - a cognitive map.

The majority of these studies are conducted by similar laboratorial principles as the initial testsetting by O'keefe and Dostrovsky.
This setting involves neural recording in the cortical regions of the hippocampal formation of free moving rats in a controlled laboratory frame. The recordings of the individual neurons were conducted by electrodes implanted in the hippocampal formation of the rat. This neural registration was done simultaneously with a recording video camera, which monitoring the location of the rat. Both signals were transmitted, recorded, and linked together by a computer, in order to locate the position of the rat relatively to the firing of the cells. In several of these studies additional equipment is installed. For instance, a special monitor recording the direction of the rat. This information is conducted by two colored LED lights positioned and secured to the head of the rat. The color of the lights detects the horizontal angle, which is recorded and transmitted to the computer. *(Taube et al. 1990a)*
This testsetting allowed the scientists to track the location, speed and direction of the rat in relation to a manipulative and controlled environment with variables as geometry, landmarks, texture, odor, level of light, etc., and led to the discovery of additional supporting spatial cells, described in the following section - each providing essential spatial information to the structure of the cognitive map.

(ii) HEAD-DIRECTION CELL

Neural recordings conducted by electrodes implanted in the postsubiculum, revealed the spatial cells termed as head-direction cells. These cells were also later found in entorhinal cortex and outside the hippocampal formation. Neuroscientists at Department of Physiology in Brooklyn, New York, managed in 1990 to systematically register the activity of these cells in relation to the horizontal orientation of the rat by head-placed LED lights. *(Taube et al. 1990)*
Their findings demonstrate that the head-direction cell establishes a constant in dicator of a particular direction within the test frame independent of the animal behavior, location and position of the truck. The cells were only firing, when the rat was oriented in a certain direction - tracking the allocentricdirection of the rat. *(Hartley et al. 2014)*

"Each head-direction cell fired at a maximal rate when the midline of the rat's head was pointed in a particular direction in the horizontal plane"

(Taube et al. 1990)

The scientists identified the characteristic of the particular direction not to be exclusive based on visual cues, but rather by multiple sensory responses representing a spatial relation within the environment. Furthermore, the particular direction was constant from day to day, indicating a certain memory acquisition. *(Taube et al. 1990)*
The preferred direction determined by the head-direction cells was not randomly settled, but fixed to the external cues of the environmental properties. The external cue was in the initial testsetting represented by a white card pasted to the wall of the test frame. White card represented a visual landmark that established a kind of reference point determining the orientation of the rat.
The findings demonstrated furthermore that the orientation was consistently fixed to the position of the landmark. If the white card, the external cue, was rotated 90 degrees relative to the test frame, the preferred direction encoded by the head-direction cells, rotated more or less equally. *(Taube et al. 1990)*
This effect is similar to the reaction of place cells, indicating a shared communication between head-direction cells and place cells.

The investigations in head-direction cells suggest that these cells provide directional information to place cells, similar to the cues of orientation provided by a compass. The cells might provide a reference point to the cognitive map, which establish the orientation and direction of the spatial representation. *(Hartley et al. 2014)*

(iii) GRID CELLS

Another type of spatial cells were discovered in 2005 by scientists at Centre for the Biology of Memory in Oslo. These cells were termed as grid cells and initial recorded by electrodes implanted in the medial entorhinal cortex, but later also found in the subiculum. The recordings revealed a different type of neural activity, than registered before, a kind of metric system, representing the position of the rat based on sensory positional and directional information of the given environment. *(Hafting et al. 2005)*

In contrast to place cells, the neurons were not only firing at one particular location, but had multiply firing fields creating a regular pattern relative to the size of the environment, similiar to a coordinate grid formed by the lines of longitude and latitudes. The grid system was not structured as a regular orthogonal system, but as a regular tessellating triangled grid with three different axes.

"Its key unit is the 'grid cell', which is activated whenever the animal's position coincides with any vertex of the regular grid of equilateral triangles spanning the surface of the environment"

(Hafting et al. 2005)

Grid cells were at first glance considered as a universal metric system persistent across difference in geometry and scale of the environment, and equally present in all explored environments. But recent studies indicated that especially the geometric properties of the space influence the regualrity of the pattern. *(Krupic et al. 2015)*
The orientation of the grid is anchored to the position of external cues, as the place cells and head-direction cells. When the cues are rotated, the grid is rotated equally as well. The grid cells are persisted, despite the absence of external cues, indicating that the grid cells are a response to the self-motion signals. *(Hafting et al. 2005)*

The dimensions between the vertex points are demonstrated to be a result of the position of the electrodes in the medial entorhinal cortex. The density of the vertex points, and thereby thescale of the grid system, depends on the anatomical position, increasing progressive in scale from dorsal to vertal of medial entorhinal cortex. Not as a linear progression, but organizedin modules jumping in scale with the approximately relationship of sqrt 2. *(Stensola et al. 2072)*

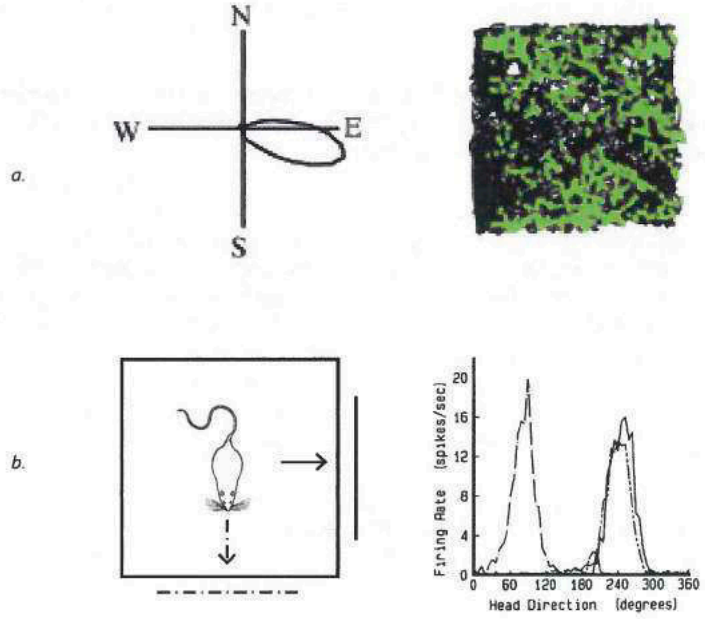


Fig. 3.03: Head-direction cells. a: The activity of the cells indicate a allocentric direction similar to a compass. The left illustration show the direction of the rat relatively to the activity of the cells. The cells are only firing when the rat is orientated in a east direction. b: The head-direction cells encode the particular directions of the rat relative to the external cues. If the external cue (the solid line) is rotated 90 degrees (the dashed line) the preferred direction of the head-direction cells is rotated 90 degrees too.

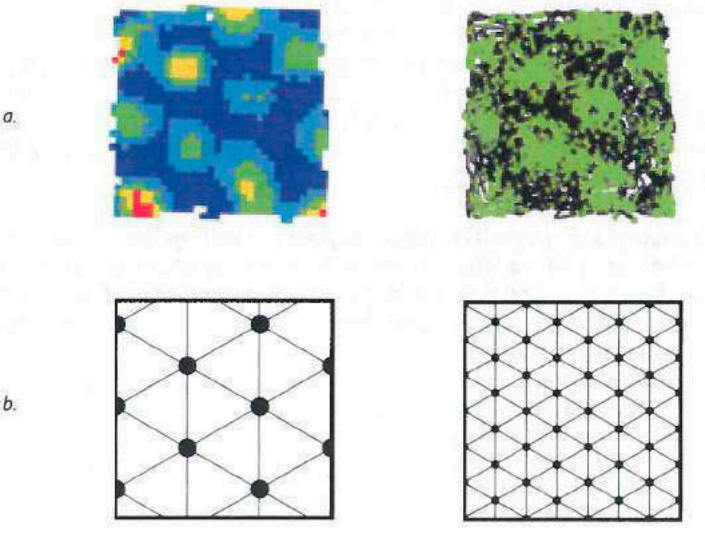


Fig. 3.04.· Grid cells. a. The activity of grid cells is encoded as a tessellating triang/ed grid spanning the whole surface of the environment. The cells are only active in the vertex points of the triangular grid b. The distance between the vertex points becomes larger in relation to the anatomic position of the recorded neuron.

(iv) BOUNDARY CELLS

A comparative study conducted in 1996 by O'keefe et al. between place fields in a squared environment and a rectangular environment indicated that the geometrical propoerties in fluenced the activity of place cells. The firing field of place cells reflected the bound aries of the space, if the environment was stretched from a square to a rectangle, the firing field of the place cells was stretched equally. *(O'Keefe & Burgess 1996)*
This discovery fostered the idea about spatial cells that provide information about the environmental boundaries.
The existence of boundary vector cells, later also labeled as boundary cells, were fully demonstrated and recorded by Colin Lever in 2009. *(Hartley et al. 2014)*
The recordings were conducted by electrodes implanted in the dorsal subiculum located between the entorhinal cortex and the CA1 subfield. *(Lever et al. 2009)*
Boundary cells were also registered in the medial entorhinal cortex as the head-direction cells and grid cells. *(Solstad et al. 2008)*

The findings suggested that the boundary cells reacted to a receptive field related to the rat. A intersection between the respective field and the boundaries of the environment would cause in a cell firing. Thereby, the firing of the cell would happen, when the rat is at a specific distance and in a specific allocentric direction from an environmental boundary, independent of the orientation and behavior of the rat. *(Lever et al. 2009)*

"For example, a given BVC (boundary cell) might fire whenever a wall or barrier is found approximately 5 cm to the south of the rat; this cell would be expected to fire along the southern perimeter of an enclosed environment and also along the northern side of a barrier introduced into the same environment."

(Hartley et al. 2014)

Boundary cells are suggested to provide essential cues about the space boundaries of the environmental geometry to the cognitive map. *(Hartley et al. 2014)*

(v) SPEED CELLS

The neuronal ability to structure grid cells led to the discovery of speed cells, based on the prediction that information about speed and direction establishes the precise structure of the grid.

"The speed signal is used to dynamically update grid-cell activity in accordance with the animal's movement in space."

(Kropff et al. 2075)

These observation s were conducted by Emilio Kropff in 2015 electrodes implanted in the medial entorhinal cortex. In contrast to the other spatial experiment, the recordings of speed cell were conducted in a customized built car without a bottom, (similar to Flintstones car). This consellation allowed the rat to naturally engage in movement at a controlled and monitored speed. By controlling the speed and recording the cells activity simultaneously, the scientists were able to compare the firing rate relative to the movementspeed. *(Kropff et al. 2015)*
The results indicated a correlation between running speed and firing rate independent of the animal behavior as grid cells, head-direction cells and boundary cells.
The firing rate of the speed cells was indepedent of the location and environmental propoerties too, but only a response to the movement of the rodents.
This is furthermore concluded by observation with totally darkness and change in visual inputs. These environmental properties did not affect the activity of speed cells, indicating that the environmental properties do not influence the neural registration of speed. *(Kropff et al. 2015)*

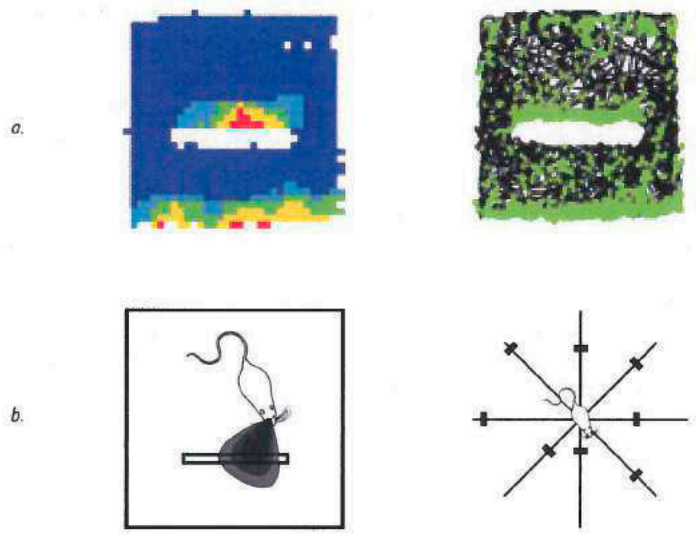


Fig. 3.05: Boundary cells. a: The boundary cells encode the space boundaries of the environment. The bound ary cells are active when a receptive field relative of the rat intersects with the environmental boundaries b: The illustration to the left shows how the receptive field is allocentric fixed to the rat. The right illustration shows how the boundary cell encodes the allocentric distance to the environmental boundaries (the black segments).

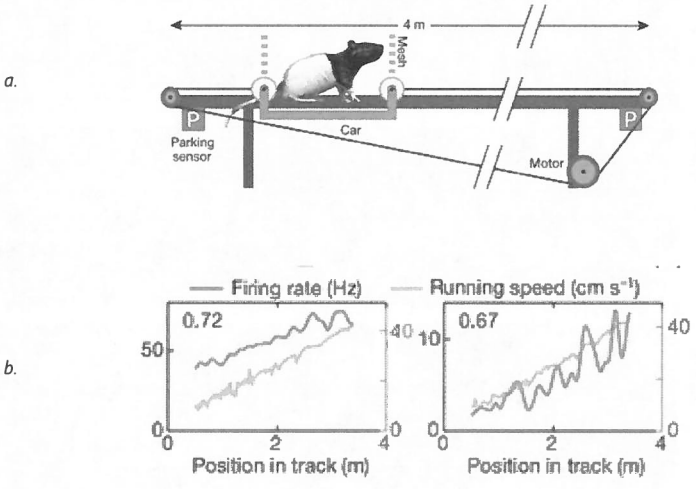


Fig 3.06: Speed cell. a: The instrument (the Flintstone car) to record the speed of the rat. b. the speed relative to the firing rate of the cells

THE PROPERTIES OF THE SPATIAL CELLS

The cognitive map is structured by the collective information of described spatial cells, all found in the hippocampal formation. The celld provide the essential information about location, direciton, distance, and environmental properties in order to establish a legible spatial representation. An following example is set in order to illuminate the respective aspects of the individual cells and their collective relations. The example is primary based on the neurological findings in rats and has to be considered as a constructed interpretation translated to a human perspective.
The illustrated environment consists of an enclosed space defined by four walls. A tree is located at the corner of the space. A subject walks from the location marked with a black dot to the location marked with a grey dot. The route is marked with a dashed line.

ORIENTATION

SC

HDC

Speed cells and head-direction cells are encoded as a result of the subject's locomotion. By exploring a space the subject receives self-reference information about both speed and orientation. The orientation is encoded by the head-direction cell and anchored to the most prominent external cues. In this case sympolized by the presence of the tree.

DISTANCE

GC

Grid cells encode a dimensional metric as a triangled discrete grid pattern. The grid is structured by the directional information and the self-motion signals encoded by respectively head-direction cells and speed cells. The grid pattern covers the whole surface of the floor area.

BOUNDARIES

BC

Boundary cells encode the space boundaries of the environment. The boundary cells react to a receptive field relative to rhe subject and the specify allecentric distance to the surrounding boundaries. The distance from the center to the grey and black lines indicate the actual distance from the subject to a encoded boundary.

THE COGNITIVE MAP

PC

Place cells encode the specific location of the subject within the environment as a collective result of the abovementioned spatial cells. One is active when the subject is located at the black spot, and the other is active at the grey spot. The input information is location-specific and based on both the environmental stimuli and locomotional inputs.

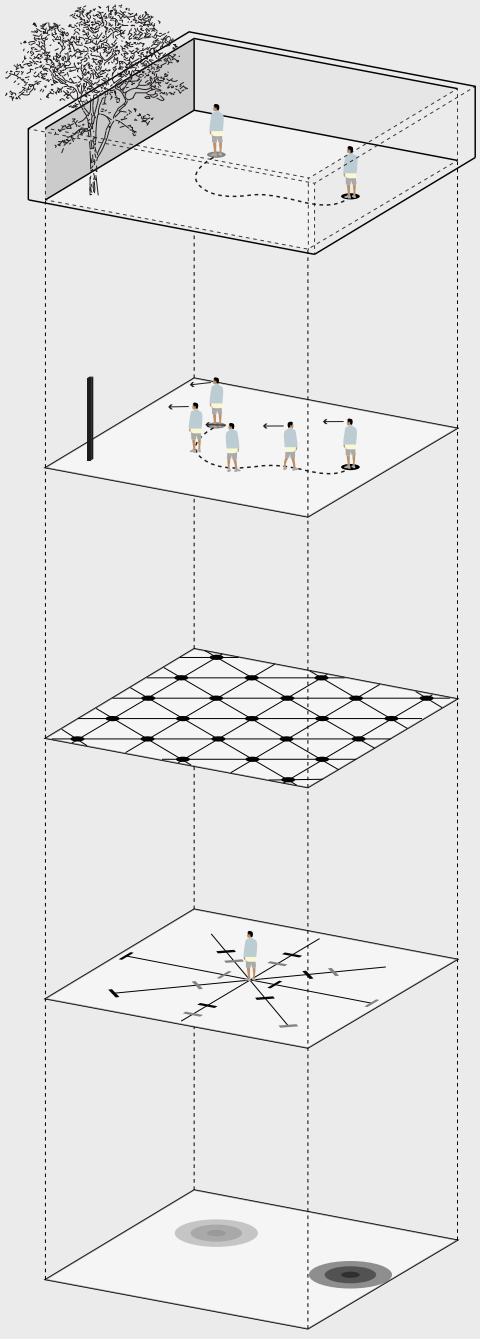


Fig 3.07: The relations of the spatial cells. The different layers illustrate how the spatial cells contribute to the structure of the cognitive mop.

NAVIGATION

The firing field of place cells represents a certain location in a given environment based on the perceived input information about direction, boundaries, and distance. Directions provided by head-direction cells, space boundaries by boundary vector cells, and distances by grid cells and speed cells.
Nevertheless, the cognitive map is not structured by a single place cell, but by the population of place cells, that together establish a firing pattern. The relationships between the activity of the individual cells, represented in the firing pattern, create the cognitive map, and offer us the ability to navigate. The following section investigates how navigation might be a product of the cognitive mechanism of the hippocampal formation.

Some of the first demonstrations emphasizing the importance of the hippocampal formation in spatial navigation were conducted by Richard G. M. Morris *(1945)* in 1981. His experiments with rodents were conducted in a water maze established by a large circular basin filled with opaque water. The rodents were navigating to a smaller hidden platform placed slightly under the water surface. This constellation made it impossible for the freemoving rat to see the platform while swimming in the basin, and left the rat exclusive to its own movement in order to navigate. By comparing the motion of both normal and brain-lesioned rats navigating in the water maze, Morris observed a significant difference in performance. The normal rats learned to swim directly to the hidden platform within the environment from trial to trial, in environments including or excluding external cues. These findings indicates a certain spatial navigation based on the previous experience of the rat. However, the rat with hippocampal lesion did not improve their route to the hidden platform at all and indicated a totally impairment in place navigation. *(Morris et al. 1982)*

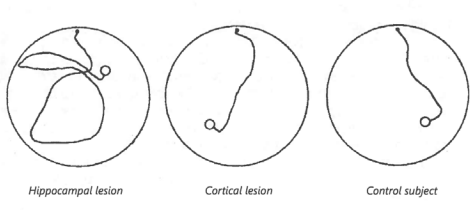
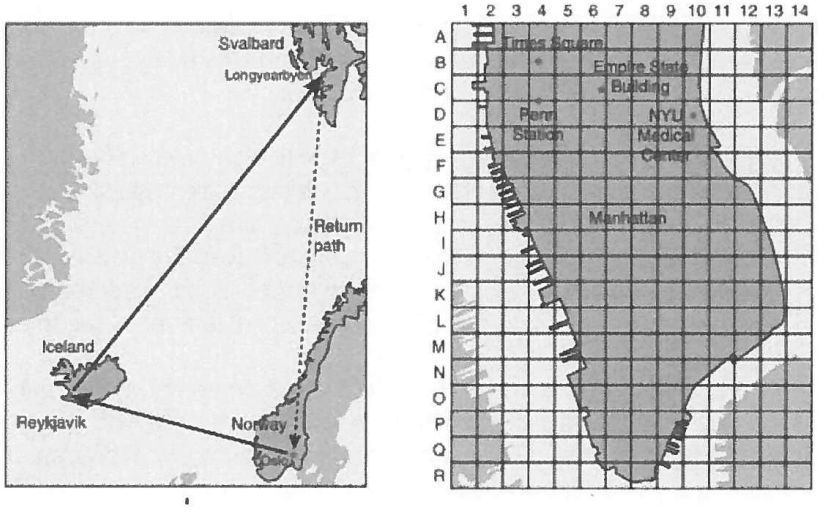


Fig. 3.08: Morris water maze. The illustrations show the route of the rat within the water maze. The rat with a damaged hippocampal formation does not improve the route to the hidden platform, while the cortical lesion and the control subject improve their route from trial to trial - indicating a certain spatial memory.

Morris' study indicated two different mechanisms of spatial processing in terms of navigation. *(i)* Navigation based on self-motion signal or self-reference information referred as egocentric information. *(ii)* Navigation based on the relationship between external cues referred as allocentric information. *(Spiers et al. 2015)*

(i) Navigation based on egocentric information is a result of self-motion - locomotion. When exploring an environment, the brain continuously updates (if the hippocampal formation is intact) information about speed, distance, and turns. This self-referenced information represents a kind of logbook that constantly notes movements, and records a spatial representation of the environment- a cognitive map based on orientation. *(Ellam 2014)*
This type of navigation is often verbally used when verbally explaining a certain route to a person: go left by the first turn, continue then twenty meters straight, and the shop will be on your right. Egocentric navigation includes the ability of path integration, which might be a function of the cognitive map that offers the ability to take shortcuts. For instance, by taking a shorter way home, despite never walking exactly that particular way before. *(Buzsáki & Moser 2013)*
In the perspective of neurological theory, grid cells might be the potential source to this egocentric information as the activity of grid cells is a result of both the speed and direction of the rodents registered by movement.
(ii) Navigation by allocentric information or map-based information is supported by external cues. Allocentric spatial information is provided by visible or detectable cues, as landmarks or boundaries, in order to establish a reference frame indicating locations within the environment. The spatial relationship between external cues defines both the current location and the layout of the environment. This kind of cognitve map, structured by allocentric information, can be compared to an ordinary map based on a compass. *(Buzsáki & Moser 2013)*
The allocentric information might potential be provided by both head-direction cells and boundary cell, which encode the spatial relationship within the physical environment.
Both mechanisms of navigation cooperate togetherand support each other in order to establish a concrete cognitive spatial representation. When the allocentric processing is minimal, for instance in totally darkness, the egocentric processing still provides a certain sense of location.The navigation within a given environment depends on the clarity of our cognitive map, constructed by the input information from both egocentric and allocentric processes. The input information is registered in the present of place cells and provided by grid cells, head-direction cells, speed cells, and boundary cells. The results from studies of these spatial cells, how the cells react to different environmental setting, might demonstrate how the environment influences our ability to navigate.

Fig. 3.09: Egocentric and allocentric navigation a: Navigation by egocentric information is based on self-motion signals. b: Navigation by allocentric information is map-based as a compass.



a. *b.*

LANDMARK

It is general concluded that the cognitive map is anchored to a number of reference points, indicating orientation and direction. The following section investigates the properties of the reference points, and how it contributes to spatial understanding.

It can be easier to navigate in the present of an external cue that gives a sense of both direction and location. An external cue can be represented by an element or feature of a given environment that in its differentiated appearance becomes a more distinct and memorable object - a landmark.
A bell tower or a high-rise building would be a typical salient landmark in a urban context, but a sound, a light source, or a tactile feeling could in that matter act as an external cue as well. *(O'Keefe & Conway 1978)*
It is, to a certain degree, subjectively varying whether a feature becomes a prominent landmark or not. *(Montello 2014)*

"What we notice in a building depends in part on our expectations, interests, training, and state of mind.
(Montello 2014)

The subjective status of the landmark makes it difficult to determinate a universal definition for what is a landmark and what is not, but several general observations, concerning studies in place cells, identify some common rules for the status of the landmark.

Experiments including several different stimulations, distal as local, indicate that hippocampal neurons encode the external cues in a hierarchical order sorted by dominance. The most prominent stimuli represent the reference point, if this cue is eliminated, the second most prominent cue takes over this position. The neurons are systematically ranking the external cues in response to the degree of stimuli, and adapts to the environment, as the different directional landmark becomes available. *(Hartley et al. 2014)*
A prominent landmark in one environment might act as an anonym cue in the other. Several experiments have investigated the logical system behind the hierarchy by including multiply cues in the same environment. The individual potential of the external cues has been studied by manipulating both the environment and the cue systematically. This included a high variety of distal and local cues - combining both visual cues with tactile and olfactory cues. In one experiment, the visual cues were represented in different curtains; aluminum foil, shopping bags, striped card, and rag, tactile cues in the sense of different floor textile; plastic mesh, sandpaper, aluminum, and rubber mat, and olfactory cues as the smell of anise, coconut, strawberry, and mint. *(Shapiro et al. 1997)*
The findings of this particular study indicated the landmark system as a hierarchical order that rank the relationship between multiple cues, distal and local, as the most prominence reference point. Furthermore, the distal visual cues placed outside the space was encoded as more prominent than the local stimulus. *(Shapiro et al. 1997)*

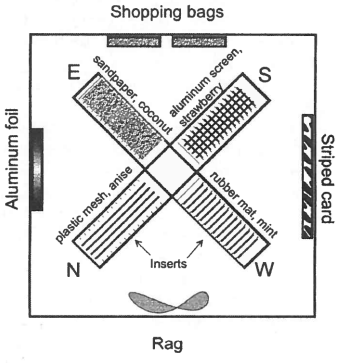


Fig. 3.10: External cues. The studies of external cues include different stimuli, local as global. The status of the stimuli as landmarks can be tested by manipulating the external cues.

In contrast, multiple cues within the same environment might in some cases impair the sense of direction. If multiple identical external cues appear in the same environment, a conflict between the landmarks might potential occur. This might in some cases result in a compromise between the landmarks. *(Hartley et al. 2014)* The situation of conflicting external cues can be compared with an environment without prominent landmarks, which might result in a more irregular cell firing of head-direction cells, independent of a particular direction. *(Taube et al. 1990b)*
Both effects, without landmarks or with similar landmarks, indicate a spatial confusion, which potentially cause in reduced spatial navigation and a certain degree of disorientation.

If a prominent landmark is encoded by the spatial cells, the specific placement of the landmark is essential to its status. The location of a physical landmark can be proximal placed in the environment, at the periphery of the environment, or outside the environment. The majority of studies in place cells have experimented with either external cues placed at the periphery of the environment, typical as a flat white cue card pasted to the wall, or as a distal object placed outside the laboratory setting. These two positions automatically limit the angle of the viewpoint to a restricted range, altering the landmark more as a surface than an object. This property makes it ideal for specifying a certain direction, but can in some cases make it difficult to

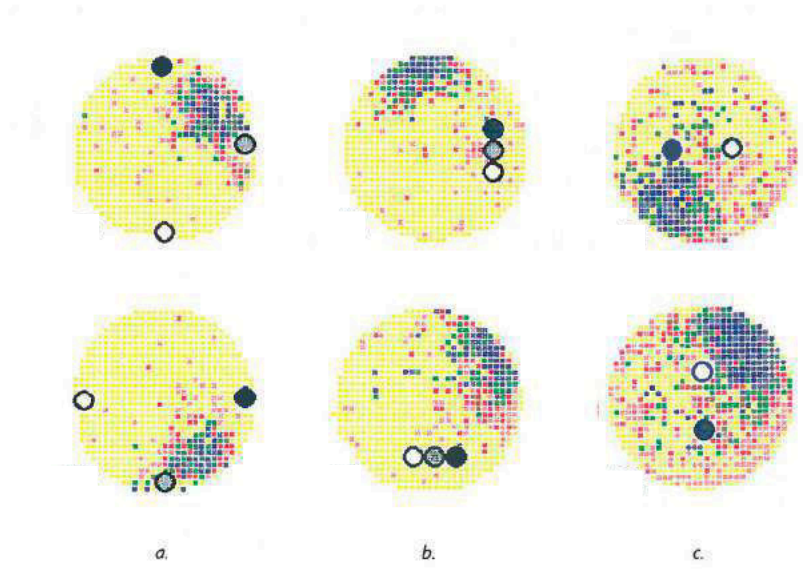


Fig. 3.11: The position of the landmark. The status of the landmark is a result of its location a: The external cues at the periphery act as a stable landmark. If the distal landmark is rotated, the firing field rotates as well. b: The same propertiesis presence by the intra-arena external cues placed close to the borders. c: The proximal cues do not act as a stable landmark. The firing field rotates independent of the cues.

distinguish between individual spaces.
On the other hand, a landmark placed closer to the observer offers a higher variation of angles relative to the location of the observer. This complicates the distinguishing between the different views of the landmark. A landmark can even be placed too close to the observer in order to act as a reference-point for the cognitive map. *(O'Keefe & Nadal 1918)*

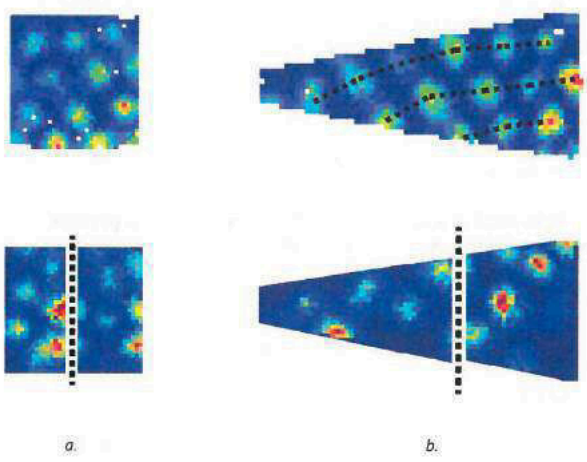
The placement of landmark intra-arena and proximal in the environment requires a certain amount of self-motion in order to reveal every side of the land mark too. The observer can by movement be in directly contact with the landmark and thereby get the possibility to register it from every viewpoint. Studies conducted with objects placed near the center of the laboratory frame, revealed in general no consistence of firing field in reaction to rotation of the objects. These findings indicate that the proximal placement affects the ability to anchor the landmarks as a stable reference-point. *(Cressant et al. 1997)*

In comparison, the landmark located at the periphery or outside the environment acts as a more stable information for navigation, providing more or less constant representation relative to the placement of the observer, where the center placed landmark vary by egocentric inputs and becomes insufficient for reliable stimuli control. *(Lew 2011)*

"The most powerful stimuli are easily discriminable ones on the cylinder wall. Next are static background cues from the laboratory frame. Finally, the object set is used rarely, despite its seeming salience."

(Cressant et al. 1997)

Fig. 3.12: The influence of the space geometry The structure of the grid pattern is effected by the space geometry a: The grid pattern within the square-shaped environment is relatively regular b: The grid pattern of the trapezoid shaped environment is distorted and irregular.

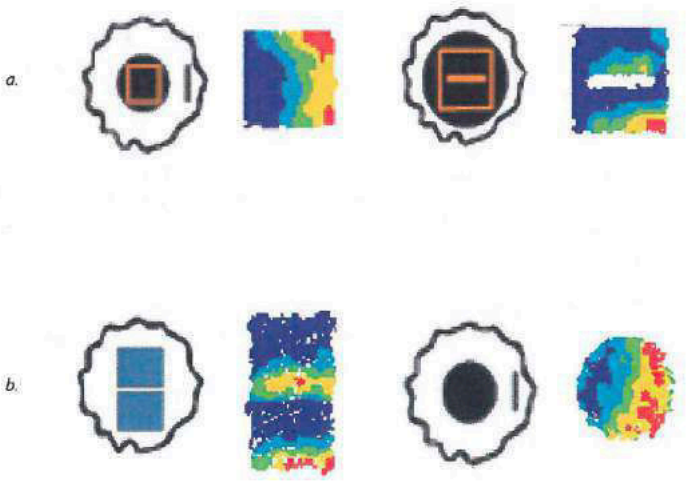


GEOMETRY

The boundaries of an environment can in some cases act as the most prominent landmark as well, despite the appearance of salient external landmarks. Experiments concerning grid cells indicated that the geometry can act as a reference point. Comparative studies between a square formed environment and a circular formed environment showed different spatial understanding. The experiment conducted in a geometrically polarized enclosure, a box, anchored the grid pattern to the space boundaries, while the grid pattern encoded in experiments conducted in a geometrically symmetrical environment, a cylinder, was overruled by external cues. These observations identified the importance of the geometrical properties in response to the orientation and especially how the geometry regarding to scale, symmetry, and homogeneity influences the regularity of the grid pattern.
Grid cells recorded in rodents exploring a simple form, as a circle or a square, provides a more or less perfect symmetrical triangular grid pattern, while rats exploring an irregular form, as a trapezoid, provides a distorted and less evenly distributed grid pattern.
Furthermore, the density of the grid pattern of the simple squared geometry was significant smaller than in the trapezoid formed environments. The grid pattern of the trapezoid formed environment was permanently more irregular, than in the square formed environment. Especially, the grid pattern of the most narrowed end of the trapezoid had higher irregularity. This reaction indicates that the relationship in distance between the walls affected the spatial registration. *(Krupic et al. 2015)*

A similar result is concluded by studies with rodents exploring novel spaces. The novelty of a space is reflected in the scale and regularity of the grid pattern.
As a result of geometrical change, the novelty of the space influences the density of the grid pattern. The distance between the vertex points are lesser in familiar environments than novel environments. *(Barry et al. 2012)*
This characteristic is also registered as a result of the

Fig. 3.13: The status of the boundaries. a: The external boundaries are encoded by head-directio n cells. A wall and a proximal ridge within the environment are both encoded by boundaries. b: A drop between two platforms and the end of the platform are encodedas boundaries too



rodent's age. The grid pattern becomes more precise in relation to the age; - grid cells mature potentially to the level of experience. This reaction is only registered in grid cells; but head-direction cells and border cells are present already first the rat explore the space. *(Bjerknes et al. 2014)*

These findings indicate that architectural properties as geometry, scale, symmetry, and homogeneity influence grid cells and thereby the spatial understanding.
Furthermore, it indicates that the novelty of the space affects the spatial clarity. The level of locomotional experience improves the ability to cognitive encode the environment. For instance, familiarity of a squared formed environments, would automatically improve the navigation of other squared formed environments.

BOUNDARIES

The geometry of space is defined by its enclosure. Studies concerning boundary cells investigate how and when the space boundaries influence the spatial under standing. Furthermore, the studies identify the status of the boundary.

According to studies in boundary cells, a boundary is not exclusive reserved to be a vertical surface, a wall, but a drop at the edge of the platform or a split between two platforms can be perceived and registered as a boundary as well. The firing of boundary cells is relative consistent regardless of both the shape and direction of the boundary and the type of boundary. The activity of boundary cells is intact despite geometrically change from a squared formed environment to a circular formed environment Furthermore, distal cues in relation to the boundaries do not affect the appearance of boundary cells. *(Solstad et al. 2008)*
The color and the type of material do not affect the firing of boundary cell. This discovering differs from the registrations of place cells that change when the

sensory qualities, as change in color or material, of the given environment are sufficiently different This indicates that only the geometrical form of the boundary is encoded by boundary cells. *(Lever et al. 2009)*
Additional boundaries placed proximal within the environment influence the activity of boundaries cells. A proximal boundary, as a discrete barrier, establishes an additional firing field, indicating that the proximal boundaries is encoded as a space boundary as well. A proximal boundary can be a floor to ceiling wall, but also a lower wall, as a ridge, can act as a boundary as well. *(Solstad et al. 2008)*
Studies conducted in environments without walls, as a raised platform, indicate the presence of active boundary cells as well. The firing field registered in these environments is placed at the edge of the platform or 5-10 cm further out, indicating the
limit of reachable space by leaning over the edge.

"Our evidence suggests that boundaries may be defined by both sensory cues and limitations to movement"

(Lever et al. 2009)

These findings indicate the status of boundaries as an important part of the allocentric spatial information to the cognitive map. *(Hartley et al. 2014)*

SEQUENCE

Numerous of independent maps can be stored in the brain as memories. Multiply visits to a particular environment improve the spatial structure of the map. Visiting multiply environments can involve multiply cognitive maps, and enable the ability to remap between individual cognitive maps, when moving from one location to another.
Studies indicate that the function of remapping is purely based locally in situations where geometrical and contextual changes are made - moving through a sequence of individual defined spaces. *(Spiers et al. 2015)*
This initiates the question; whether how long a sequence is? And what might interrupts a sequence and cause a remap?

"Neuronal representation of travel paths does not consist of long uninterrupted neuronal chains but are o en broken into repeating chunks by prominent landmarks, state changes or reinforces"

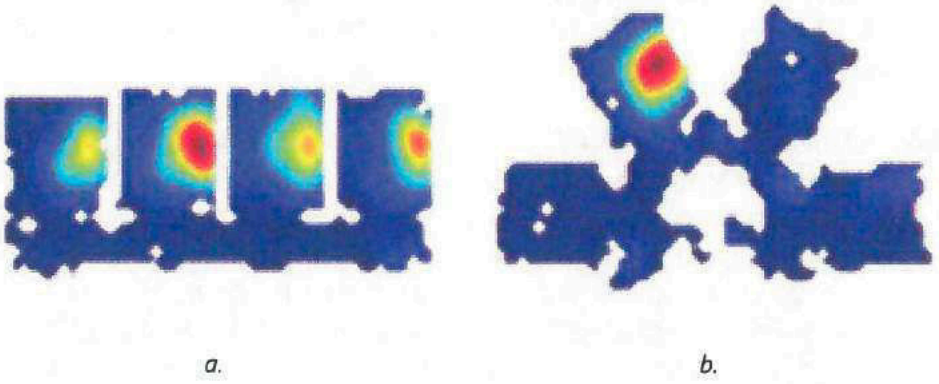
(Buzsáki & Moser 2013)

The elimination of a prominent landmark do not necessary cause a remap, but removing a boundary of an environment or changing the geometry would most likely influence the place cells and cause in a remap. *(O'Keefe & Conway 1978)*

Other external cues as contextual or geometrical changes might result in a remap as well. For instance by the introduction of another color or doubling the size of a room. *(Spiers et al. 2015)*

Neural recording of place cell in similar environments with more or less identical stimulation results in equal place fields, indicating no remapping. These envi ronmental properties could be present in such as the corridors of a labyrinth or the hotels room along a row of parallel oriented apartments.
Studies conducted with rodents exploring four identical parallel organized rooms showed identical place cells representation, despite the self-motion of the rat
The sequence of similar spaces would most likely result in reduced navigation and disorientation. *(Grieves et al. 2016)*
These experiments indicate a reduced ability to distinguish between the individual rooms, when the rooms are more or less identical. Additional studies, with same identical rooms, but organized in different angular directions resulted in a remap, both tested with and without the present of a landmark. These studies indicate that the direction is essential for structuring the spatial representation and the disquisition of individual space. The spatial correlation between the spaces is relative to the angle of separated. If the difference between the orientation angles of the
apartments is small, the spatial correlation between the spaces is large and vice versa.
(Grieves et al. 2076)
The relationship between the spaces defines the sequence, and especially the doorways become a particular interesting component in terms of spatial under standing. The doorways represent the segment between the neural representations and establish the conjunct points or access point of the sequence.
Studies indicate a clustering of cell firing around the doorways, which might indicate that doorways act as an essential environmenatl feature. *(Spiers et al. 2015)*

Fig. 3.14.· The sequence of spaces. a: Parallel organized apartments provide identical firing fields, which in dicate the similarities of the spaces. b: Similar apartments organized in different angular directions provide different firing fields, which indicate a discrimination between the spaces.



PRINCIPLES DERIVED FROM NEUROSCIENCE

As the neurological theory of experiments of rodents has demonstrated, the cognitive map is structured by the population of place cells firing in reaction to the sensor y external stimuli . The place cells operate on the basis of the additional spatial cells, head-direction cells, grid cells, boundary cells, and speeds cells, that all provide the necessary information about orientation, distance, and space boundaries. The accuracy of this input information is essential in terms of spatial understanding and fundamental in cognitive processes concerning spatial navigation. The most important properties of the spatial cells are defined in following four principles:

(i) HIERARCHICAL CUES

The cognitive map is anchored to a single or several external reference points determining orientation and direction. Prominent stimuli of the environment, as a visual landmark, a simple space geometry, a tactual difference, a sound, a odor and etc., are encoded by the neural registration of head-direction cells. Each stimulus is systematically organized in a hierarchical order based on its dominance. The combination of both distal and local prominent stimuli is ranked as the most important reference, secondly the distal cues placed at the periphery of the space, thirdly the distal cues outside the space, and lastly the local stimuli placed proximal. The absence or the conflict between two external cues would potential led to a indistinct reference point.

(ii) GEOMETRIC DETERMINANCE

The ability to determinate distances, proportions, and spatial relations is offered by a cognitive metric system. This metric system is encoded in the triangular pattern of grid cells received by self-motion signals concerning both speed and orientation. The more regular the grid pattern is encoded, the more is the spatial proportions perceived and understood. The novelty or familiarity of an environment and the geometrical properties of a space in term of scale, symmetry, and homogeneity affect the spatial clarity, which are neural represented by the regularity of the grid pattern. An inhomogeneous or novel environment results in a distorted grid pattern, while a familiar or simple environment provides a more regular grid pattern.

(iii) SPACE BOUNDARIES

The cognitive map is provided with a reference frame defining the borders of the map. The borders are encoded by boundary cells as an allocentric neural reaction to the environmental boundaries. The space boundaries are typically defined by motional limitation, as a wall or an end of a platform, but a smaller ridge or a drop in the floor within the space can act as a space boundary as well.

(iv) SEQUENCING

The spatial understanding is constructed by numerous of cognitive map; each representing individual spaces discriminated by the variation in sensory external stimuli. A variation in grid, space boundaries, orientation, or external cues would most likely cause in a remap. Two identical spaces providing same stimuli would be attached to identical cognitive map. The connection of individual spaces would result in a sequence, combining the cognitive maps. Distal cues or doorways act as essential junction-points between spaces.

The following chapter seeks to validate the neurological principles in an architectural context.
The neural mechanisms identified in studies of rodents is discussed in relation to a human perspective.
Furthermore, the neurological principles are tested on well-known architectural cases in order to investigate the correlation between the neuroaffective aspects and the architectural intensions.

(iv) ARCHITECTURAL VERIFICATION

THE HUMAN BRAIN

The majority of knowledge concerning spatial memory is gained by studies including animals. Especially, electrophysiological studies of the rodents brain offer a useful insight of the underlying neurological mechanisms relative to spatial memory. The following section investigates the correlation between these studies in rodents and studies with the human brian.

Several studies indicate a significant functional correlation between the brain of the rat and the human, despite the general neurological difference from species to species.
Obviously, a human brain is radical bigger anatomically than a rat brain, and the human brain is capable of learning actions that the rat brain never will process. Nevertheless, the overall brain volume is not totally potential with the functional capacity. For instance, the elephant brain is much bigger than the human brain, but the elephant is for instance not capable of reading books, studying algebra or designing cities. However, studies indicate a certain relationship between the size of subregions and the intelligence. *(Cluck et al. 2014, p. 43-44)*
For instance, anatomical changes in the hippocampal structures have been registered in subjects with a certain decrease of functional capacity like patients suffering from Posttraumatic Stress Disorder or Alzheimer. *(Astur et al. 2005)*

This correlation is also concluded in a study concerning spatial representation of the human hippocampal formation conducted by the Institute of Neurology at University College London in 2000. The scientists managed to analyze and compare the anatomic size of hippocampus in the brain of London taxi drivers and a group of control subjects. Their results indicated that the posterior hippocampus of the taxi driver, with extensive training in navigation, was significant larger than control group. This data supports the correlation between anatomical size of subregion and capacity, but also emphasize the essential role of the human hippocampus in terms of spatial navigation initiated by the neurosurgeries of the midtwentieth century. Furthermore, the findings indicate that local neural plasticity, similar to the cognitive biological process of LTP, is generated as a response to environmental perception. *(Maguire et al. 2000)*

The prominent status of hippocampus in spatial memory is furthermore concluded by several neuroimagnig studies. Even neural activity similar to the reaction of place cells has been documented both in monkeys and humans, but the neuronal mechanism of the human spatial memory is not totally clarified yet. *(Bird & Burgess 2008)*

Especially, the risk by interventions in the brain has implicated these studies. There by, functional magnetic resonance imaging FMRI, has been the preferred method of studying brain activity in the human brain, because the experiments can be conducted without operational penetrating the scalp. Only a few electrophysiological studies have been conducted with electrodes implanted in the human brain. This includes a study involving seven subjects suffering from epilepsy revealed a certain correlations between neural activity in hippocampus and a specific spatial location. The patients were exploring a virtual environment, while electrodes, implanted in the hippocampal formation, monitored the neural activity. This study is not comparable with the studies conducted on rodent in term of validity and accuracy, but indicates that the underlying human navigation is computed as a map-like representation in the hippocampus similar to the cognitive map registered in rodents. *(Ekstrom et al. 2003)*

Several studies with utilized Virtual Reality and fMRI have investigated principles concluded from the electrophysiological studies of rodents. Early studies, psychological and neurobiological studies, have investigated the properties of hippocampus in terms of spatial memory by analyzing rodents navigating in mazes. This setting has been complicated to conduct in a human scale. Nevertheless, scientists managed in 2005 to conduct the Radical Arm Maze experiment on humans by using a virtual constructed maze. This experiment concludes similar result as the experiments conducted on rodent, and especially that the spatial nature of the maze activates neural networks in the human hippocampus. *(Astur et al. 2005)* Furthermore, similar correlation between studies in rodent and humans has been conducted by the Institute of Neurology at University College London. They instigated both brain activity and human behavior in a virtual environment included a landmark, space boundaries, and distant cues. They recorded neural activity while participants were exploring an environment in order to investigate the cognitive neural communication relative to the human behavior. Multiple recordings indicated a certain correlation between the right hippocampus relative to remembering space boundary-related location, and neural activation in right dorsal striatal as a reaction to learning landmark-related locations. *(Doeller et al. 2008)*
Similar basic human mechanisms and strategies in term of spatial navigation are also observed in animals, which indicate a certain cognitive correlation. This includes mechanisms as path integration, as described previously, and wall-following, which is a behavior for acquiring the environmental scale and geometry. *(Eilam 2014)*

The above mentioned studies do not comprise the

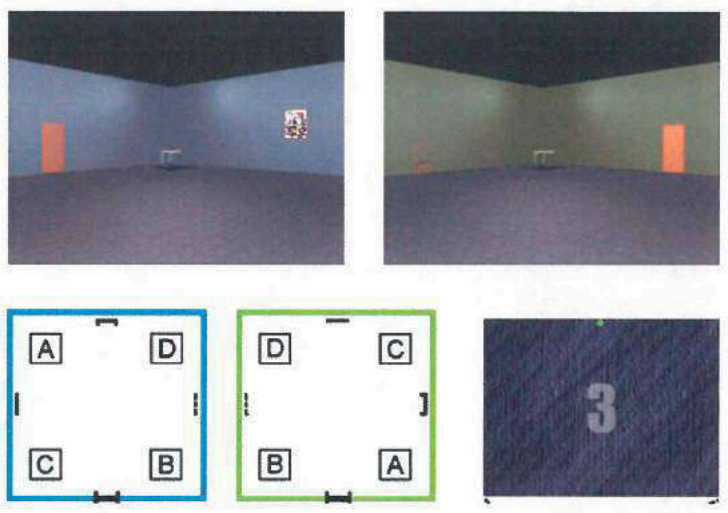


Fig. 4.01: Virtual reality environment. This experimental task involves participants exploring two virtualspac es; a blue and a green. The participants have to navigate as quickly and accurately within these spaces. Each space contains several objects, which act as proximal external cues.

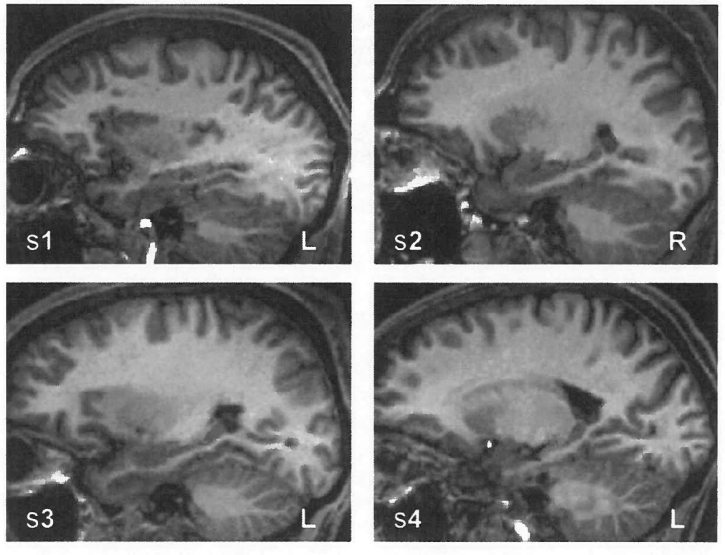


Fig. 4.02: FMRI prediction. High resolution fMRI decodes the octivity of neurons. The prediction maps indicate neural activity in the hippocampus representated-by the white dots. The results of the findings show abstracted representations of the virtual environment encoded in the human hippocampus relative to the location of the participants.

same level of detail as the studies in animals in relation to the cognitive map, but they sufficiently indicate a certain correlation between the rodent brain and the human brain concerning spatial memory. Furthermore, it is clearly indicated that neural mechanisms in the human brain is comparable with the cognitive map theory, and it is reasonable to assume that the cognitive processes of the animal brain can provide insight into how humans perceive, understand, and remember the physical environment.
To verify the principles based in the neurobiological mechanisms it is be relevant to analyze them in relation to the existing architectural principles in order to understand how these have been expressed and used in terms of architectural design.

ARCHITECTURAL THEORY

A large amount of architectural principles have throughout history been formulated in order to establish a general codex for the ideal architectural order. Commonly, the majority of these architectural principles are formulated by a certain architectural segmentation, - by filtering the architecture to only include the important fragmentations. The exclusive essence of architecture is naturally rooted in the features of architecture, as a wall, a door, a roof, a stair, etc., which by their individual relevance becomes a part of collective architectural order.

For instance, Marc-Antoine Laugier reduces his general principles to a minimum, and only includes three parts; the column, the entablature, and the pediment.
Laugier emphasizes these principles as the true principles of architecture and considered them as essential for achieving the total beauty. He describes the architectural features in detail by referencing to the simplicity of the primitive hut. He mentions the ancient monument Maison Carree in Nîmes as a main example of this novelty and simplicity, and stresses that walls, doors, and windows can only consequently be added if it is absolute necessary. *(Laugier 1953/1977, p. 11-38)*
A modern example of stressing the principles by fragmentation is the 14th International Architecture Exhibition of The Venice Biennale 2014 directed by Rem Koolhass. The exhibition named Fundamentals emphasizes the basic parts of architectural history.The exhibition established as a historical index of elements included 15 subgroups spanning from minor parts as toilet, fireplace, and balcony to facade, roof, and floor. Each element selected on the basic of previous works and architectural history in order to express the essential of architecture and constitute the position of contemporary architecture, similar to the purpose of the true principles of Laugier.
The presented principles based in neuroscience differ from the abovementioned architectural principles in terms of perspective. The architectural theories are naturally centered and grounded in the features of architecture, while the neurological principles reflect the influence by the features of architecture. The architectural theories only consider the observed and to a certain degree not the observer.
The architectural features act in the context of neuroscience as external cues and the original architectural terminology becomes secondary. A wall, a facade, and a ceiling become barriers. A door and a corridor become connections. A stair or a fireplace becomes a landmark.
As introduced in the prelude, the psychological principles by Kevin Lynch, expressed in his book The Image of the City, enhance a similar perspective to the designation of the architectural elements as the neurological principles. Lynch distinguishes from the original designations of the city by emphasizing the psychological impact in the terminology of the elements. Lynch operates in the scale of the city and analyzes the elements of the city. He denotes streets, canals, railroads, or transit lines becomes paths, shores, walls, or railroad cuts becomes edges, building, signs, or mountains becomes landmarks, and etc..

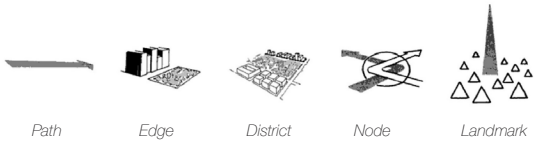


Fig. 4.03: Urban principles by Kevin Lynch. The five elements.

The principles of Lynch and the present study share furthermore some common registrations, despite the difference in scale - from the public image of Boston and Los Angeles to the cognitive map of a rat in a quarter-of-a-square-meter box. Especially, two of Lynch's five principles contain similar properties. Firstly, Lynch describes a barrier that separate one region from another as an edge. He emphasizes the edges to represent lateral references or linear breaks defined by limitation of movements. These edges are present in the form of a waterfront, harbor front, freeways or streets. The denotation of an edge include many of the same aspects as space boundaries. Especially, how an edge can establish a boundary is equally to how boundary cells encode a space boundary. A drop, as the river bank, or a ridge, as a topographical throughway, can act as an edge similar to the definition of a space boundary.
Secondly, Lynch's definition of a landmark in the city is similar to the neurological description of an external cue acting as a reference point. Lynch defines the landmark to include both the distal global landmark and the proximal local landmark. The global represen-

Fig. 4.04: Elements of Architecture. From the Biennale 2014 Fundamentals.

tation in the form of a tower, domes, or hills. The local representation by facades, trees, or minor details. He stresses the characteristic of the landmark to be an expression of singularity and saliency. Characters that make them memorable in the urban context. Similar to the neurological understanding of external cues, Lynch emphasizes the importance of multiply landmarks, and especially the importance of the spatial relations between a sequential series of landmarks. Furthermore, he ranks the landmarks in a hierarchical order in relation to their significance and prominence in the spatial condition, similar to the hierarchical order of the external stimuli observed in the neurological studies. *(Lynch 1960, p. 45-83)*
In contrast, Lynch claims that a sound or a smell can support the visual landmark, but not stand as a landmark by themselves. This is in conflict with the neurological findings that indicate that a reference point can be fixed to a single odors or sound. *(O'Keefe & Conway 1978)*

ARCHITECTURAL CASES

The neurological findings concerning the cognitive map theory are a step further in understanding the spatial mechanism of the human brain. How we as humans function and act in relation to our surrounding environment. The prelude offered a historical review of this aspect and introduced the analogical development between humans and architecture. In relation to the results of this historical analogy, individual architectural cases have profoundly succeeded to satisfy the described functions of the human being, both physical, by adapting to the proportion and motion of the human, and psychological, by evoking our emotional system and influence our memories in numerous manners.
It is reasonable to assume that the neurobiological principles can be verified by these spectacular buildings as a validation for their presences and investigate how elements of an architectural success maybe is a product of the architectural features ability to influence our spatial memory - consciously or unconsciously.

A number of cases, in which some of these principles seems to be expressed as a design strategy, will be examined. As these principles of spatial presence and navigation have been active in humans as well as other mammals long before the manipulation of the lived environment in terms of architecture was invented, they must be expected to have been explored through a process of trial-and-error, and therefore be present in buildings considered successful across stylistic periods and architectural trends.

To start where the prelude ended by the psychological aspects of architecture, the Finnish architect Alvar Aalto *(1898-1976)* has been enrolled in modern history of architecture, due to his humanistic approach founded in studies of the human.
The environment constructed as a result of his architecture seeks to go beyond its practical usage and pursuits the physiological and psychological needs of its users.
Aaltos philosophy, upheld and represented by his architecture, is the starting point for the following investigation. A selection of Aaltos works establishes the foundation for a psychological process reflected in the neurological approach introduced be this present study. To visualize both the use of psychological consideration relatively to studies in spatial memory, but also to validate the principles in an architectural context in order to understand what these principles might mean in terms of architectural design.
The examined cases are classified into four sections, each investigating different aspects of the neurobiological principles. The respective cases are investigated by the use of relevant literature and pictures, but are primarily analyzed by the layout of their floor plan. The properties of the floor plan, as a two dimensional representation of the architecture, are similar to the standard output of neural firing registration of the spatial cells, and the comparison between them might therefore be reasonable. The recorded cell firings are usually illustrated as a two dimensional projection, and exclude the information about height from the registration. According to this neurobiological perspective, it might therefore be most relevant to visualize the properties of the cognitive map in the representation of the floor plan view.

Fig. 4.05: Sanatoriu Paimio - aerial view. Sanatorium (1933) by Alvar Aalto.

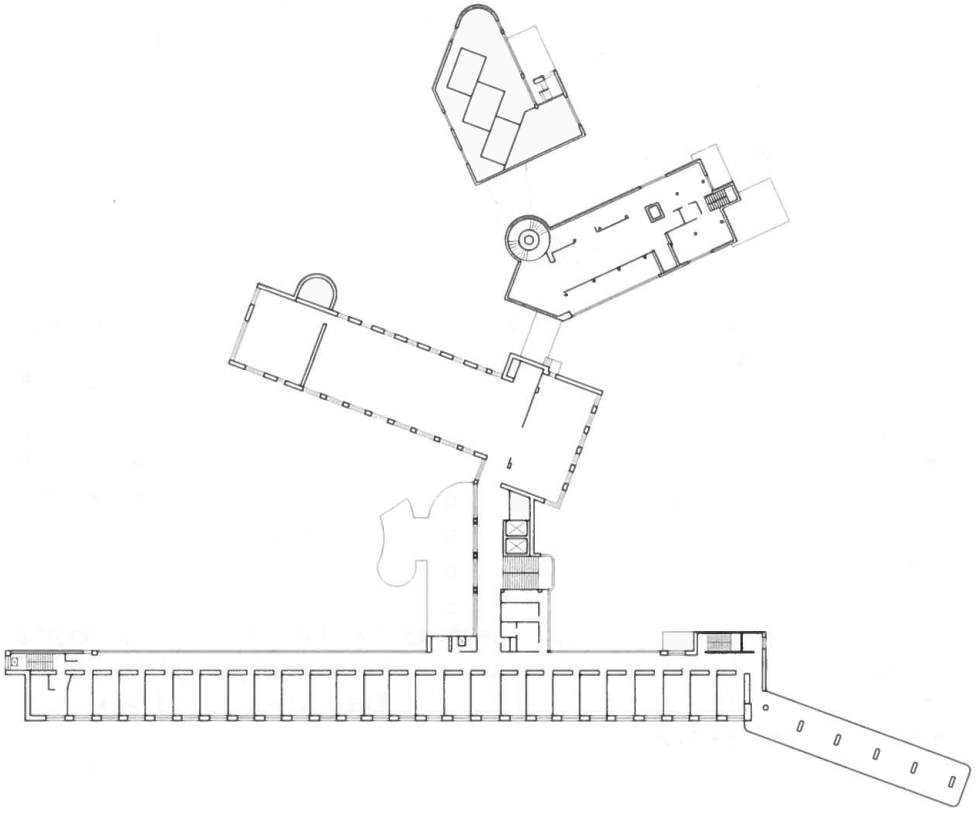
(i) GLOBAL COHERENCE

The following section seeks to examine the global relation of multiply cognitive maps in terms of:

(i) *Grid*
(ii) *External cues*
(iii) *Orientation*

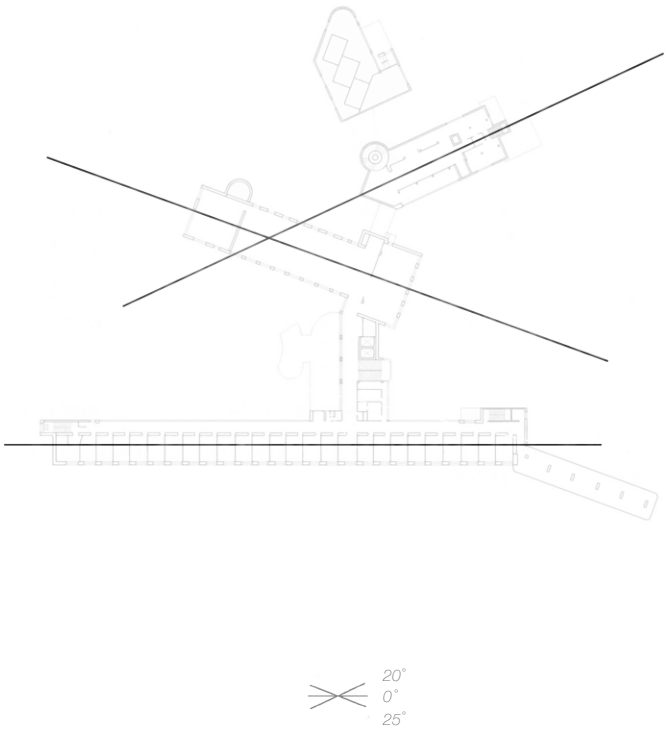
The tuberculosis sanatorium in Paimio *(1933)* in Finland designed by Aalto is considered one of the most desirable and impressive examples of humanistic design. Aalto pursued the sanatorium to be an active promoter of healing just by its architecture. He intended the building to be a medical instrument and used evidentical medical and psychological knowledge to retrieve the ultimate conditions for the patients. Fresh air, maximum daylight, and good hygiene were considered recognized and important treatments against tuberculosis at that time, and used systematically by Aalto as design parameters throughout the project from the surrounding landscape to minor detail as door handles. Noticeable, Aalto furthermore highly considered aspects as navigation and spatial understanding in every scale. At a local level, Aalto used proximal cues to improve the navigation by carefully implementing color schemes to underline and emphasize the function of the individual spaces. The private spaces as wards were painted in a brownish color while
public spaces appeared in a white, grey and yellow color, - distinguishing the more prominent spaces from the intimate. *(Aalto 1998, p. 11-16)*
In the large perspective, Aalto designed the building with four wings organized in a fan-like shaped composition. All wings more or less linked together in a spatial adjacency by a central volume. This heterotopic composition constructs a hierarchy of axial lines reaching out by several different directions towards the surrounding nature. *(Porphyrios 1982, p. 7-8)*
The most prominent axis is drawn by the narrow six story patient-wing reaching as an extensive wall from west to east. This wing contains more or less identical rooms facing south organized in a parallel order by a long corridor. Opposite, oriented in a slight angled west-east direction, is the communal wing positioned, establishing together with the patient wing a trapezoid shaped courtyard narrowing towards the main entrance. The communal wing contains prominent public functions as dining room, lecture hall, and a library. Two smaller volumes are hinged to the building at the north side containing housekeeping functions and a heating plant. These volumes are, despite their smaller scale and the sheltered position behind the communal wing, relative perceptible as a result of the chimney, which stands as a prominent external landmark for the whole complex.

Fig. 4.06: Sanatorium Paimio - plan.



North

Fig. 4.07: Sanatorium Paimio - Directions. The building volumes of the sanatoriumare organized in three directions.



The orientation, the scale of the wings, and the transparency of the hallways provide a continuous view to the chimney, which ties the local representation together in a global relationship and provides a sense of allocentric direction. This spatial relationship can be compared with the composition of Acropolis, Athens. *(See apendix B)*

Acropolis consists of a collection of buildings with distinguish axial order. The buildings might represent individual spaces and thereby individual neural representation, but they might be globally linked together by the salient landmark constituted by the Statue of Athena Promachos. The prominence the landmark might potential chunk the different neural representations of the travel path into one sequence for both Acropolis and the Sanatorium. Especially the self-motion signals received by path-integration might reinforce the correlations between the neural representations. (*Buzsaki & Moser 2013)*

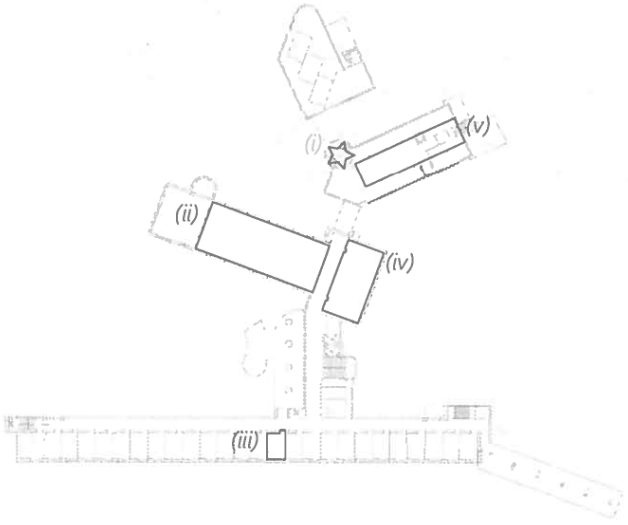
The sanatorium appears and operates as one unit, but contains a high level of diversity. Unity is presence in the mutual junction and the general expression, while diversity is obtained in the orientation, scale and geometry.

Each prominent space of the sanatorium might most likely be encoded in the cognitive map as individual representations because of the spatial discrimination in scale, geometry, and orientation. Nevertheless, the representations might be closely combined by the global legibility of the buildings.

The center volume, the chimney, and the visual correlations might contribute to a global cohesion, but especially the combination of both local and distal cues of the sanatorium might be an important feature in terms of spatial navigation. As described in the neurological theory, the relationship between distal and local external stimuli act as the most prominence landmark, and might accommodate to a global clarity of the sanatorium complex. *(Shapiro et al. 1997)*

"Wherever you stand, new aspects enrich the space-time conception of the complex. Each of the

Fig. 4.08: Sanatorium Paimio - Spaces. The prominent spaces have different characters in terms of orientation and scale.



(i) Chimney, (ii) Dining hall, (iii) Patient room, (iv) Lecture hall, (v) Kitchen

walls has its own existence and is formed according to the function of the rooms behind it, but all are modeled and related to each other by a strong plastic vision."

(Giedion 1953, p. 632)

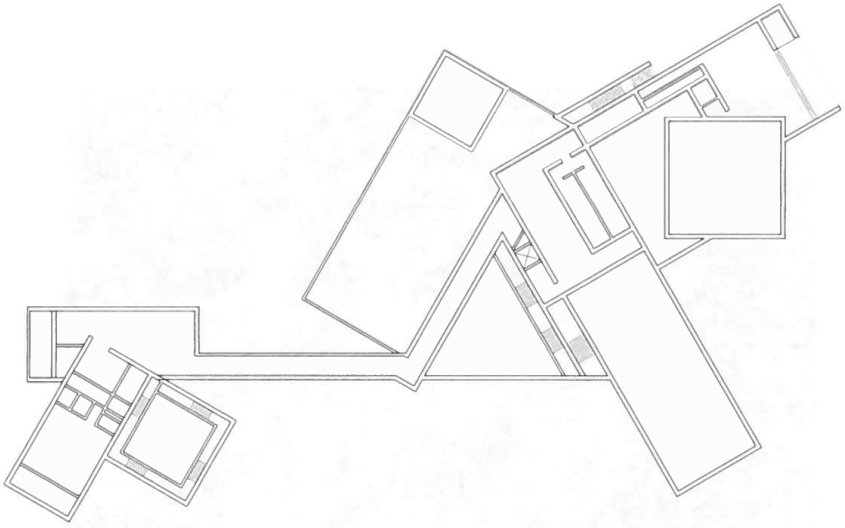
The Sanatorium Paimio has as a result of both the architectural philosophy and the function as a medical treatment center the responsibility to accommodate practical aspects as good navigation and clarity to a higher degree. This responsibility is fulfilled as described by the series of architecture features, which each consumes to a global adjacency. But the status of the individual architectural feature in this aspect can be difficult to determinate. The following supportive analyses investigate this aspect in order to emphasize and visualize the importance of the individual elements in terms of spatial navigation by examinating cases that eliminate and isolate certain properties

Fig. 4.09: Chichu Art Museum - aerial view. Chichu Art Museum (2004) by Tadao Ando

CHICHU ART MUSEUM

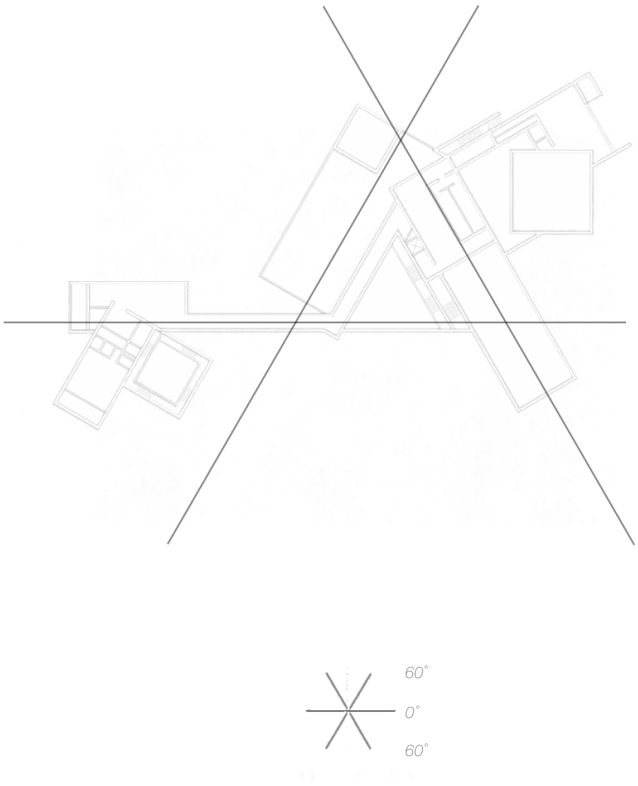
Chichu Art Museum *(2004)* eliminates the possibility of a physical external landmark, because it is, as the name means, positioned within the earth - sunken into the mountains of the Japanese island, Naoshima. This composition offers limited views to the sky and provides only occasionally views to the surroundings.
The museum, designed by the well-known Japanese architect Tadao Ando *(1941)*, distinguishes radically from the sanatorium in aspects as function, style and use of material, but it is comparative in terms of spatial composition.
The axial order of Chichu Art Museum is structured by three shifted grids as the sanatorium - orientating the spaces individually. This individuality of spaces is furthermore emphasized and defined by the variation in both scale and geometry of each exhibition room, which differs between simple geometries as a square, rectangle, and triangle. The high variation of environmental boundaries affects the cognitive map, and profoundly influences the regularity of grid cells pattern, - both in terms of geometry, but also in orientation,

Fig. 4.10: Chichu Art Museum - plan.



North

Fig. 4.11: Chichu Art Museum - Directions. The exhibition spaces of Chichu Art Museum are organized in three diferent directions.



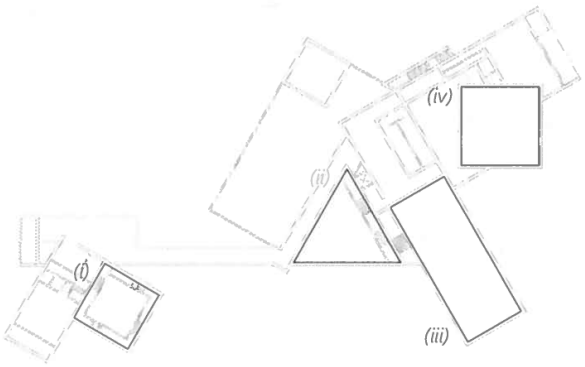
symmetry, homogeneity, and scale. *(Krupic et al. 2015)* The Chichu Art Museum practices this spatial variation by introducing different geometries - each with different orientation. The geometrical changes might most likely influence the place fields and cause in a remap, resulting in individual cognitive maps for each prominent space. *(O'Keefe & Conway 1978)*

Furthermore, the radical increase in proportions from space to space would also most likely cause in a remap. *(Spiers et al. 2015)*

Especially, the segmentations between the prominent spaces are important to notice. Despite the similarity of the corridors in both the Sanatorium Paimoi and The Chichu Art Museum, the organization of them is significant different. The sanatorium is organized from the center and out, - each corridor starts by same reference space. In contrast, the Chichu Art Museum is structured in a linear composition with separated start and end, which makes the journey continuous trough the museum. The continuous corridor is furthermore emphasized by the use of materiality and colors, which is hold to an absolute minimum throughout the building. The corridors offer similar stimulus, and might generate identical neural representation, which makes it difficult to discriminate the spaces from each other. *(Buzsáki & Moser 2013)*

The architectural composition of Chichu Art Museum by the high discrimination between the prominent space and the similarity of the corridors makes it relative easy for first-time visitor to distinguish between the exhibition halls, but very difficult to place them in relation to each other in a global constellation.The spatial correlation would most likely be represented by a collection of independent cognitive maps linked together by self-reference information, received by exploring the museum.

Fig. 4.12: Chichu Art Museum - Geometry. The individualism of the exhibition spaces is emphasized by their respective geometry.



(i) Entrance stair, (ii) Atrium, (iii) Walter De Maria Room, (iv) Claude Monet Gallery

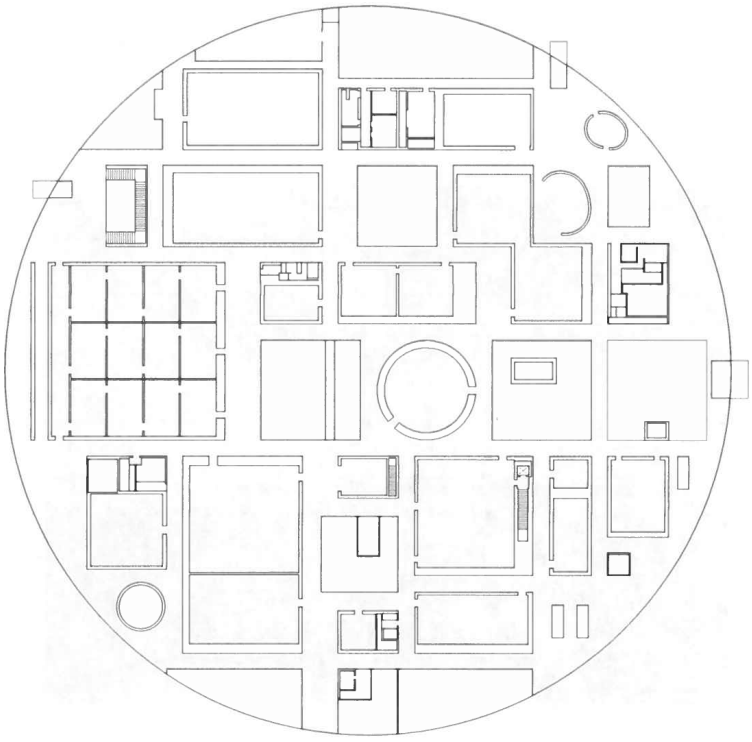
Fig. 4.13: The 21st Century Museum of Contemporary Art - photo. The 21st Centruy Museum (2004) by SANAA

21st CENTURY MUSEUM

In contrast to the use of shifting grids and the heterotopic composition of both the Sanatroium Paimio and Chichu Art Mueseum, the 21st Century Museum of Con temporary Art *(2004),* Kanazawa, is strictly organized by a single orthogonal grid system. The museum is designed by SANAA, and exudes their minimalistic style thorough the museum. The building consists of a numerous similar sized boxes placed inside the perimeter of a glass cylinder, defining both the exhibition halls inside the boxes and the hallways in the voids between the boxes.

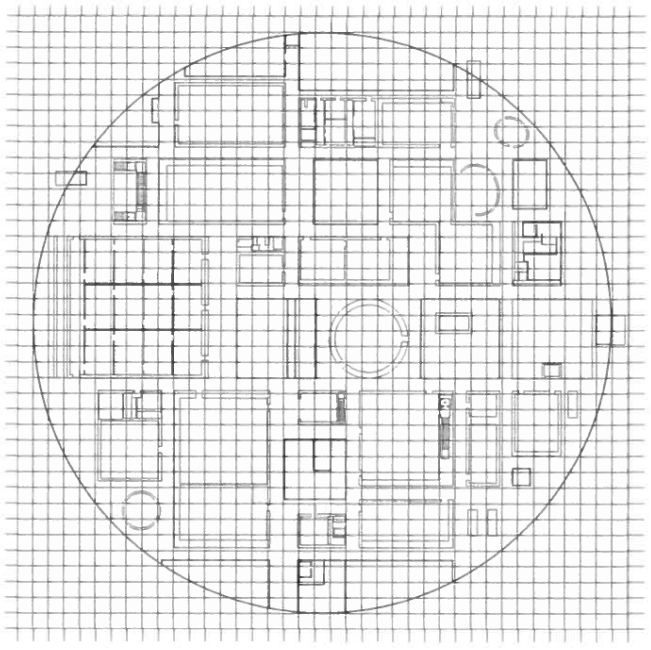
Every hallway and every box is more or less identical and offer equally spatial setting in terms of orientation, dimension, and geometry. Furthermore, the museum provides minimum local cues, and it is more or less exclusively up to the motion of the observer to differentiate between the individual spaces. The observer is absolute dependent of self-reference information in order to navigate. The environment is purified for external cues and offers equally sensory information throughout the building, similar to navigating in a maze

Fig. 4.14: The 21st Century Museum of Contemporary Art - plan



North

Fig. 4.15: The 21st Century Museum of Contemporary Art - Directions. The museum is symmetrical organizes by a ortogonal grid.



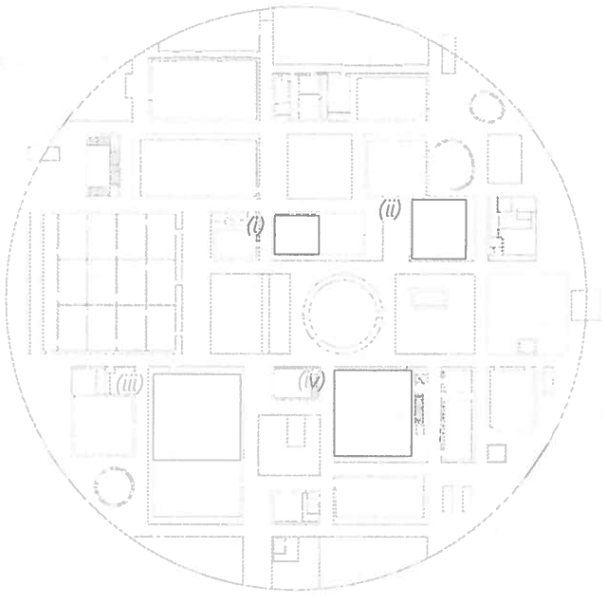
or in totally darkness. Pattern separation is only possible by exploring and by using path integration.
This spatial situation can be reflected in the experiments involving rodents exploring four parallel orientated spaces. This experiment showed comprehensive spatial repetition by identical place field for each space. Only a smaller discrimination in the frequency of cell firing was registered, indicating a minimal influence by path integration. *(Spiers et al. 2015)*

"SANAA's architecture has many elements that are impossible to understand unless one actually "experiences" it."

(Kazuyo & Ryue 2005, p. 100 - 113)

These architectural cases illustrate different variation of space sequence, and how individual segments of a sequence might collaborate in a coherent spatial understanding and a global system. Each of the projects represents a sequence of cognitive maps, because of both the spatial composition and the scale, but communicates them in different ways. The architectural setting influences the experience of the observer by the balance of external cues, global as local, and effects the navigation of the observer by controlling the amount of expressed egocentric and allocentric information.

Fig. 4.16: The 21st Century Museum of Contemporary Art - Spaces. The exhibition spaces are almost same size, direction, and geometry.



(i) Exhibition room, (ii) Exhibition room, (iii) Exhibition room, (iv) Exhibition room

(ii) **INDIVIDUALISM**

The following section seeks to examine the individualism of the respective cognitive maps in terms of:

(i) *Orientation*
(ii) *Space boundaries*

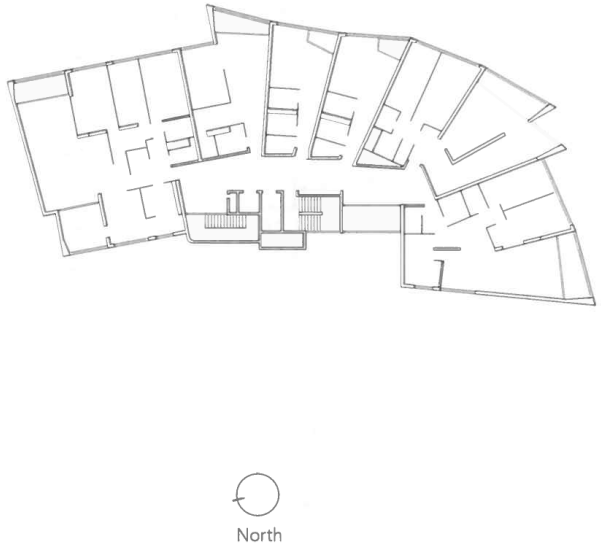
The fan-shaped floorplan followed Aalto throughout his architectural carrier. A composition he used in several buildings across functionality - from public buildings to apartment blocks.
In the category of apartments, the floorplan layout of both Hochhaus *(1962)* in Germany and Schonbuhl high-rise apartments *(1968)* in Switzerland follow same composition. Both apartment blocks have a circular organization that draws parallels to the floorplan layout of Panopticon *(1791) (see appendix B)* Panopticon was a conceptual idea by the English theorist Jeremy Bentham *(1747-1832).* The building was designed to offer a single officer the full view of every cell of a prison. The prison cells of Panopticon were arranged around a common center point and estabished the periphery of a perfect circle. This concept offered a single watchman the possibility to observe each and every cell from the center position.
As neurological studies indicate, the constellation of both the cells of Panopticon and the apartment of Aalto fan-shaped floor plan would most likely cause in discrimination between the individual unit, despite their similarities in scale and geomerty. Studies of rodents indicate that place cells distinguish visual identical apartments as a reaction to a variation in angular orientation. *(Paz-Villagran et al. 2006)*

"The place cells are sensitive to the angular orientations of the local environment"

(Grieves et al. 2016)

The directional information of the respective prison cells together with the self-motion signals stand as the only spatial information that distinguishes the cells from each other. Neverthelses, the studies involving similar apartments by different angular direction indicate that this amount of input information is sufficient in order to differentiate the firing pattern between the individual units. Each apartment would most likely be represented as individual cognitive maps. (*Grieves et al. 2016)* Despite the similarities from the circular plan of Panopticon to both apartment block of Aalto, several differences can be noticed. In contrast to the symmetrical organized plan of Panopticon, both apartment blocks differentiate in local geometry from one unit to another as well. The directions defined by the apartment separation draw a more heterotopic composition. Furthermore, the distorted local geometry is emphasized by the exterior space boundaries of the

Fig. 4.17: Apartments buildings - plan. a: Hochhaus (1962) by Alvar Altoo. b: Schbnbuhl (1968) by Alvar Aalto.



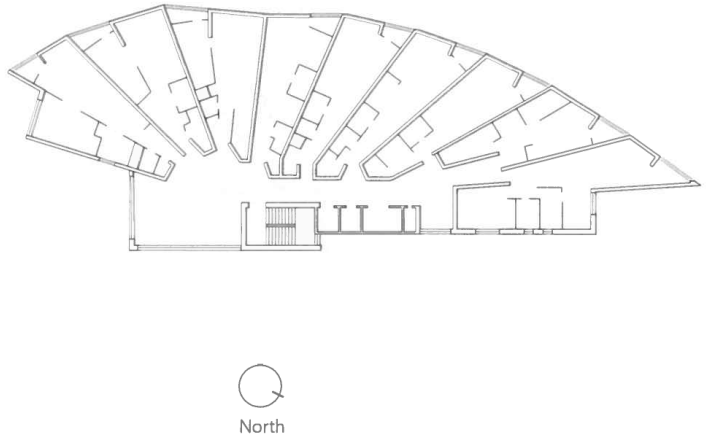
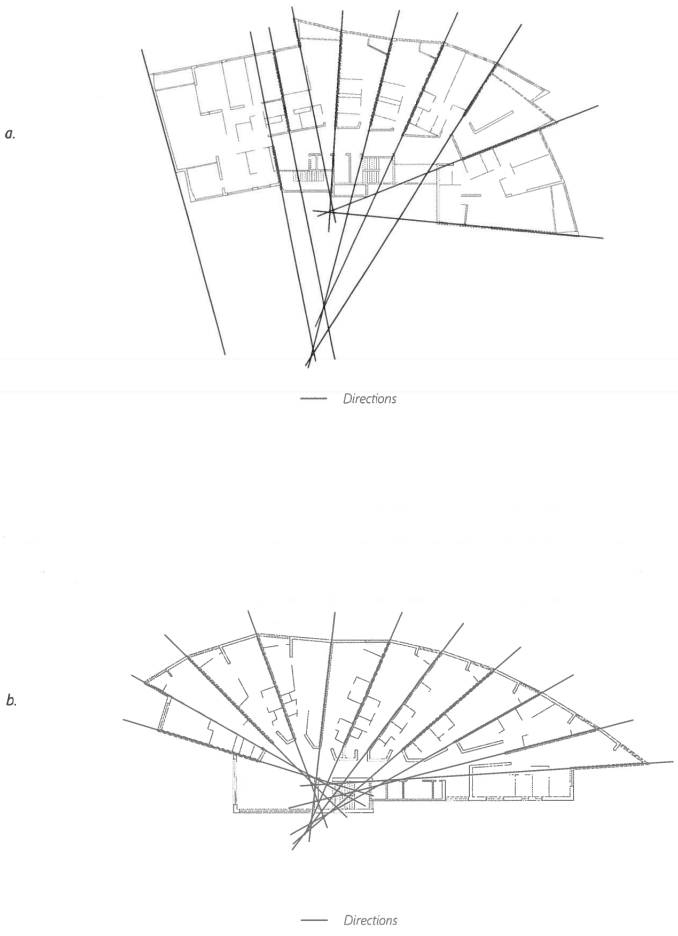


Fig. 4.18: Apartments buildings - boundaries. a: Hochhaus. b. Schonbuhl



individual apartment, which distinguish from the perfect arch and represent individual oriented segments instead. Especially, the firing of grid cells is influenced by the space geometry. Studies indicate that the firing pattern of grid cells encoded in highly polarized and distorted environments, as represented in both apartment blocks, become irregular and homogeneous. Particularly, non-parallel space boundaries influence the nature of the grid pattern. It is suggested that the asymmetry and irregularity of the local geometry influences the perception of the space, which might result in an inadequate spatial understanding at the first glance. *(Krupic et al. 2015)*

However, due to the function of the apartments as housing units, the environments naturally convert from being novel to becoming familiar for the residents. This reaction influences the grid pattern, which progressively becomes more regular in response to the environmental familiarity. *(Barry et al. 2012)*

This indicate, that the perception of the space appears significant more clear and legible for an experienced observer, than a first-time visitor, and could potential results in a higher environmental affiliation for the individual resident.

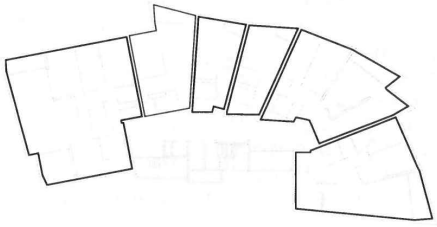
"Aalto has taken the rectangular order of Le Corbusier's basic dwelling unit, which makes up his high-rise apartment slabs, and distorted it into diagonals in order to orient the dwelling unit toward the south for light and for the view"

(Venturi 1988, p. 50)

Aalto manages to use very simple and general architectural instruments in order to individualize the apartments. The cases illuminate how multiply units can be cognitive distinguished by the spatial orientation and geometry. This might be a trivial observation, however, the relation of the design principles employed to achieve this individualism grounded in neurobiology, let us understand, how it is archived and the implications of it.

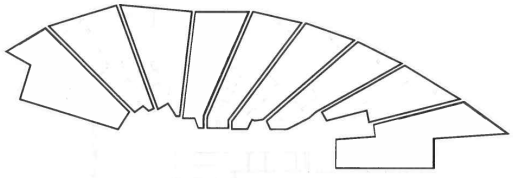
Fig. 4.19: Apartments buildings - maps. a: Hochhaus b: Schonbuhl

a.



Apartments

b.



Apartments

(iii) SPACE DEFINITION

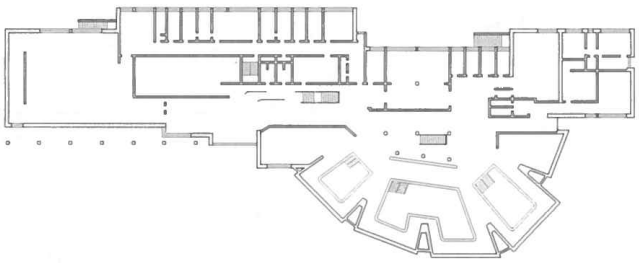
The following section seeks to examine the restriction of the cognitive map in terms of:

(i) *Geometry*
(ii) *Space boundaries*
(iii) *Grid*

Aalto investigated the conflicting relationship between rectilinearity and the heterotopic expression in public buildings both by discriminating space as previously described, but also in order to unify and establish a general space clarification.
Rovaniemi City Library *(1965)* and Seinajoki Library *(1968)* located in Finland treat this relationship in similar ways. The libraries include areas that accommodate both repetitive regular space systems and discontinuity and distorted environments. *(Porphyrios 1982, p. 1-3)*
The floorplan layout of the libraries is perspective to the constellation of the ancient theater of Acropolis *(see appendix B)*, which includes the combination of a linear and parallel system and a prominent circular space. The stoa of Eumenes consists of a long corridor, a promenade, leading to the prominent amphitheater, Odeum of Herodes Atticus.
Similar, the libraries of Aalto consist of repetitive parallel-orientated spaces organized and served by a linear corridor, which leads to the center of the main library space. This composition establishes a significant hierarchical relationship between the spaces by form and scale; the main library room as the most prominent function, and the repetitive space as secondary functions. As mentioned in the previous section, the physical similarity of the environments, as the secondary spaces, would most likely be represented in identical cognitive maps, while the irregular and asymmetric space, in this case represented by the main library room, might result in a remap and a different cognitive map. *(Grieves et al. 2016)*
This cognitive response might potential emphasize the functional hierarchy in an environmental manner by highlighting the prominent space prior the secondary ones.
Furthermore, the doorways leading to the respective spaces have an importance status for the mental representation of the environment. The secondary spaces have similar entrance, connecting the room with the linear corridor, by a regular door that establishes the same architectural setting for each space. The doorways represent the separation between the individual cognitive representations, but if the doorways and the spaces are more or less identical, the cognitive map would most likely be the same. This might cause a conflict between the spaces, and a naturally led to a certain lack of navigation. *(Spiers et al. 2015)*

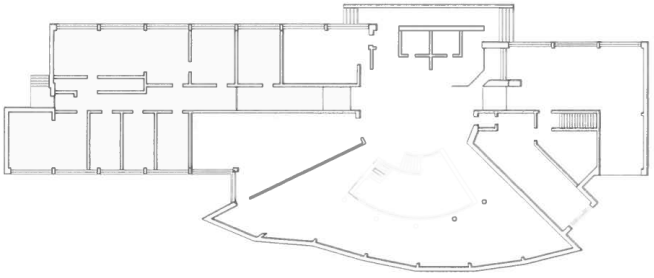
Fig. 4.20: Aalto libraries - plan. a: Rovaniemi City library (1965) by Alvar Aalto b: Seinäjoki library (1968) by Alvar Aalto.

a.



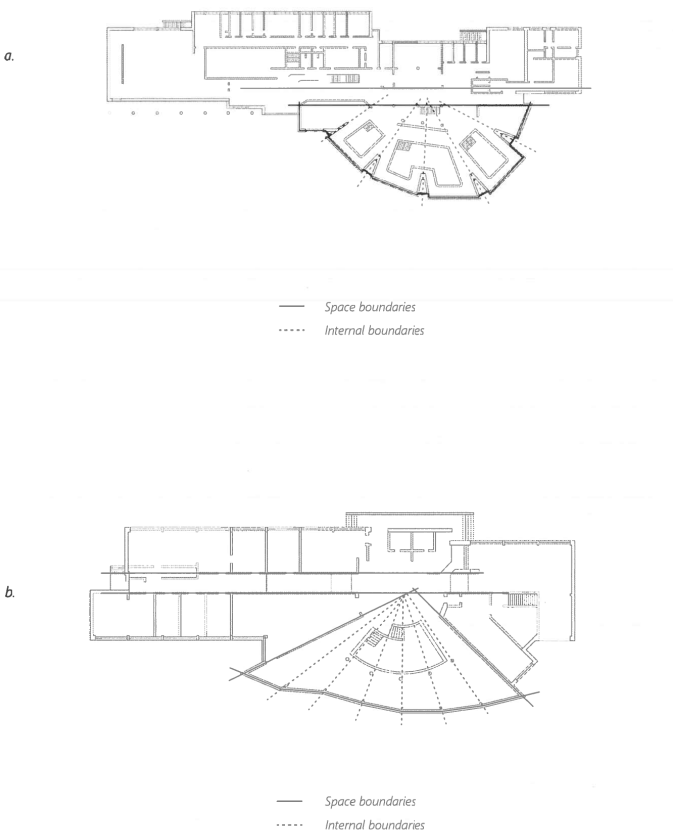
North

b.



North

Fig. 4.21: Aalto libraries - boundaries. a: Rovaniemi City Library b. Seinäjoki Library

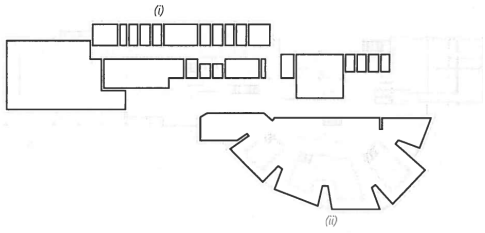


In contrast, the library room is entered differently as a naturally ending of the corridor. Additional, the library room is entered in the center of the space, which high legibility and a full view of the entire environment, similar to the property of the previues described Panopticon. This might emphasize the importance of the library room.
The architectural properties of the library space concerning both the previous described entrance and the geometry might furthermore potentiate the space as a continuous environment. The space provides a general transparency and legibility as a reaction of the architectural features, and might most likely be represented as a single cognitive map. Each section of the library room would most likely be perceived as a part of the main space, and the internal walls and drops would potential act as internal boundaries and proximal landmarks, and not necessarily as space boundaries.
This proximal separation of the main library room might furthermore be emphasized by the presence of the exterior wall. The exterior wall consists of several segments divided in relations to the section of the library room. Each segment is slightly angled in relation to the previous. This architectural feature can be compared with the exterior wall of the previous described apartment blocks, and might emphasize the individualism of the respective library sections.

The use of proximal and external space boundaries, as Aalto represent, is an essential architectural feature of the free plan, introduced by Mies Van Der Rohe in the early stage of the modern era of architecture.
The organization of the free plan challenges the definition of spaces by blurring and rethinking the space boundaries. The traditional definition of a space as a matter of four walls transforms in the modern perspective into a relationship between a series of architectural surfaces and levels instead. The doorways of the traditional space act as an important feature that separates the cognitive map from each other. (*Spiers et al. 2015)*

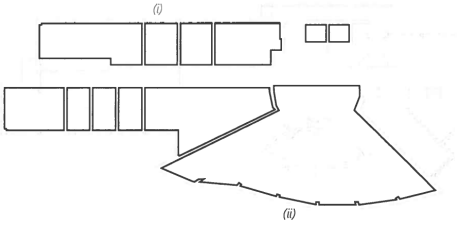
Fig. 4.22: Aalto libraries - maps. a: Rovaniemi City Library b. Seinäjoki Library

a.



(i) Secondary spaces, (ii) Main Library room

b.



(i) Secondary spaces, (ii) Main Library room

The modern organization of the floorplan discards the traditional doorway and introduces new spatial constellations with fragmented proximal boundaries.
The architectural composition of the main library room of both cases and the cognitive reaction of them might illustrate the main purpose of the modernistic organized floorplan as a continuous spatial representation.

(iv) **PROXIMAL LANDMARK**

The following section seeks to examine the status of the proximal landmark in terms of:

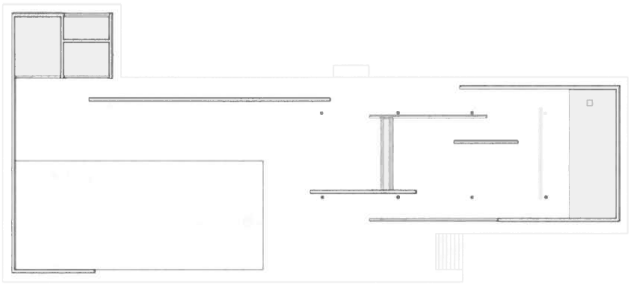
(i) *Space Boundaries*
(ii) *Tactility*

It is suggested that the external cues are anchored to the cognitive map by prominence in a hierarchical order. The section concerning the global sequence examined the importance of the global landmark, as a reference point for several cognitive maps, but also local cues can act as an essential element of directional information. *(Shapiro et al. 1997)*

The intra-arena or proximal placed boundaries within the environment might act as visual local cues instead of space boundaries. For instance, the proximal walls of the Barcelona Pavilion *(1929)* might act as local landmark by their salient expression. The central and exposed position within the pavilion and the colorful material, the green alpine marble and the golden onyx, emphasize the prominence status of the landmarks. Especially, the color contrast of the marble in relation to the more anonymous sand-colored travertine cladding highlights the salient appearance and might anchor the walls as a stable reference point to the cognitive map. The proximal landmarks might provide information about orientation, comparable to the function of the white cue card pasted to the wall of the laboratory frame in several neurological studies. *(Cressant et al. 1997)(Taube et al. 1990)*
The use of curtain walls and the floorplan composition of the pavilion offer a continuous and more or less uninterrupted view to the proximal landmarks, which provide high clarity and legibility of the environment. Similar effect is present in The Therme Val *(1996)* in Switzerland designed by Peter Zumthor. The building, a robust rectangular block, frames an interior space containing a large collection of different thermal baths from a large outdoor pool to small intimate hot springs. More than 15 individual baths are located within the building, and placed like small boxes inside the main interior space. This composition enhance both principles from the traditional conception of a space, with individual space inside the small boxes, but furthermore express principles from the free plan, by the continuous open space between the boxes. The main spaces are literally floating together into only one spatial representation. The individual spaces are furthermore emphasized by having similar doorways, which establish the same ground setting for each space, comparable to the secondary spaces of Aaltos libraries.
The interior pool of the Therme Vals acts, like the proximal walls of the Barcelona Pavilion, as a local landmark for the main space. The central placement

Fig. 4.23: Landmarks - plan. a: Barcelona Pavilion (1929) by Ludwig Mies van der Rohe. b: The Therme Vals (1996) by Peter Zumthor.

a.



b.

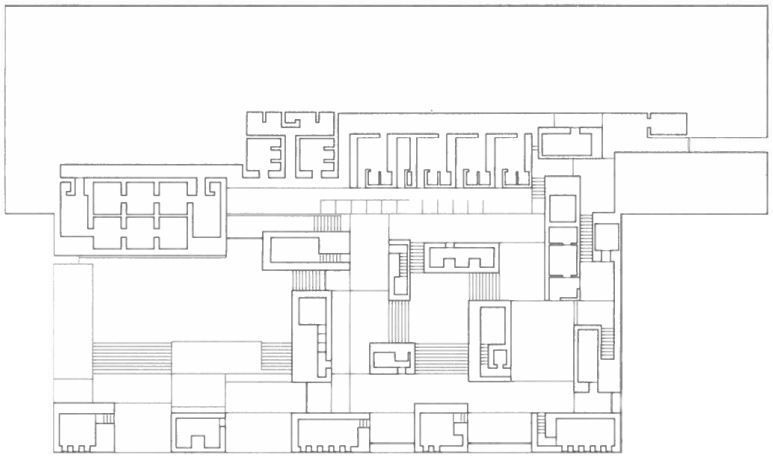
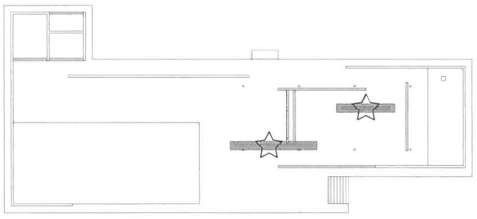


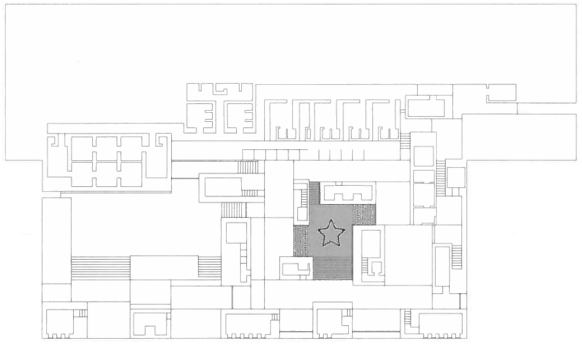
Fig. 4.24: Landmarks - proximal landmark. a: Barcelona Pavilion. b: The Therme Vals

a.



Marble walls

b.



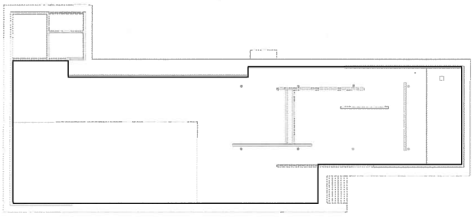
Center pool

and the notable lighten color of the water contributes to a salient appearance and becomes a stable referencepoint of the entire mainspace. Furthermore, by introducing another material in form of water, might streghten the status as landmark. Especially, because it provokes another haptic peception that the stone floors.

The modern organization of the floorplan discards the traditional doorway and introduces new spatial constellations with fragmented proximal boundaries.
The architectural composition of the main library room of both cases and the cognitive reaction of them might illustrate the main purpose of the modernistic organized floorplan as a continuous spatial representation.

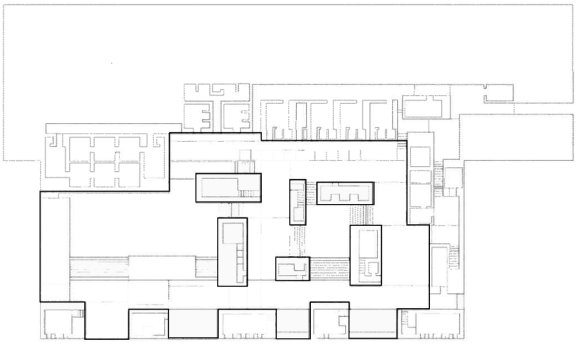
Fig. 4.25: Landmarks - maps. a: Barcelona Pavilion. b: The Therme Vals

a.



Pavilion

b.



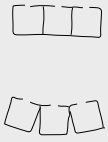
Main space

DESIGN PRINCIPLES

The architectural cases demonstrate the practical usage of the principles derived from neuroscience, and illuminate how these can be expressed as a design strategy. The selected cases adresses four different architectural phenomena:

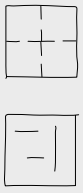
(i) GLOBAL COHERENCE

The global coherence and the discrimination of individual spaces depends of the individual spatial properties in terms of geometry, scale, transparency, and orientation, the presence of an global prominent landmarks, and the self-motion signal of the observer. Especially, the combination of local and distal cues might be essential in order to establish a global coherence and increased navigation within a given environment with several spaces.



(ii) INDIVIDUALISM

The spatial properties in terms of geometry and orientation might be useful in order to distinguish spaces from each other, and establish a certain degree of spatial individualism.
The difference in orientation, irregularity, and asymmetry of the local geometry might emphasize the discrimination of the respective spaces.



(iii) SPACE DEFINITION

The space boundaries act as an important spatial information in order to seperate the individual spaces. The traditional space organization, with four wall and a doorway, might divide the spatial perception into individual representation for each space. The properties of the free plan might blur the seperations between the spaces, and combine several spaces into one representation

(iv) SEQUENCING

A proximal landmark might reinforce the spatial coherence of a single space. Several areas might be preceived as one space by the presence of salient landmarks or continious materiality that links establish a local correlation.
Furthermore, the landmark located intra-arena provides essential information about orientation.

The last chapter concludes and reflects the theoretical findings.
Furthermore, the general process of the present study and further potentials are evaluated.

(v) SYNTHESIS

CONCLUSION

In conclusion, this theoretical study demonstrates how architecture affects our spatial understanding and how the underlying cognitive mechanism processes our perception of the physical environment.

The neurological theory of this study profoundly identifies a correlation between our spatial memory and the cognitive mechanism of the hippocampal formation. The cognitive mechanism structures our physical environment in a mental representation, a cognitive map, due to the external stimulation. As input informations to the cognitive map, spatial cells are constantly encoding the external stimulus both as a response to the spatial relations, allocentric information, and the self-motion signals, egocentric information. The architectural properties influence the information encoded in spatial cells and determinate the legibility of the cognitive map. Furthermore, the architectural features provide the essential sensory information to the cognitive map in order to understand and navigate within the space. Architectural features as geometry, scale, symmetry, and orientation influence the clarity of the cognitive map and colors, lights, odors, materials, sounds and external landmarks offer essential sensory information about direction and orientation to the individual representation.

The architectural verification of the neurobiological principles demonstrates how these architectural parameters are employed and explored in architecture of to day. Furthermore, it concludes that the understanding of the neurobiological response to the architectural principles, let us understand how to archive or avoid a certain environmental character, and offers the ability to manipulate our physical surroundings in order to receive the desired psychological understanding of the environment.

The presented principles derived from the neurological theory demonstrate processes of cognitive mechansims, which have been active in humans as well as other mammals long before the manipulation of the lived environment and identifies how architecture fundamentally, across stylistic periods and architectural trends, influences our spatial perception.

Fig. 5.01: Conclusion - process diagram. The diagram illustrates the different phases of the present study

REFLECTION

The observations presented by the present study might for some become trivial and even banal, however the principles derived from neuroscience, let us understand how these design principles can be archived and the implications of it. The neurological findings demonstrated in this present study have to be considered as a supportive methodological approach, that helps us understand how we encounter and respond to the built environment. The neurological considerations do not stand as an alternative approach or objectify the humanities to be inclusive and single-minded, but rather offers an academic epistemological instrument to enrich the creative process. The neurological theory might establish the required knowledge to argumented creativity or evidence-based design.

The present study operates in the tension between two disciplines, architecture and medicine. The intercorrelation between these professions has historically been practices for millenniums, but the specific study design of present study, grounded in evidence-based medical literature, only represent a minor fraction of the architectural publications. This might reflect the empirical approach of the study, which is customized to the presented theory. Especially, the epistemological division between the disciplines might influence the results. Neuroscience includes an enormous amount of evidence-based literature, which is focused of the preventions of diseases, while the literature of architectureare mainly grounded in personal philosophies and opinions in order to express style and taste. The combination of these contrasting theoretical approaches might invalidate the final results. The present study comprehends and combines the perspectives of both, but seeks to treat them separately.
Firstly, the architectural theory is used as an introduction to the neurological theory. Secondly, the well-documented neurologcial findings concerning spatial memory are presented and concluded as an independent part.
Lastly, the neurological conclusions are verified in the architectural perspective by a selection of cases, in order to demonstrate the presence of the findings. The architectural cases are subjectively selected by its relevance. Other cases might demonstrate differently, or even illuminate other aspect of the research.
In order to subtract the subjectivity of the selection and verification, it might be relevant to establish scientific experiments customized to address the principles derived from neuroscience. These specified experiments could be conducted by measuring the brain activity of participant exploring 1:1 mock-up models or a virtual environment.
Furthermore, the present study is primary grounded in neurological studies of rodents. The correlation between the species is addressed and underlined in present study. The principles derived from neuroscience are exclusively based of animal studies, due to the lack of experiments concerning neural activity of the human hippocampal formation. The more or less immediate application of the animal finding to the human perspective might influence the validation of the study, because of the deviations in the perspective of the human. In order to fully demonstrate the conclusions of the neurological findings, the studies might be demonstrated by humans as well.

Finally, the principles derived from neuroscience might stand as an epistemological instrument in order to understand the cognitive reaction to an architectural phenomenon, as described previously, but they might in addition be a useful tool in order to validate or evaluate the so-called soft value of architecture. Paradoxically, the empirical result of neuroscience, the qualitative data, might provide the essential information about the impact of the aesthetic interventions and creative intensions, in order to evaluate its efficiency. Similar, to how technical aspects as indoor climate, sustainability, economy, etc. are evaluated.

In perspectives, the cognitive neuroscience might stand as a natural continuation of Laugier's metaphor The Primitive Man, who acts as a response to his instincts. The heat from the sun tells him to find shelter in the forest, the damp of the rain tells him to find cover in a cave. If the measured neural activity goes prior the subjective evaluation and reflection, the neural registrations might tell us the naturally instinctive cognitive reaction to environmental perception. The Primitive Man in the perspective of today might be the Intelligent Person, that adapts to the neurocognitive-reaction of the environmental stimuli.

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The initial search includes general literature in the field of both disciplines, in order to establish the fundamental contextual knowledge of the research problem. This includes especially background literature concerning the biological aspects.

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[Assessed 10 October 2016]
b: Own illustrations

Fig. 3.03: Head-direction cells.
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b left: Own illustration

Fig. 3.04: Grid cells.
a: https://www.google.dk/url7sa=i&rct=j&q=&esrc= s&source= images&cd= &ved=OahUKEwjRIJKv787RAhWEDywKHQu8AQQQjxwIAw&url=http%3A%2 F%2Frstb.royalsocietypublishing.org%2Fcontent%2F369%2F1635%2F20120510&psig=AFQjCNGOmtWmkgBtYb1JmHYKxTc1Sv-9Vw&ust=1484938025509391
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Fig. 4.06: Sanatorium Paimio - plan.
Own illustration

Fig. 4.07: Sanatorium Paimio - directions.
Own illustration

Fig. 4.08: Sanatorium Paimio - space.
Own illustration

Fig. 4.09: Chichu Art Museum - aerial view.
http://benesse-artsitej p/en/art/chichu.html [Assessed 4 January 2017]

Fig. 4.10:
Chichu Art Museum - plan.
Own illustration

Fig. 4.11: Chichu Art Museum - directions.
Own illustration

Fig. 4.12: Chichu Art Museum - geometry.
Own illustration

Fig. 4.13: The 21st Century Museum of Contemporary Art - photo.
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Fig. 4.14: The 21st Century Museum of Contemporary Art - plan
Own illustration

Fig. 4.15: The 21st Century Museum of Contemporary Art - Grid.
Own illustration

Fig. 4.16: The 21st Century Museum of Contemporary Art - Spaces.
Own illustration

Fig. 4.17: Apartments buildings - plan.
Own illustration

Fig. 4.18: Apartments buildings - boundaries.
a: Hochhaus. b. Schonbuhl Own illustration

Fig. 4.19: Apartments buildings - maps.
a: Hochhaus. b. Schonbuhl Own illustration

Fig. 4.20: Aalto libraries - plan.
Own illustration

Fig. 4.21: Aalto libraries - boundaries.
Own illustration

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Own illustration

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Own illustration

APPENDIX

Fig. 6.01: Acropolis - plan.
http://www2.warwick.ac.uk/fac/arts/classics/students/modules/greekreligion/database/clumca/
[Assessed 6 January 2017]

Fig. 6.02: Panopticon - plan.
https://commons.wikimedia.org/wiki/File:Penetentiary_Panopticon_Plan.jpg
[Assessed 6 January 2017]

The appendix includes supportive material to the theoretical part:

Appendix A: *Definition*
Appendix B: *Additional cases*

APPENDIX

ELECTROENCEPHALOGRAM (EEG):

One of the most common methods of recording electrical brain activities is electroencephalogram (EEG). EEG records, tracks and evaluates the electric impulses in the brain from numerous of electrodes placed on the surface of the scalp. Each electrode registers the electric impulses and transmits the signal to a computer.
The degree and location of the respective brain activity can be analyzed by these recordings.
The intensities of brain waves vary from 0-200 microwaves and indicate the certain state of activity, wheater you are sleeping, in coma, or awak e. The frequency increase potential with the higher degree of cognitve activity.
The EEG result can be classified into four different categories deeding on frequency of microwaves:

Alpha waves: 8-13 cycles per second, awake and in a quiet, resting state of cerebration.

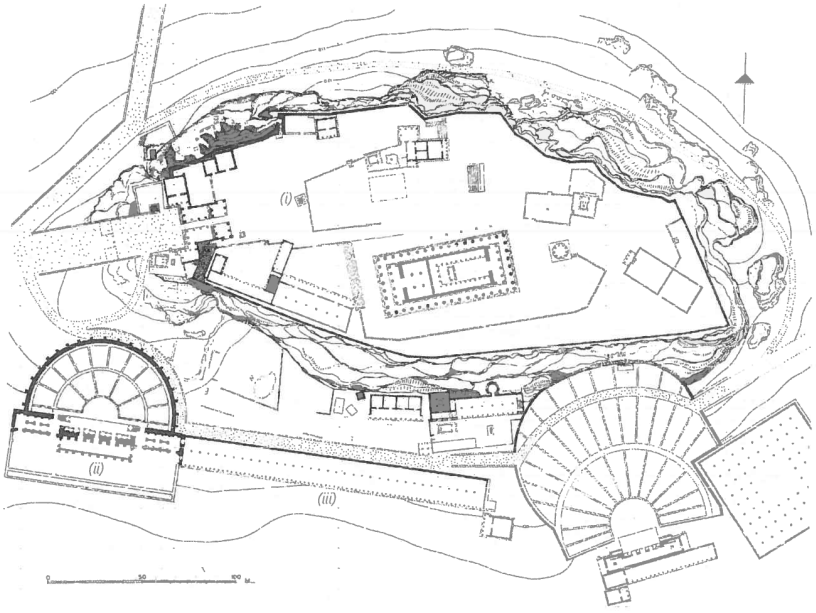
Beta waves: 14-80 cycles per second.

Theta waves: 4-7 cycles per second. Emotional stress.

Delta waves: 3.5 cycles per second. Deep sleep.

The electric impulses are generated by active neuron, which is receiving, processing, and transmitting information from one neuron to another. The activity from one single neuron can not be recorded by the EEG, but in case of synchronous firing by thousands or millions of neuron, the activity is potential big enough to be registered. *(Hall 2006, p. 721 - 726)*

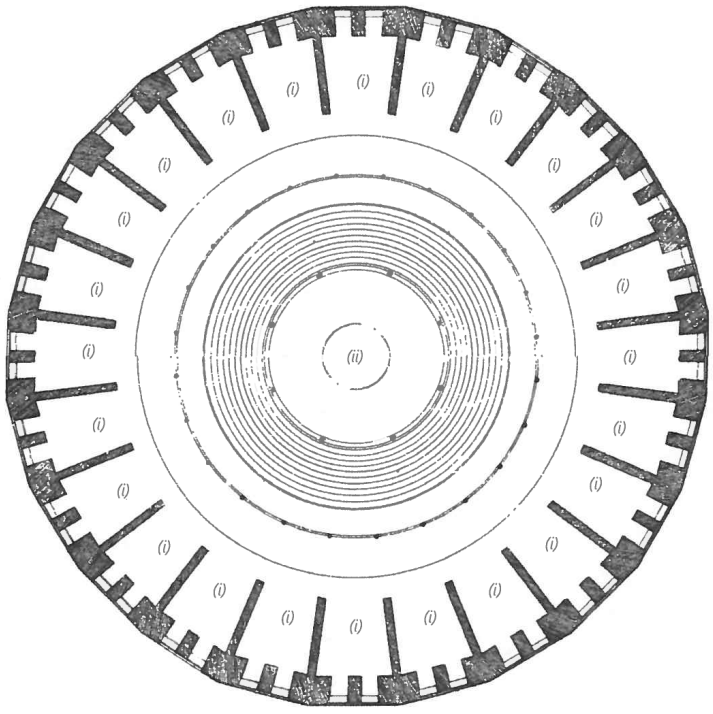
Fig. 5.01. Acropolis - plan.



(i) Statue of Athena Promachos, (ii) Odeum of Herodes Atticus, (iii) The stoa of Eumenes.

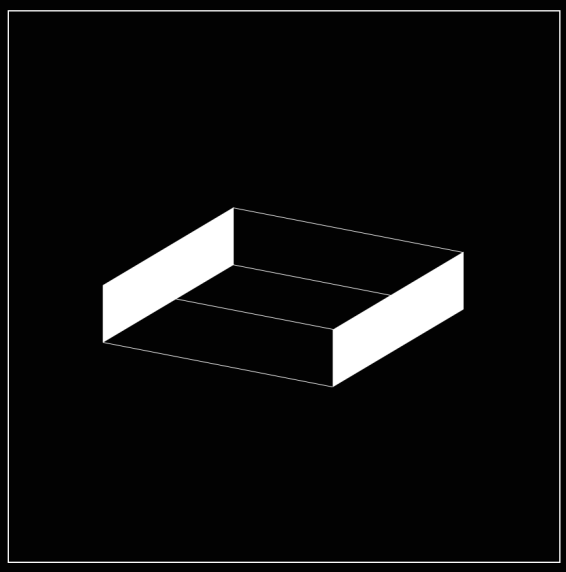
APPENDIX B - ADDITIONAL CASES

Fig. 5.02: Panopticon - plan.



(i) Prison cell, (ii) Watchman guard tower.

2nd PART



ARCHITECTURE , TO REMEMBER

TOWARDS UNDERSTANDING ***HOW ARCHITECTURE INFLUENCES***
THE NEUROCOGNITIVE MECHANISM OF SPATIAL ***MEMORY***

by

NICOLAJ Ø THUNBO

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READER'S GUIDE

The present report represents the second part of a long master thesis, and concerns a practical project grounded in the theory presented in the first part.
The practical part exemplifies how the theory can be applied and integrated in an actual project.

The report is structured chronological. Firstly, the primary analysis, investigations, and design process are presented, secondly the design solution, and lastly the supplementing contents included the appendices.

The full colored pages mark and present a new chapter, and furthermore conclude and summarize the conclusions from the previous chapter.

The Harvard Style of References is used as the standard referencing method throughout the report. *(Anglia Ruskin University 2008)*

ABSTRACT

Our physical environment acts as an evidential part of our memory. Each and every given situation is encoded in our cognitive map, spatial as non-spatial, and represents individual sensual inputs of our surroundings. Since architecture characterizes the majority of our everyday life, our sensual contact with it must respect the process of remembering.

The principles derived from the neurological studies let us understand, how architecture can influence our spatial memory and establishes together with principles from both Kevin Lynch and Christian Norberg-Schulz the theoretical groundwork in order to understand how architecture and nature influence our ability to form new memories.

A recently rejected vision about a Landscape Hotel at Holmland Klit near the Weastcoast, Denmark, is object for this theoretical application in practice. The Landscape Hotel represents a hybrid between the ordinary holiday home and a holiday resort and offers a space exclusively reserved to comprehend new memories by stimulating other senses than the everyday life. The theory let us understand how the individual functions of the Landscape Hotel from the private hut placed isolated in synergy with nature to the historical and revitalized Klitgård are emphasized by the architectural properties.
By focusing on the sensual dispositions, the individual fragments of our memory; as the sound of the door, the feeling of the cold wind, the sight of the tall silo, the smell of the fresh heath, and the taste of the local food, the individual parts of the Landscape Hotel takes its form. Through a process of refining these sensual inputs of both architecture and nature each and every space enhances the intended experience of being at the Landscape Hotel.

This approach demonstrates how evidence-based knowledge of neurocognitive mechanisms of spatial memory can be applied in practice, and exemplifies how architecture facilitates our ability to form new memories.

Fig. 0.01: Huts in the fog. Visualization of the private huts located within the extensive heathland by the westcoast of Denmark

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Fig. 0.02: Japanese Shinto Shrine. The temple is rebuilt as a replica for every 20 years. This is done in order to maintain the spiritual, cultural, and community bonds of the architecture. The temple is about 2000 years old and clearly illustrates how the spirit of the space can be maintained or even streghten in a new building.

FROM THEORY TO PRACTICE *YOU- OR U-VALUE?*

This report pursuits to demonstrate how the principles derived from neuroscience can be used as an applicable instrument in order to design more humanistic and evidence-based architecture. In the transition from theory to practice, it is importance to emphasis how these principles might operate as an essential tool equally as for instance technical calculations. The principles derived from neuroscience have to stand as guidelines for the process of designing, and not act as an explicit design answer.

"Theory has to a high extend lost contact with the concrete life-world. This is particularly the case with technology, which is today considered a mere means to satisfy practical demands"

(Norberg-Schulz 1980, p. 15)

Thus describe the Norwegian architect and theorist Christian Norberg-Schulz (1926-2000) this critical phenomenon, in his book Genius Loci: Towards a phenomenology of architecture.
I find it relevant to integrate this important phenomenon as the starting point of this report, because the attitude has, in my perspective, not changed positively these days. Especially, the status of the technology, as Norberg explicity adressed in 1980, would be an actuel point of departure. The following recent example illustrates the focal point of this critical discussion in a modern context.

Svinkløv Badehotel, a historical and national known wooden hotel from 1925 located by the westcoast at Jammerbugten in Denmark, tragically burned down to the ground a summer night in 2016.
This historical hotel was considered as a Danish natural treasure and a representative example of good Danish architecture soaked in both wonderful social and personal memories. *(Emborg & Kragh Jespersen 2000, p. 3)*

Almost instantly after the tragedy, a national discussion took place whether the old spirit of the place could or should be reestablished in a new building. Just 8 days after the accident, the fund behind the hotel presented the preliminary plans for the reconstruction of the hotel at an open press conference. An unanimously committee of the fund had decided to reestablish the historical hotel. This decision was almost constantly received in public as a popular and reasonable decision in the aftermath of the beloved hotel. The fund assessed to have sufficient economical and local support to realize such a project. The only primary obstacle in the way of receiving this popular goal was, at their point of view, The Building Regulation of today, which besides representing the biggest challenge at the moment also precluded a replica of the historical hotel. *(Strømgaard 2016)*
In other words, The Building Regulations, which original was adopted as an instrument to secure good energy, security, and health condition, prevented that Svinkløv Badehotel, an almost evidential example of good architecture, was built.
By that, the discussion changed from being concentrated about how to establish a hotel with same qualities as the old one in a modern context, to a discussion whether the building could approve the practical regulations. In my perspective a negative transition from quality to quantity.

A tragicomical aspect in this discussion, the fire started due to a technical defection in a dryer. This articulates the question whether the hotel was not burned down to the ground if it was built by the standards of today? But it should simultaneously articulate a question whether it had been such a successful hotel if it was built by the standards of today?

The danish phychologist Svend Brinkmann describes this phenomenon, when a instrument becomes a goal, or vice visa, as a critical modern tendency. He terms this tendency as Instrumentaliseringen, and describes the phenomenon as a process when quantitative values, the measureable data, becomes the focus and dominates the actually meaningful goal. He encourages to a general reflection as prerequisite in order to oppose this phenomenon. *(Brinkmann, p. 12-25)*

"Vi er blevet gode til at måle og veje verden, men dårligere til at vurdere værdien af det, vi måler og vejer" (Brinkmann, 2016)

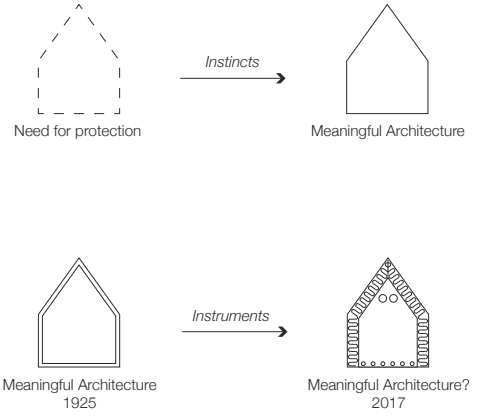


Fig. 0.03: Meaningful Architecture. Laugier see meaningful architecture as a result of the human nature, the human instincts. This process might be relevant to reflect in a modern context, where we are able to instrumentally measure the performance of architecture.

Seen in the light of above mentioned dilemma, the practical report has to demonstrate how the theoretical principles, in this case the neurological principles, can be implemented in practices in order to reach meaningful architecture, but further how the instruments, the theoretical principles derived from both neurology, technology, sustainability, functionality, or aesthetic, can be implemented in practices in order to reach meaningful architecture.

METHODOLOGY

A methodology that in particular adresses this critical process is the Integrated Design Process. *(Knudstrup 2004)* The Integrated Design Process describes a to secure that the technical considerations becomes an integrated part or an instrument in the process of design a building. It stresses the synthesis of architectural knowledge and technical solutions, and illustrates how the aspect of both can be optimized and integrated in a synchronized five-phases process.

As this project introduces another perspective to the field of architectural design, than adressed by the Integrated Design Process, the concrete procedure of the methodology, might be irrelevant in this case. Especially, the specific instructions of how the subprinciples of construction, energy consumption, and indoor environment are applied seems more or less incompatible in this context.
Nevertheless, the overall purpose of the process, to integrate evidence-based knowledge to the process of architectural design, might be applicable to this project as well. Grounded in this academic strategy, the individual phases of the Integrated Design Process, and the conclusion of the theoretical part, the following chapter are settled and used as milestones throughout this project in order to secure an integrated process with a neurological focus. *(Knudstrup 2004)*

(i) The first phase establishes the first step from theory to practice and introduces the initial problem of the project. The problem is examined and investigated in relation to conclusions of the theoretical part, and how the theory might be useful in order to answer the design challenges is analysed.

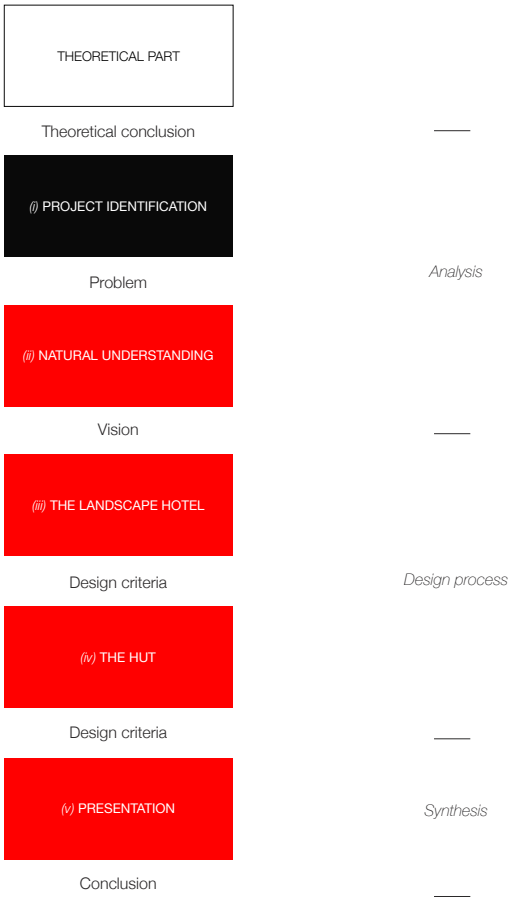
(ii) The second phase continues the analytic approach and investigates the concrete circumstances of the context. General architectural theories are supportive to this approach in order to enlighten the actual conditions of the site in details.

(iii) The third phase establishes the design process together with the following phases. Both phases represent different iterations and try to bridge the theory and the present project. This phase treats aspects considering the center of the Landscape Hotel.

(iv) The forth phase presents the second part of the designproces, and examines aspect about the hut from an urban perspective to the architectural details. The included experiments for the previous phase and this phase are primary driven by aspects from the theory, but also more general architectural consideration are included in order to make the project as realistic as possible.

(v) The finally phases presents the design solution. This phase furthermore presents a synthesis that also concludes and reflects the whole process from the neurological based theory to an architectural project.

Fig. 0.04: Process flow diagram of practical part. The five filled boxes represent the individual phases of the practical part assigned from top to bottom in a chronological order.
The text inbetween the boxes described the individual conclusion and the text besides the boxes describes the related processes inspired by The Integrated Design Process.



The first chapter introduces the initial project problem based in a recently rejected proposal of a landscape hote positioned at Holmsland Klit in the far west of Jutland, Denmark.

The circumstances about the project are firstly shortly introduced and discussed, then the area is analyses and investigated in both a historical and contemporary perspective, and lastly the project is examined and evaluated in relation to the neurological theory in order to approach the main challenges of the project.

(i) PROJECT IDENTIFICATION

Fig. 1.01: Contrast between nature and holiday homes.
Numerous of holidays home are located as smaller villages at Holmsland Klit, and define a clear border between the heartland and the holiday plots.

PROJECT BRIEF *LANDSCAPE HOTEL*

The theoretical principles presented in the first part of this thesis are of a general character, and they might therefore be applicable in many different architectural scenarios. Neverthelss, in order to examine and visualize the optimal potential of the principles, a project concerning a Landscape Hotel at Holmslands Klit is chosen as object for this report. This particular project is preferred based on several reasons, but mainly because of its function as a space for vacation. Vacation is an escape from the stimulaitons of our everyday life, and a platform for new experiences and new memories. Besides this, the project contains several potentials that might be highly relevant in relation to the theory. These potentials are described and concretized in the following chapter, just after the project brief. Each potential is formulated as a part of the analysis of the area. The three potentials are defined by following headlines *(i)* Childhood Memories, *(ii)* Nature as culture, and *(iii)* Natural understanding.
In order to understand the point of departure, the following section just briefly introduces the starting point, which underlies a project concerning a Landscape Hotel at Holmsland Klit.

The present project is grounded in an urban vision of Holmsland Klit conducted by the urban company Norrøn. This vision is characterized in an informative report that contains a thorough analysis of a 81 Ha rural area located at a smaller holiday area named Bjerregaard in the western Jutland.

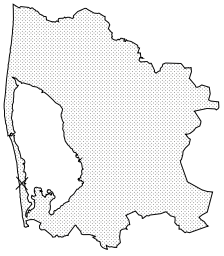
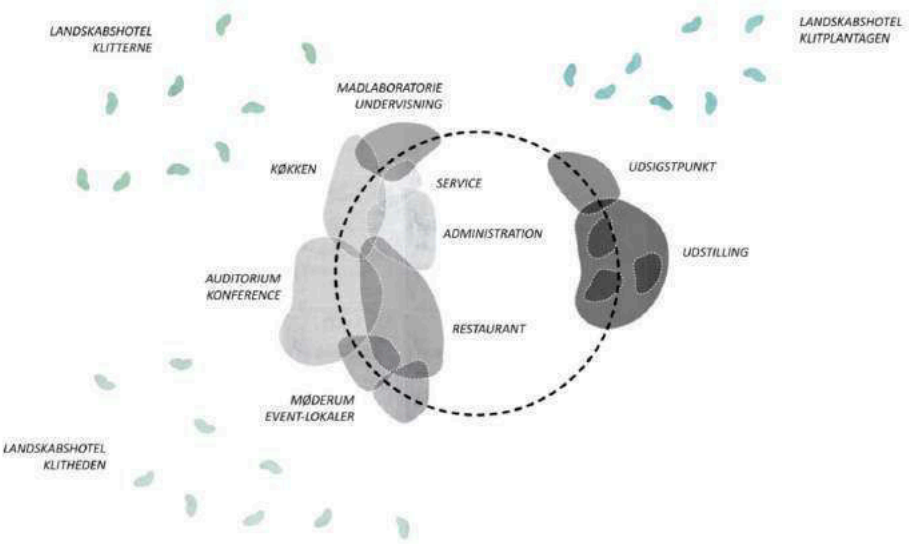


Fig. 1.02: Location - Ringkøbing-Skjern. The location at the westcoast.

The report investigates and illustrates the potentials of the area in a commercial perspective.
Grounded in a sustainable strategy for tourism that

Fig. 1.03: Proposed function diagram. The initial mixture of programs for the Landscape Hotel and the conceptual location of them.



both focus to enrich the experience of the exiting landscape and to benefit the local community, Norrøn concludes the incentive to establish a hotel situated and incorporated in the landscape – a Landscape Hotel.
The Landscape Hotel is intended to be a hybrid between the ordinary holiday house, which is the common vacation form of the area (82%), and the traditional seaside hotel, similar as Svinkløv Badehotel. In addition, the Landscape Hotel should contain several public functions that reflect the contemporary holiday trends, expand the holiday season, and attract a wider population of divers visitors. Norrøn suggests that the hotel such include, besides ordinary accommodation for the visitors, a restaurant, auditorium, viewpoint, exhibition, event- and lecture rooms, and bath- and wellness facilities. Norrøn formulates and illustrates some general principles on how a Landscape Hotel can be incorporated into the landscape, but the location and appearance within this particular area is not concretized in further details.
The vision of the Landscape Hotel at Holmsland Klit has been examined and evaluated by the administration of Ringkøbing-Skjern Municipality. The administration was generally excited about the concept of a Landscape Hotel and accepted and appreciated the possible potentials of such a tourist attraction. Nevertheless, the authorities rejected the proposal, because of it location within the landscape. *(Ringkøbing-Skjern Kommune 2016)*
This evaluation by Ringkøbing-Skjern Municipality occurs naturally due to the critical circumstances about building a hotel in a nature-protected area. However, it seems paradoxically that the administration evaluates the particular vision about a Landscape Hotel as good, and furthermore recognizes the great potential in terms of tourism and local improvement, but on the other hand rejects its further existence because of its interaction with the landscape, which is an essential element and a presupposed condition in the existence of a Landscape Hotel.
This project takes it starting point by the aspects of this paradox and investigates, how the theoretical principles might justify and permit the existence of a Landscape Hotel, and furthermore demonstrates how it is perceived and understood within the spectacular landscape of Holmslands Klit.

Fig. 1.04: Site area. The 81 Ha of land is located at Holmsland Klit in a area named Bjerregaard.

(i) CHILDHOOD MEMORIES

The rural condition of Holmsland Klit brings to mind circumstances about the primitive hut by Laugier introduced in the theoretical part, and how the primitive man instinctively uses the essentials elements in order to satisfy his nature. Only the essentials are present in nature, and meaningful as a natural order. The actions of the primitive man illustrate how this fundamental meaning might be a general human need.

As the neurological theory described that our early memory or childhood memory is essential to our further cognitive perception and understanding. We might be cognitive educated by our first impressions and navigate in relation to these adapted memories. *(Brorson 2013, p. 112)* The previous described mnemonic device named Methods of Loci illustrates how these stable childhood memories can be used as a memory technic, but also advanced neurological studies in the cognitive map indicate the importance of these previous memories. Studies assume that a universal cognitive map is established within our memory by our early years experiences. It is indicated that this universal map operates as a reference map that supports our ability to navigate and orientate throughout life. *(Sharp 1999)*
Especially, the registrations of grid cells indicate this phenomenon. *(Rowland et al. 2016)*
Laugier's emphasis to the primitive man might stand as a picture of this fundamental association and illustrates, how man is longing for the meaningful essence of life.
Nevertheless, this phenomenon is not only present by the historical stories of Laugier, but is also reflected in the society of today. A general urge to explore our roots is becoming a tendency these days. Especially, the media accommodates and stimulates this back-to-nature desire, with series and documentaries that expose and report about the simple and primitive life as Bonderøven, Alene I vildmarken, Out in the Wild. *(Holm-pedersen 2012, p. 13-16)*
This tendency is furthermore present in our everyday habits, where organic and local produced food is becoming more and more popular, and authentically experience or meaningful acts are requested to a larger degree.

Whether this reaction is a fundamental need implanted in our memory, a reaction to the massive urbanization, or just a temporary trend is difficult to determinate, but a potential architectural intervention within Holmsland Klit might accommodate and take advantage of this general desire. Furthermore, the Landscape Hotel must respect and uncover the present meaning of the environment in order to both justify and permit integrated buildings within the environment and to enhance an authentic experience of the rural landscape.

THE (HI)STORY

In order to accommodate this request, it might be naturally to examine the nature of Holmsland Klit. Ringkøbing-Skjern Municipality, also known as Naturens Rige, the kingdom of nature, is the largest municipality in Denmark measured by area, and has more nature per citizen than any Danish municipality. These attractive circumstances make Ringkøbing-Skjern a popular destination for tourism with about 5.1 mil. stays every year, only surpassed by the municipacilities that includes the biggest cities - Copenhagen, Aarhus, and Aalborg. Especially, the localized potentials are important in this calculation, but as the other municipalities offer the citylife as the main attractor, the visitors at Ringkøbing-Skjern municipality are mainly attracted by the nature.
Namely, 70% of the tourists choose the nature, and especially the westcoast, as main reason-to-go factor. This is highly reflected by the buildings at the area, which contains of 7.000 holiday homes located at Holmsland Klit. *(Ringkøbing-Skjern Kommune 2014, p.4)*

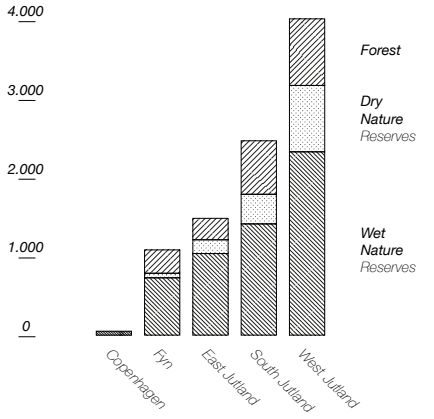


Fig. 1.05: Area of nature - diagram. Ringkøbing-Skjern Municipality offers more than 4,000 m2 of nature per. citizen.

It is an ambition of the government of Denmark and a clear vision of Ringkøbing-Skjern Municipality to emphasize this quality of nature, and to use it as a growth factor for tourism in order to improve the experience of being within the nature. *(Ringkøbing-Skjern Kommune, 2014, p. 7)* They especially highlight the story of the nature, as an important aspect of the tourist experience. *(Ringkøbing-Skjern Kommune, 2014, p. 23)*

Fig. 1.06: Nolli map. A large number of holidays homes are located both south and north from site.

Fig. 1.07: Childhood memories. Our fascination and memories of nature might stand as a essential part of our own nature.

This intention corresponds with the abovementioned longing for nature, and might illustrated both a need and a potential for establishing a Landscape Hotel. But how can the Landscape Hotel enhance and facilitate these stories about the local environment?

Two recent projects supported by Ringkøbing-Skjern Municipality are focused on this issue and try to cultivate and emphasize the stories of the West Jutland. Both projects are started in order to improve and communicate the character of this magnificent area.
In order to secure the popular status of the holiday homes now and in the future, Ringkøbing-Skjern Municipality together with multiply other municipalities has completed a project named Rethink the Holiday Home. The project investigates how cultural event can improve the vacation in West Jutland and emphasizes the experience of the historical elements.
The study concludes that especially the gastronomy of the Westcoast might be the potential link between the local nature and culture. The findings highlight that a narrative approach to the gastronomy might be an effective promotion of the place and might attract a new audience to the area. *(Molders 2015)*
This includes especially a visitor group named Foodies, who is characterized as couple 45+ travelling without kids. The preference of this target group is generally an authentic experience with good quality, high standards of food and wine, and informative cultural experiences. *(Ugeavisen 2016)*

Another project that investigate this narrative approach is the project named New Nordic Noir that seeks to express the stories of West Jutland though a TV-serie. The project is set to be an alternative to the existing majority of TV-shows about the citylife and wants to portray the qualities of the dramatic Danish landscape. *(Ringkøbing-Skjern Kommune 2017)*

Both mentioned projects reflect how the rural conditions of Holmsland Klit can be communicated and explored by cultural interventions. Especially, how the stories of the area can incorporated in every sensation, the sight of the extensive landscape, the sound of the ocean, the smell of the flowering fields, the taste of the local produced food, and the feeling of the soft and warm sand in order to attract tourists and commnicate and establish old as well as new memories. Especially, the multi-sensual experience might be an important feature in order to evoke previous memories. This situation is very precisely emphasized in Steen Steensen Blicher's poem Mit Hjemland about the heathland from 1814:

"Min Fødestavn er Lyngens brune Land, Min Barndoms Sol har smilt paa mørken Hede, Min spæde Fod har traadt den gule Sand, Blandt sorte Høje boer min Ungdoms Glæde. Skjøn er for mig den blomsterløse Vang, Min brune Hede er en Edens Have: Der hvile ogsaa mine Been engang, Blandt mine Fædres lyngbegroede Grave."

(Dalsgaard, 1998, p. 96)

Fig. 1.08: En jysk fårehyrde på heden. (1855). Olie on canvas by Frederik Vermehren (1823-1910). The heathland was a common motive in both litterature and art in the Golden age of Danish Painting.

(ii) NATURE AS CULTURE

As the vision about the Landscape Hotel has been evaluated and judged by the administration of Ringkøbing-Skjern Municipality, it would be relevant to scrutinize the decision in order to illuminate the primary issues to the refusal. An extract of the official note is as following:

"Projektet tænkes placeret i en af disse landskabskiler – et uberørt naturområde der har stor landskabelig og naturmæssig værdi, samt rekreativ værdi og herlighedsværdi for de mange sommerhuse i Bjerregaard-området." *(Ringkøbing-Skjern Kommune 2016)*

The main incentive of the administration to overrule the decision of establishing a Landscape Hotel at Holmsland Klit was the problematic location within an area protected by the national law of nature protection named naturbeskyttelsesloven. This law is often refereed as paragraph 3 and classifies about 10 % of the Danish nature as protected. It is established in order to preserve the existing nature reserve and the belonging wildlife, and generally considered as one of the strictest law in Denmark.

The majority of the site at Holmsland Klit is paragraph 3 protected as heath-area. Heathland is a common character in the Danish landscape, and occurred already 10,000 years ago after the latest ice age. Later, the heartland became a natural resource for the Danish farmers in the 1700's and covered about 60% of Jutland, when it had its greatest extent. (*Dalsgaard 1998, p. 2)* This has changes dramatically since, where most of the heathland has been further cultivated into farmland or plantation, in some areas as a reaction of restricted agriculture, but primarily because of natural circumstances.

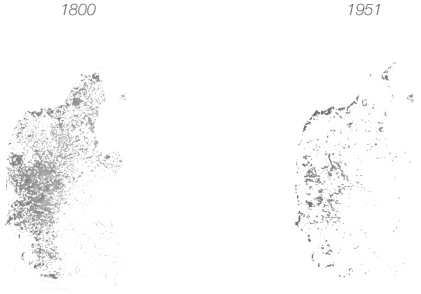


Fig. 1.09: The history of heart area. The expansion of heathland has changed dramatically since 1800.

Because the long-lasting heathland, as found at Holmsland Klit, is not a natural phenomenon, but rather a man-made constellation of a historical landscape and a previously area of agricultural interest. Heath has only a lifetime of about 20-25 years and can only be maintained or multiplied by either seeding by grazing animals or man-made cultivation by heathburning, as Jeppe Aakjær describes. *(Kommunernes-Landsforening 2011, p. 10)*

"...heden brænder; plantagemændene får travlt med projekter; atter nogle hundrede tønder lyngjord indvundet til Hedeselskabet; glæd dig Jylland, du tabte en naturejendommelighed, du mistede dit urgamle særpræg, og fik som erstatning 100.000 favne pindebrænde!"

(Dalsgaard, 1998, p. 99)

These circumstances accumulate another substantial paradox as the heathland of Holmslands Klit is categorized as protected nature, but are maintained and cultivated to appear unnatural and as a notion of the historical extensive heathland. This adaption of the heathland, to express and reflect a prominent development in society, changes the definition of the place, to become a cultural environment, a Kulturmiljø, instead of a natural phenomenon. *(Naturstyrelsen 2003)*

"Natural landscape thus becomes cultural landscape, that is, an environment where man has found his meaningful place within the totality"

(Norberg-Schulz, 1980, p. 40)

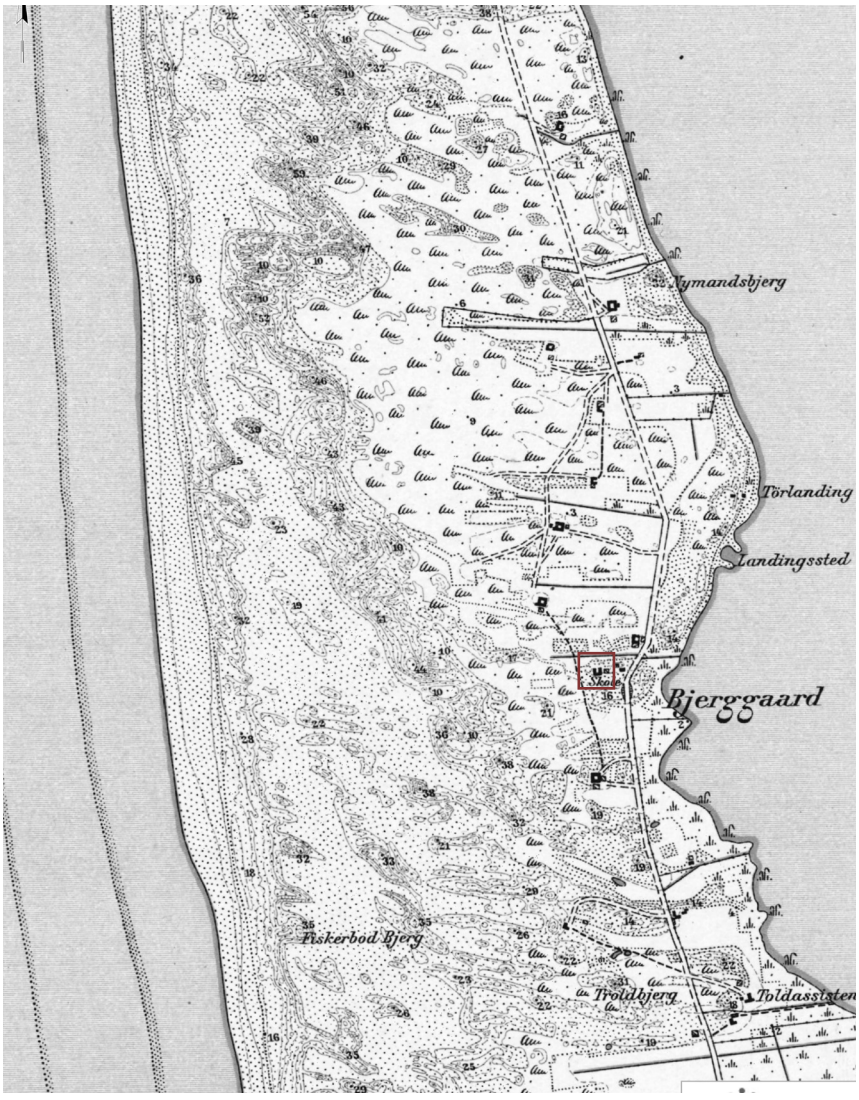
Thereby, the landscape of Holmsland Klit alters from not only being a natural environment, but to represent a historical stage, which symbolizes the natural character. This enhances the memories and stories that human engagement with the nature has constructed in order to be meaningful and authentic.
An essential element of this cultural story about the heathland is the Vestjyske Klitgård, the typical farm of the westcoast, which underlies the existence of the extensive heathland. In the perspective of abovementioned paradox, one might assert that they presuppose each other.

This synergy between the heathland and the Klitgård was naturally, when the heathland was a natural resource of the farmers, but is not current by the circumstances of today. Nevertheless, the belonging Klitgård of the particular site is still present today, at the eastern corner of the site. As the Klitgård represents a fundamental element in the stories and memories of the present appearance of the landscape, it would be natural to use this building as a focus of the Landscape Hotel both as a symbol of the history, but also to respect and learn from the hundreds of years, which has passed with the Klitgård.

THE VESTJYSKE KLITGÅRD

The history of human adaption has formed the properties of the Klitgård. Especially, the climate has, as it influences the character of Holmsland Klit, characterized the Klitgård from its location in the landscape to the chose of materials. It might be relevant to analyze the properties of the Klitgård as case in order to illuminate these historical elements.
The Vestjyske Klitgård represents a cultural heritage and a stand as characteristics of Holmsland Klit. Therefore, authorities both local and national have defined regularities in order to maintain and preserve the farms.

Fig. 1.10: The location of the Klitgård. The Klitgård were traditionally position of the eastern side of the dunes. The red square marks the existing Klitgård at site.



The Klitgård stands as a solid focus for the natural surroundings both geographic by being a significant prominent silhouette in the flat heathland, but also as a cultural focus by establishing a safe home to the farmer, the family, and their animals. This status of being a safe and private environment to the family is highly expressed by the typical form of the Klitgård. The four-winged typology establishes a legible enclosure defining outside from inside and public from private. Furthermore, the enclosure secures a microclimate in the inner yard that is more or less isolated from the tough wind from west. *(Dunn Andersen 2000, p. 57)*

The location of the Klitgård was highly determined by the natural resources in order to minimize the distance to both the grazing animals on the heartland and the crops on the meadow, but especially to reduce the forces of the wind from the ocean. The Klitgård was typically located at the transition between the heathland and arable, and just at the eastern side of the dunes sheltered from the west wind. *(Dunn Andersen 2000, p. 38)*

The Klitgård represents furthermore an exceptional local building tradition. Especially, by the choice of materials that reflects the local resources and illustrates how modern principles as sustainable and circle economy were a natural procedure at that time. Many of the used materials have its origin in the local area. The thatched roofs made of straws collected near the fjord, brick burned by local clay, stones found by the beach used as paving, and lumber recovered from wrecked ships. *(Miljøministeret 2005, p. 2)*

The authorities wish to preserve the Klitgård appearances and status as important landmarks of the region. The original function of the building as farms is in most cases irrelevant today, and new puplic functions can be incorperated in order to maintain the attraction of the historical buildings. Especially, functions that respect and benefit the architecture of the traditionel Klitgård and its belonging surroundings are recommended in order to carry the long tradition of the Klitgård forward. *(Miljøministeret 2005, p. 6)*

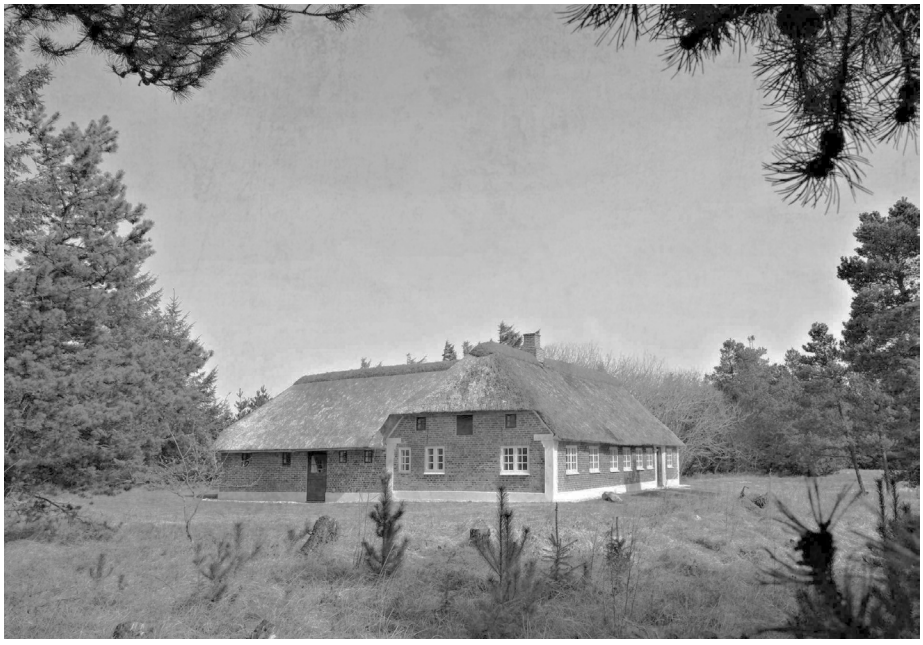
Functions that address tourism and commercial purposes might be obvious for this purpose considering especially the location. This might also be natural in a historical perspective, as the Klitgård acted as an essential part of the tourism since 19th century, where the farm regularly rented rooms out for tourist in the summer time. *(Dunn Andersen 2000, p. 107)*

A future development of a Landscape Hotel must respect the properties of the Klitgård, and take advantage of the accumulated knowledge and adaption on the Klitgård represented in the cultural evolution, and furthermore embed the memories and stories that both the Klitgård and the surrounding landscape contains.

Fig. 1.11: The Klitgård - form. a: The typical four-winged form of the Klitgård. b: The existing Klitgård. The Klitgård located at site is in relatively good conditions and consist of three different wings enclosing a smaller courtyard.

a.

b.



(iii) NATURAL UNDERSTANDING OF HOLMSLAND KLIT

The rural character of Holmslands Klit is relevant in the perspective of the theoretical part in terms of its characteristic topographic. The extensive character of the heathland defined both by its scale, continuity, and horizontal character establishes a magnificent urban context, which represents an almost empty "flat plain". A more or less blank canvas to test the spatial principles derived from neuroscience. An architectural intervention within this extensive landscape might undeniably influence the natural understanding of the space. This phenomenon might also illustrate why the Landscape Hotel were rejected at the first place.

"On a flat plain, extension is general and infinite, but usually variations in the surface relief create direction and space"

(Norberg-Schulz, 1980, p. 32)

As the theoretical part derived from neuroscience mainly operates in a architectural scale and is not directly applicable to this particular surrounding, it might be relevant to include other theories in order to understand both the urban scale and the natural environment. In order to comprehend these aspects as well, it is relevant to emphasize the theories that already have been supportive to the theory. As referred and described previous, it seems natural to emphasize the psychological studies of Kevin Lynch, presented in his book The Image of the City, in order to enlighten the urban aspects of the area. Furthermore, Christian Norberg-Schulz phenomenological studies of the natural setting described in Genius Loci: Towards a Phenomenology of Architecture have been and is used in order to understand the perceptual influence of the landscape.

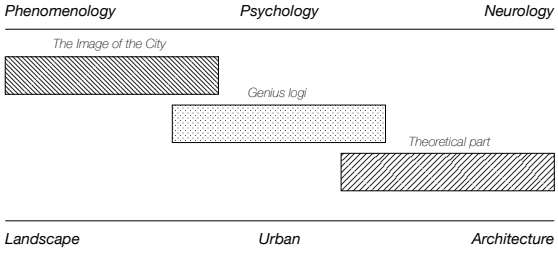


Fig. 1.12: Diagram of supportive theories. The different theories establish a connection between scale and perspective.

Principles from these theories establish the theoretical basis in order to demonstrate how these architectural interventions is perceived and understood, and furthermore justify how architectural elements might compliment the natural understanding of the place tested and examined in the following designprocess.

But in order to justify the relationship between the built and natural environment, a deeper understanding of the current natural conditions is required.

First of all, the natural understanding is not exclusive a result of the landscape; the high trees in the woods, the soft sand of the beach, and the colorful appearance of the heathland, but a analogy of both the extensive landscape and the dynamic sky. *(Norberg-Schulz, 1980, p. 23-24)*

Especially, the flat and open topography of Holmsland Klit emphasizes this relationship, where the character of sky highly influences the experience of the landscape on a daily basis - as a natural and temporal rhythm. At daytime, the pale and uniform colour of the sky and the general low position of the sun accentuate the horizontal direction of the landscape and offer an extensive and clear view of the surroundings. At night, the comprehensive darkness blocks the sight almost entirely and triggers other senses in order to navigate and orientate within the landscape - the roaring sound of ocean, the tactility of the heathland, and etc.. *(Norberg-Schulz, 1980, p. 41)*

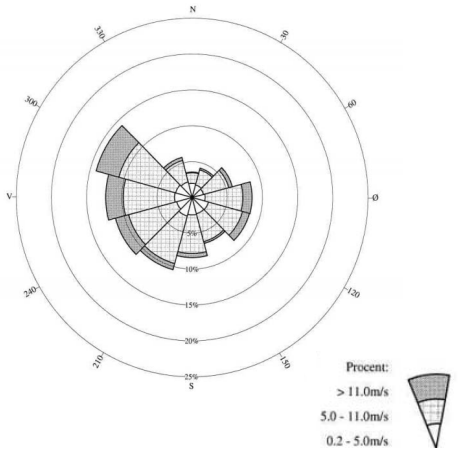


Fig. 1.13: Windrose. The wind of Holmsland Klit is especially very tough from the ocean during the day.

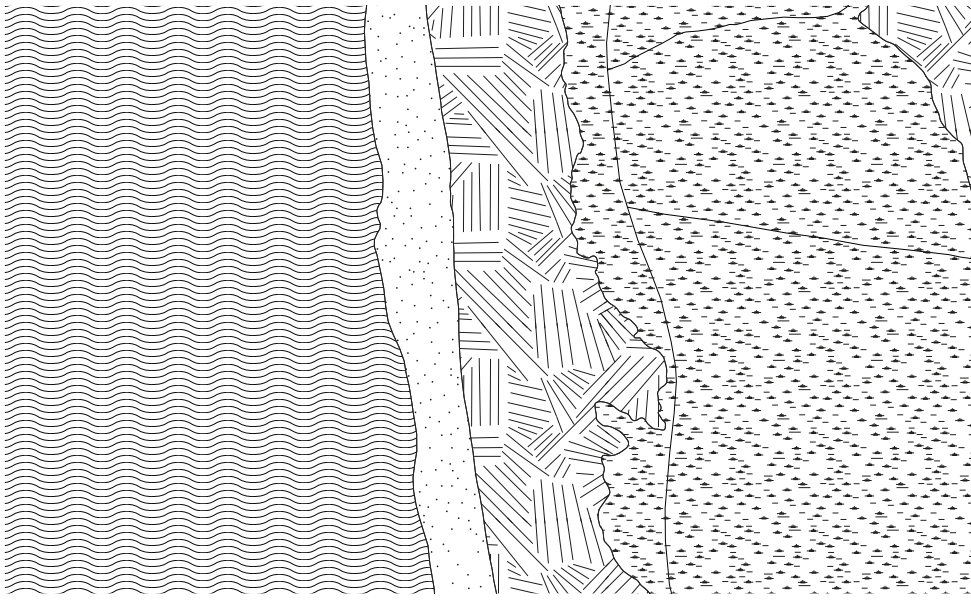
The paramount natural force at Holmsland Klit is undoubtedly the wind. The thermal difference between the ocean and the land results in a strong and dynamic wind conditions. The wind will be strong from west to east by the day, when the sun heats the ground, and opposite, a strong wind from east to west in the night. *(Kunstakademiets Arkitektskole 2008, p. 95)*

The wind maintains the dynamic property of the sky, which in combination with the sun determinates and dictates the character of the seasons. The transformation of the season is mainly presence in the colors, both by the sky, but especially by the changing appearance of the heathland, from the characteristic distinctive purple color of summer to the coherence brownish color of winter. These natural phenomena of time have been inspiration and object to art and literature for generations, and platform to stories and interpretation of artists as Steen Steensen Blicher and Jeppe Aakjær. *(Dalsgaard 1998, p. 3)*
A natural rhythm is not only defined by temporal time,

Fig. 1.14: Natural order. Different layer with different characters are present at site.

Fig. 1.15: Section of site. The section illustrates the extensive and flat character of the site.

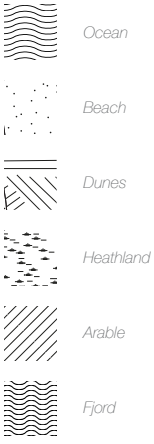
Fig. 1.16: Natural order - patterns. The map show the different layers of nature.

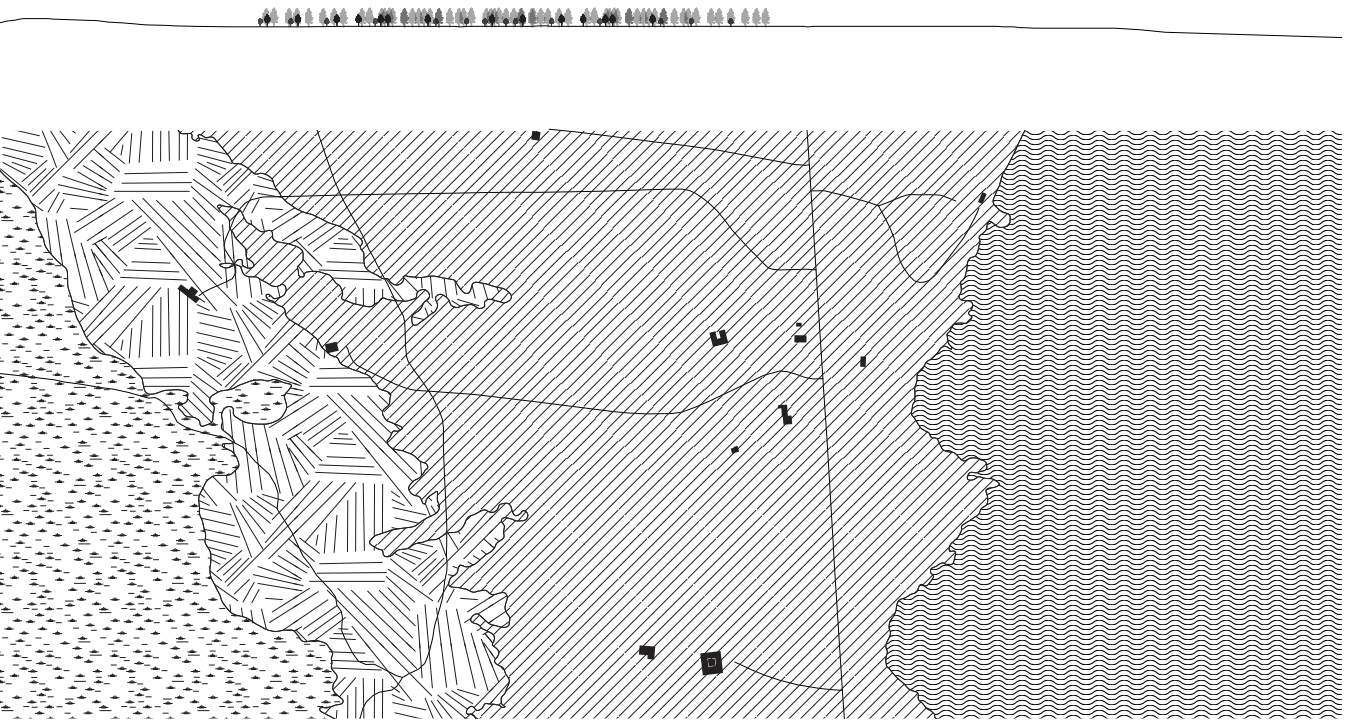


days and seasons, but also the long time has dynamically shaped rhythms within the landscape that provides both direction and orientation to the landscape.

These layers of landscape are especially presence at Holmsland Klit, where the respective layers are compacted into the narrow piece of land between the dynamic and dramatic ocean in the west to the silent and steady Ringkøbing Fjord to the east.

Each layer represent a specific character and reveals individual fragmentations of the same story.
The following pages illustrate these different layers of both history and nature.





The contextual and bureaucratic circumstances about the Landscape Hotel contain many paradoxical aspects that might be relevant to address.
First of all, why built in a nature protected cultural area? Then how to implement buildings within a rural context? And lastly how can the architecture influence how the building is perceived?
The neurological theory might stand as an essential instrument in order to answer these critical questions.

The following chapter offers a look at the magnificent landscape and seeks to illuminate the exiting character of the space by accentuate the respective layers of nature.
The different sections of the natural order are shortly described from the perspective of the theory, but they are mainly presented in pictures. As parts of the landscape might be familiar to the observer in different ways, the pictures stands more or less alone, and let it be up to the individual observer to obtain a certain conception of the space based on previous experiences and memories.

(ii) NATURAL UNDERSTANDING

Fig. 2.01: Westcoast
Fig. 2.02: The beach

THE BEACH defines a transition zone between the ocean and the barrier of the dunes. A transit zone not only for the people who gets drawn by the extensive ocean, but also a transit zone for the ocean to transform from wild waves to silent water. The condition at the westcoast is highly defined by the forces of the wind and is only occasionally pleasant for longer stay in the summertime.

THE DUNES stand as a visual and physical boundary and define a protective wall to the heathland. The dunes break the horizontal extension and frame the area. The silhouette of the dunes appears very strong in contrast with the background color of the sky, and defines a surrounding boundary *(Norberg-Schulz, 1980, p. 40)*
These boundaries might stand as a strong cue in order to determinate a certain idea of distance within the large area of monotone heathland. *(Doeller, King, & Burgess, 2008)*

The silhouette of the surrounding dunes is dominating and appears almost uninterrupted around the heathland. Only a single man-made element, the silo, breaks the consistent topline of the dunes and establishes a prominent and salient landmark. This landmark might stand as an essential reference point in order to orientate within the area.

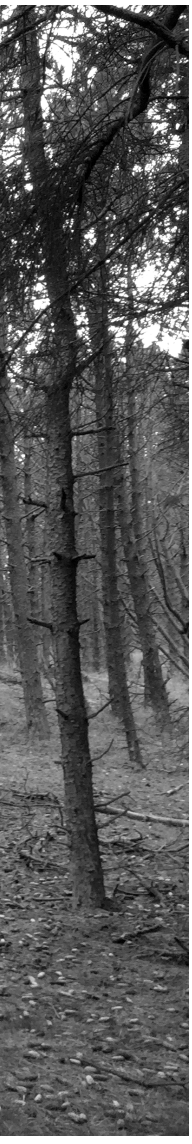
Fig. 2.03: Dunes
Fig. 2.04: Straw
Fig. 2.05: Silo

THE HEATHLAND is defined and framed by the dunes and represents both a continuity and extension by its material. This use of material might stand as a local cue that brings a spatial coherence and encodes the heathland as one element and representation.

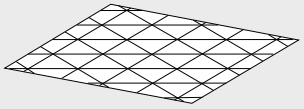
Fig. 2.06: Heathland
Fig. 2.07: Heath close-up

THE ARABLE consists of a grove of trees located east of the dunes. The trees is not a natural phenomenon at the site. They are primary planted in order to establish a wind barriere towards east. The enclosed and dark character of the woods opposes the the extensive heathland.

Fig. 2.08: Forest
Fig. 2.09: Arable

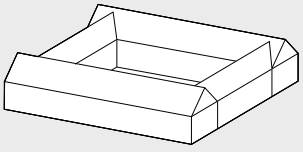


The conclusions of the initial considerations in relation to the transition from the theory to the project, the project brief, and the context analysis are composed into three layers of visions. Each layer represents aspects that has to be considered and incorporated in the Landscape Hotel.



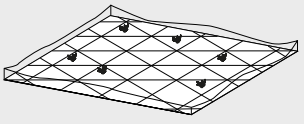
(i) GROUND LAYER

The Landscape Hotel must establish an alternative to the over stimulated lifestyle in the densely populated city and represent simplicity, sobriety, and freedom by only considering the essentials. The Landscape Hotel must furthermore extend the tourist season and audience by emphasizing the authentic and multi sensual experience found in a synergy with nature, good quality, comfort, and localized gastronomy.



(ii) HISTORICAL LAYER

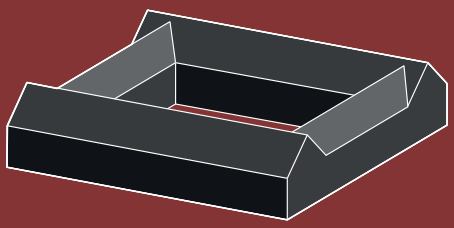
The present cultural circumstances grounded in the analogical relationship between the extensive heathland and the Klitgård must be the focus of the Landscape Hotel. The cultural features and architectural adaptions of history must be preserved, respected, and reinvented in the additional functionality of the area.



(iii) NATURAL LAYER

The Landscape Hotel must respect the rural characters of the surroundings. The flatness and extensiveness of the topography represented both by the continuity of the heathland and the appearance of the existing elements within the landscape must be upheld and undisturbed in order to maintain the seasonal and sensual experience of the landscape. This place is discovered not chosen.

Fig. 2.10: Visions of the Landscape Hotel.



The following chapter represents the first part of the design process and seeks to transform the conclusion from the previous analysis into an architectural intervention – the Landscape Hotel.
The approach of this process is primary defined by the neurological theory and operates according to the principle of the cognitive map. The following pages describe this neurological based approach further in details.

(ii) THE LANDSCAPE HOTEL

PROGRAM

The list of programs is composed as a result of both the initiated proposal of Norrøn, the analysis, and by inspiration from similar cases. The analyses and the location at the historical Klitgård clearly request a need for quality instead of quantity, and a significant restriction in both number and size of functions.
The nature has to stand as the primary reason-to-go, and the choice of functions must respect and emphasize this by only representing the essentials. Especially, Svinkløv Badehotel has been an inspiration to this approach. Svinkløv Badehotel represented another kind of luxury, than we ordinary associate with luxury. Where the typical resort of today includes an overwhelmed number of indoor activities, as swimming center, sports facilities, playground for children, and etc. Svinkløv Badehotel highly prioritized the outdoor environment it was located in, and used that as the main activity of the place. Furthermore, especially the gastronomic experience at the hotel was a central attraction of the place, by offering local produced and cooked food in local circumstances.

The Klitgård has to represent a social communal center of the Landscape Hotel and a protected base before entering the wild nature. This space has to respect the introvert and isolated expression of the Klitgård by offering social functions at the hotel, but at the same time be extrovert and include and emphasize the experience of the spectacular landscape, it is locate in.

Only three social functions have to constitute the main activities at the Klitgård beside the general accommodation. The activities within these social functions have to offer different sensual input in a social constellation, and the natural circumstance has to be a key element for every scene.

LIST OF PROGRAMS

Communal center:

General functions:	Quantity	Size	
Ordinary rooms	*10*	*20*	m^2
Handicap friendly rooms	*2*	*30*	m^2
Social functions:			
Restaurant/Food laboratorium		*200*	m^2
Bath		*75*	m^2
Auditorium		*75*	m^2
Service functions:			
Kitchen		*50*	m^2
Reception		*40*	m^2
Entrance		*30*	m^2
Wardrobe		*10*	m^2
Administration office		*20*	m^2
Cleaning room		*5*	m^2
Technical room		*20*	m^2
Restrooms		*10*	m^2
General storage		*30*	m^2
Other:			
Meeting room		20	m^2
Viewpoint		10	m^2
Storage yard		80	m^2
Total		935	m^2
Parking		40	pcs.

Fig. 3.02: The existing Klitgård. Seen from the road

STORY

As described in the theoretical part, the cognitive map might be fundamental to our memory and encodes previous as well as present spatial properties based on sensorial inputs for each given experience - whether it is related to a spatial composition or not. This means that architecture, as the primary contributor of spatial information, acts as an obligatorily and essential part of the memory and learning functions in our every day life. *(Sharp, 1999)*

The value of each sensory information is individual, and each person establishes his or her own mental representation of the given situation based on previous experiences.

"Our memories are prejudiced, in the full sense of the term, by our past history and beliefs."

(Damasio 2010, p. 133)

It is therefore more or less impossible for an architect to fully control a complete perception or experience of a space, as each person is encoding an individual image of the situation. Instead, as the neurological theory tells us, we have to consider the individual sensual input that constitutes to the creation of the cognitive map, in order to understand and manipulate the experience of the space. As the structure of the cognitive map illustrates, the human brain do not and can not store the complete images of our experience. It only stores and recalls in fragments or dispositions. In other words, we are remembering different fragments of the same experience depending on our past and history.

"Images can be experienced during perception and during recall. It would be impossible to store maps that underlie all images one has experienced, in their original format"

(Damasio 2010, p.140)

The architect must therefore consider the present sensory information as individual fragments that all lead or emphasize the same intensions of the space. Each disposition might lead to a recall of the full experience.

"Finally, dispositions can be used to reconstruct the maps in early sensory cortices, in the format in which they were first experienced"

(Damasio 2010, p.140)

As architecture only represents the props that permit the users to engage and experience, the architect must carefully choose and combine these individual fragments in a meaningful way in order to establish unforgettable experiences and thereby unforgettable spaces.

These days a traditional design process start with a general concept or a higher perspective, but starting with the dispositions instead might comprehend the process of remembering, and might establish the basic framework in order to produce new memories.

"Since our feelings and understanding are rooted in the past, our sensuous connections with a building must respect the process of remembering."

(Zumthor 2010, p. 18)

Artists such as painters, writers, and poets work to a larger degree with this kind of process. Abstract art express this process very clearly, by only presenting the essential dispositions, in order to led the observer to construct the final image on their own.
Movie directors and theater directors operate also typically with this technic in a more or less controlled environment. By manipulating a certain setting and a certain treatment of the individual scenes, they try to provoke or evoke different feelings, experiences, or atmospheres of the observer.

Inspired by this approach, the following section defines and analyzes several scenes that represent certain important situation within the Landscape Hotel. This is primarily done by testing and setting different disposition that each evokes a sensory expression or reaction.
Seven carefully selected scenes are introduced; three of these scenes concentrate on actions and movements by elaborating different essential transits from one zone to another, the three next scenes focus on different social interaction that might take place at the Klitgård, and the last scene involves the hotel room placed out in the heathland, isolated from both everyday and everyone - the hut.

SCENES

#THE ARRIVAL

KLITGÅRD

#THE RESTAURANT

#THE BATH

#THE AUDITORIUM

TRANSITION

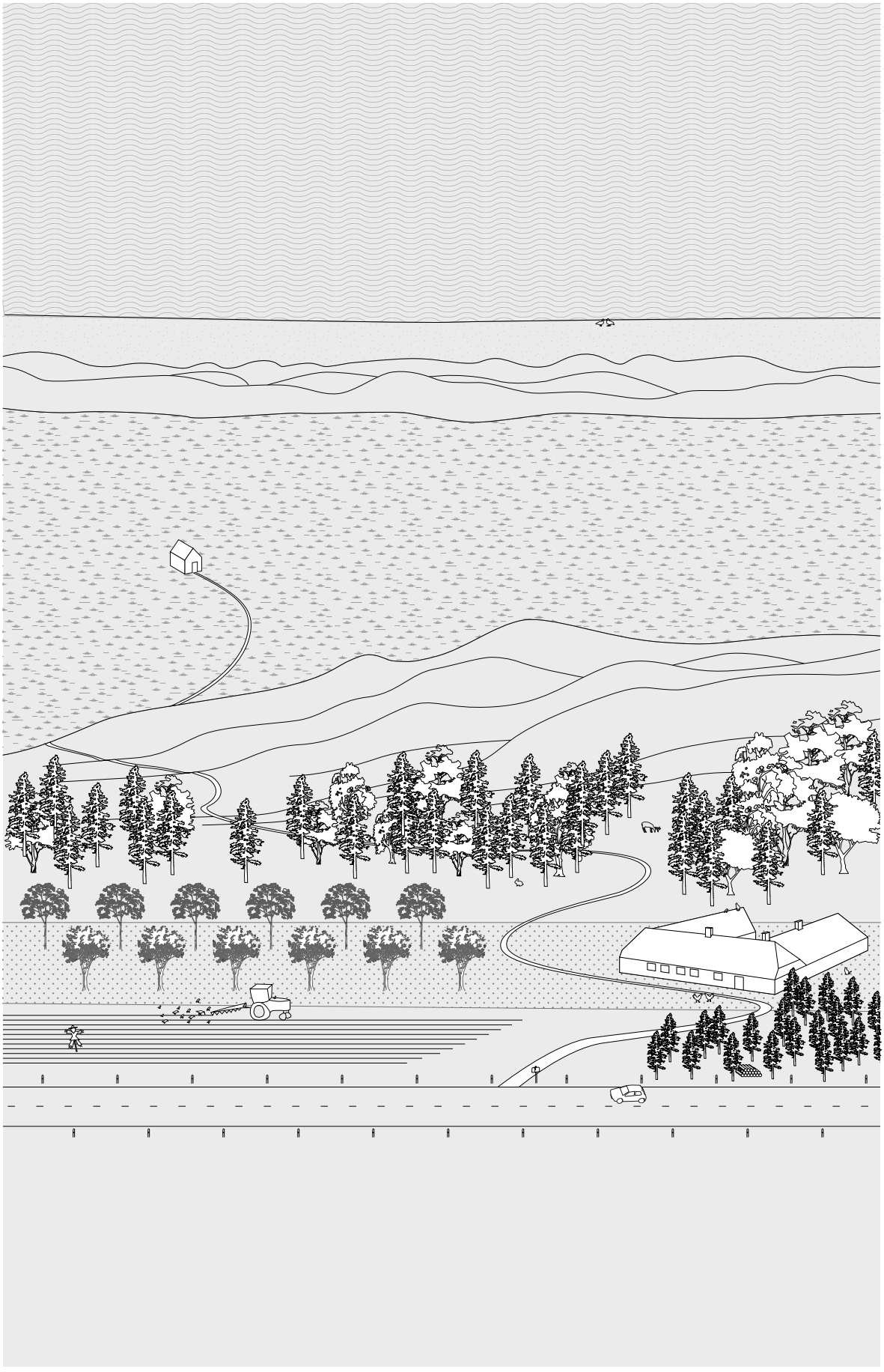
#THE PATH

#THE HALL

HEATHLAND

#THE HUTS

Fig. 3.01: The story. The illustration shows the journey from the Klitgård to the huts. The individual scenes are found on this journey.



#SCENE*THE ARRIVAL*

The first scene includes the first expression with the Landscape Hotel and illustrates the transition from parking the car to entering the hotel. As the Klitgård represents an important part of this project and a historical memory of the area, it might be natural to use the original path and the front door as important elements of this scene.
The existing elements of the naturally circumstances defines many of the dispositions of this scene, because the sensorial expressions of the situation are already presents. This does not necessary means that these fragments are ideal in order to maintain the requested sensorial experience, and might therefore be adjusted or changed if another disposition fits the situation better.

But in order to decide this and fulfill the matrix of dispositions, a general vision of the scene must be composed and establish the main purpose of this particular situation. This vision is developed as a result of the analyses and stand as an objective guideline to the situation, similar as a film manuscript that represents the initial stage of a movie.

VISION
This scene establishes the first meeting with the Landscape Hotel and is the transition from outside to inside. An intimate zone that enhances both the climate adaption and the first silent human interaction characterize this transition.

The most important part of this scene might be the threshold between outside and inside. This boundary is highly present by both the massive brickwall of the Klitgård and the green wooden door. Only a few windows of the façade and some smaller windows in the top of the door reveal the activities on the other side. The change in climate, both in temperature and wind power between inside and outside might even more emphasize this harsh transition.

To accommodate and soften this transition from outside to inside and to reduce the climatically influence when opening the door, a porch might be optimal. A porch can establish a climate neutral zone, which historically has been a traditional part of the Klitgård, as a result of the often very windy and cold outdoor weather conditions.

This porch has to establish a void between two very contrasting surroundings and functions and the first informal meeting before literally checking in to the hotel. Especially, the choice of material and the proportions of the space are important in order to enhance these climate technical and intimate conditions.

The following study investigates these aspects by testing different combinations of materials and different spatial proportions.

Fig. 3.03: The arrival - dispositions

ACTIONS	 Arriving with car	 Walking along the path	 Opening the door	 Taking off coat

SENSUAL DISPOSITIONS

Sight

- Surroundings

			
...	Forest	Built environment	...

- Potential landmarks

			
"Klitgård"	Front door	Handle	...

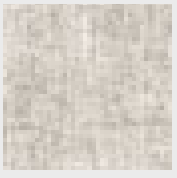
Hearing

- Sounds

			
Nature	Gravel	Door	...

Haptic

- Contact materials

			
Metal	Stone	Brass	Cloth

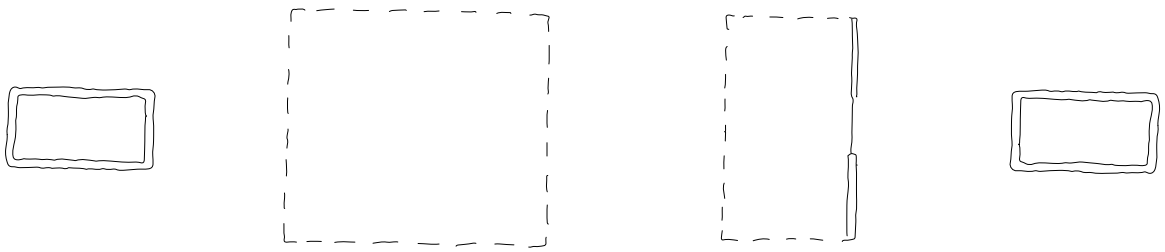
- Ground textures

			
Grass/stone	Stone	Cobblestones	...

- Climate

			
Natural/varying	Natrual/varying	Under roof/sheltered	...

Fig. 3.04: The arrival - boundaries. The different spatial restrictions from the car to entering the Landscape Hotel



First of all, the material and proportions have to emphasize the function of the space as a transition zone for only short temporary stays.
The use of light and soft materials as wood or white plaster makes the space pleasant and welcoming and clearly communicate that the environment has changed from outside to inside. Especially, the brightness of the floor has a significant importance in this context.

In contrast, the use of bricks gives the space a colder and resilient character that to a higher degree accommodates the outdoor conditions weather as wall. Furthermore, the throughout usage of bricks might influence the acoustics of the space that does not invite to longer conversations.

The composition of the bricks as floor enhance a certain direction. The herringbone composition offers diagonals lines that somehow influences the relation between the persons to a higher degree than the longitudinal lines of the other composition.
This aspect of intimacy is furthermore highly influenced by the proportions. The narrow situations force the persons to interact in order to pass each other.

As the visitor will arrive in a car, walk along the path through the natural environment, and then enter the Landscape Hotel. The visitor will be introduced to different definition of spaces in a short periode of time. From the small space in the car to the large space along the path.

An smaller space before entering the Landscape Hotel might illustrate the extensive quality of the natural surroundings along the path and symbolize a temporal stay as the space in the car.

Fig. 3.05: The porch - material and proportions. a: Brick as primary material. b: White plaster as primary material. c: Wood as primary material

a.




b.




c.




SOCIAL SPACES

Based on the previous analyze, the Landscape Hotel seeks to facilitate different variation of social interaction. The social functions of the hotel has to contribute a certain collectivism and allocentric approach, where people get the possibility to associate their attention, interest, and actions to the social engagement with other people instead of isolating or centering them self. The architecture has to invite to reflection and contemplation among and between other people.

The theory stands as a helpful instrument in order to reach this, but also sociological studies of human interaction might provide some essentials guidelines that emphasize the psychological reactions of social engagement.

Especially, the different sensual inputs, illustrated in this project by the sensual dispositions, are important in the social perspective at very different levels.

"In contact between people, the senses come into play at highly disparate distances."

(Gehl 2010, p. 33)

The same applies to the spatial cells, as they are a reaction to the sensual input as well. For instance, the boundary cells only reaction in a certain distance to the boundary, and grid cells are only present by locomotion.

The senses can be divide into "distance" senses and "close" senses, depending on their reachability. Taste and feel nornally need a certain bodily contact with the object or person in order to be registered. They are therefore classified as "close senses". While the vision, hearing, and smelling is activated by distance and therefore classified as "distance" senses. *(Gehl 2010, p. 33)*

This is of course a generalization of the different senses, and is not present for every scenario. For instance, you can feel a certain temperature at distance, similar, as you smell a certain odor at a distance.

The anthropologist Edward T. Hall studied this social cohesion and registered, how people interact with each other. He termed these observations and theori-

Fig. 3.06: Proximics. The distance to a person or object evokes different sense, and defines different zone of interpersonals.

es as proxemics. Inspired by these studies, the urbanist Jan Gehl defined some intervals of distance in his book Cities for People that characterize what information each sense register relatively to the distance, as illustrated above.

The sight provide the first sensorial information already by a distance of 300 to 400 meters, where it might be possible to evaluate by the silhouette, whether it is a human, an object, or something else. But until about 100 meter distance, body languages and actions becomes visible, and by 22-25 meter, it would be possible to see facial expressions and mimic. The sound becomes relevant at this stage too, where one-way communication is possible.
In order to have a conversation, smell body odor, or fell difference in temperature, the distance has to be less than 7 meters. *(Gehl 2010, p. 33-35)*
At a distance under 7 meters, the distance of interpersonal relations is reached. The close phase of a puplic distance is from 3,7 m to 7,6 m. The social space is entered at a distance of 3,7 m, where interaction among acquaintances is common.

The personal space is reached by a distance of 1,2 m, where especially the sensual input of odors might be highly present. In the distance of reach, about 0,5 m is the intimate space, that activates the senses of feeling and in some case taste as well.

These sociological observations in connection with the neurological theory of spatial cells provide insight in, how architecture can facilitate a certain human interaction. Architectural geometry, proportions, and texture might not dictate the sensual experience, but might facilitate a basic framework to accommodate a certain sensual experience by manipulating the different sensual stimulations.

#SCENE*THE RESTAURANT*

This scene is grounded by the historical analyses that examine the primary qualities of the Klitgård and point out the potentials of the distinctive characteristic typology. The courtyard is an essential part of the Klitgård and might retain similar status after the transformation to a Landscape Hotel.

In order to enhance this, it might be naturally to place the main social function of the hotel in this center - the restaurant.

The function as a restaurant naturally evokes a multi sensual experience, as smell and taste are highly important in this context.
As these sense are defined as “close” senses, this sense would normally be inside a certain distance of personal space and enhances a situation ideal for two-way communication and detailed conservations.

VISION
This scene illustrates the historical as well as social center of the Landscape Hotel. The courtyard represents this protected and social heart of the building, which offers space for relaxing dining facilities accessible during the whole year.

As the functions are defined to be dining facilities and its location includes the present courtyard, many of the sensual input are already present. Nevertheless, several of these fragments opposes each other, as for instance the changing weather conditions and the outside dining possibilities.

Therefore, it might be relevant to reflect and examine the role of the courtyard in a modern perspective by studies of contemporary architectural cases that rethink and emphasize the purpose of the courtyard.

Eating

ACTIONS

SENSUAL DISPOSITIONS

Sight

- Surroundings

People

- Potential landmarks

...

Hearing

- Sounds

Talk

Haptic

- Ground textures

Cobblestones

- Climate

Natrual/varying

Taste

- Dining

Food

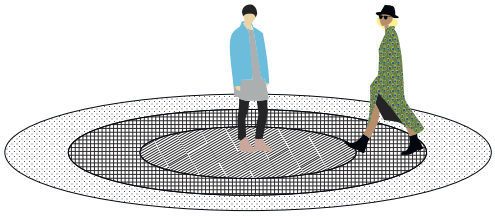
Odor

- Personal

Person/food

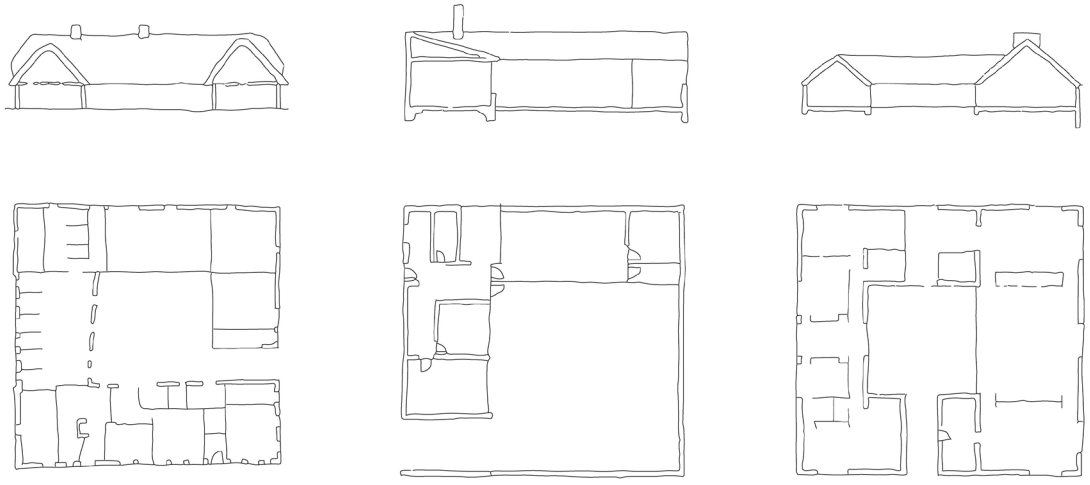
Fig. 3.07: The restaurant - Dispositions

Fig. 3.08: Personal space. Crossing a persons personal space evokes "close" senses as smell and feeling.



Personal

Fig. 3.09: Courtyard - floorplans.



The Klitgård (1900)

Kingo House (1958)

Baron House (2005)

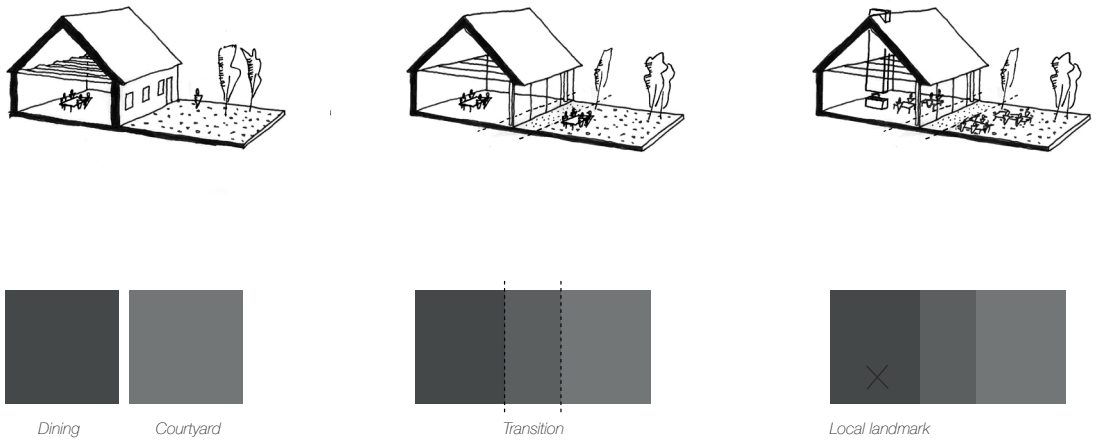
The three plans represent the most important part of this analyze and show first of all the original floorplan layout of the Klitgård in relation to both a renovation project of a older farm, Baron house by John Pawson, and a modern interpretation of the traditional Danish farmhouses, Kingo house by Jørn Utzon.

The common aspect of these three houses is the introvert character, which clearly opens towards the center of the building instead of the surrounding environment.
They all isolate the house from the surrounding in order to establish a sheltered, controlled, and private environment in close connection to the house. This connection is furthermore strengthened in both Baron House and Kingo House by the usage of large window section.
Especially, the boundary between the living room and the courtyard is totally transparent and both spaces float more or less together to one unit. This fusion emphasizes the qualities of both spaces and blurs the transition between outside and inside. The extended courtyard becomes available not only in the summer period, but usable on an annual basis.
The glass partition walls create a clear visual connection between the courtyard and the living room, but also the usage of materials emphasizes this relation. Kingo Houses use tiles in a similar color and size for both the indoor floors and outdoor ground. Just a small difference in the roughness of the surface illustrates more or less only a haptic discrimination.
According to the neurological theory, a radical change in texture might influence the spatial cells and result in a remap, but only a minor textual change might not be registered as a boundary.
Baron House uses some of the same textual principles as the Kingo House, but they are introduced in another way. The courtyard is paved with cobblestones in a large irregular composition, while the indoor floor is a uniform concrete surface. To equalize the difference between the roughness of the stone surfaces, a layer of smaller stone is introduced in the intersection between the two textures.
This layer creates a more fluent transition between the spaces and a clearly connection between outside and inside.

a.

b.

Fig. 3.10: Courtyard - inspiration. a: The courtyard of Baron House opens into the indoor spaces that surrounds it. b: The Barcelona Pavilion operates with the floating space connected by visibility and coherence in materials.



It might be naturally to use some of the same principles at the Landscape Hotel to extend the space of courtyard and to make the social center usable for the whole season.
This is physically done by removing the massive wall between the indoor space and the courtyard and replace it with a transparent surface. This might give space to a smaller transition zone under the overhang that introduce another floor surface and offers a sheltered area outside. To emphasize the connection even more, the function, as a restaurant, has to continue from inside to outside.
Additional, the individual spaces have to share the same internal landmark in order to tie the space to the same reference. The fireplace might with its importance and appearance represents this visual connection.

Fig. 3.11: Connections - courtyard. Simple principles from the neurological theory might establish a clear connection between the indoor dining space and the outdoor courtyard. a: Existing conditions. b: Implementing a glass wall and a transition zone. c: Introducing a strong proximal landmark.

a.

b.

Fig. 3.12: Proximal landmarks - inspiration. a: The use of floor materail at the Kingo Houses clearly indicates a certain connection from inside and outside. b. The fireplace stand as a clear proximal landmark in Frank Lloyd Wrights buildings.

#SCENE*THE BATH*

The second social function to include at the Landscape Hotel is an outdoor bath. As the area of existing Klitgård is occupied by the restaurant and associated service functions, the bath has to be organized in a separate and new environment.
This situation reflects the exiting sensorial information, which is almost unknown. The only known disposition related to the function of the space as a bath might be the haptic perception by being in water. The rest of the disposition has to be defined by the new design and location.

The function as a social bath implies a certain undressed conditions for the users. This state radically influences the interpersonal distance and extends the intimate space significantly, especially among people that do not know each other. Furthermore, by being in the same water as other people might be established a haptic cohesion that influences the personal space between the involved subjects.

These properties might enable an intimate social situation that does not include bodily contact, which in most cases might be uncomfortable for strangers. The normally “close” sense of feeling, can in this case, becomes a “distance” sense that might establish an intimate space among acquaintances as unknown people.

The architecture of the bath has to enhance this and emphasize this sensual perception through its spatial and textual properties. In order to comprehend this, the sensual stimulation by other senses than the haptic sense has to be limited and controlled to a certain degree.

VISION
This scene includes a bath for contemplation and well-being in a social context. The environment in its entirety establishes an intimate space that only represents refined sensual expressions related to its function.

Bathing

ACTIONS

SENSUAL DISPOSITIONS

Sight

- Surroundings

...

- Potential landmarks

...

Hearing

- Sounds

...

Haptic

- Contact materials

Water

- Climate

...

Taste

- Food

...

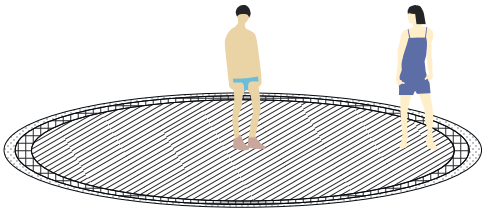
Odor

- Personal

...

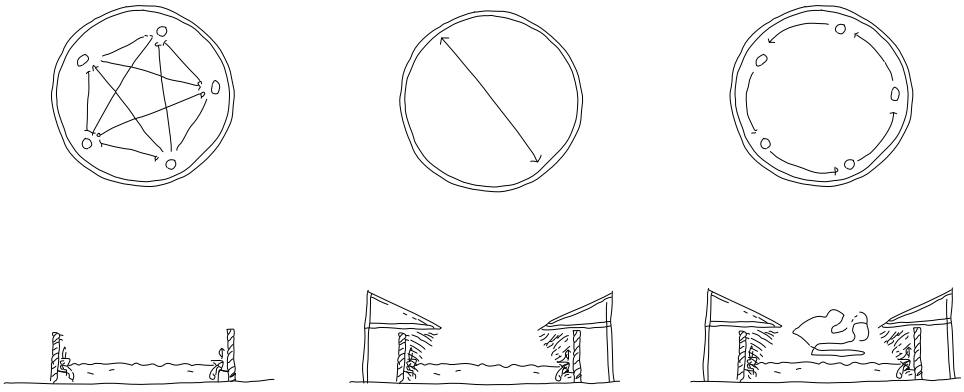
Fig. 3.13: Dispositions - Bath

Fig. 3.14: Intimate space. The interpersonal zone get adjusted when taking of cloth. The intimate zone becomes much bigger in an undressed situation.



Intimate

Fig. 3.15: Bath - properties. The circular form establish different spatial properties. a: The users placement at the perimeter of the circle offers equal views. b: A diameter over 7 m prevent conversation across the bath. c: The circular form bounce the sound around to prevent conversation with the person beside.



a. *b.* *c.*

Especially the geometric and the proportions of the space might influence this. A circle form might be optimal in this case. First of all, baths in general are often associated with the round form, because of both practical and ergonomically aspects. Furthermore, the circular form offers equal conditions for the users, when located at the periphery of the circle, according to sight and distance to boundaries. The diameter of the circle has to be above 7 meters according to Gehls standards in order to prevent longer and detailed conversations. A conversation with a neighbor might still be possible, but the geometry and choice of material might prevert this as well.

The circular form allows the soundwaves to travel along the wall. If the wall is made of a very reflective material as concrete, the soundwaves, depending on the intensity of the sound, travel all the way around the bath. Everybody might hear the conversation and the transmitter might perceive his own voice as an echo.

The introvert form excludes the surrounding nature horizontally and opens to the sky by framing it. Furthermore, the reflection of the water emphasizes the character of the sky.
In order to protect the users from rain a smaller overhang is needed. An overhang might furthermore create a smaller shadow by the users that decrease the exposure of the individual user. The outdoor condition might even more naturally establish a steam, as a result of the warm water in contact with the cold weather. This might decrease the visibility within the bath.

a.

b.

Fig. 3.16: Bath - inspiration. a: The circular form creates a introvert form that give focus to the sky above. b: The overhang provide shadow and shelter for the people.

#SCENE*THE AUDITORIUM*

As the restaurant and the bath promote social engagement on a personal level, the auditorium represent sa certain distance and orientation that prioritize the senses of vision and hearing.

Especially, these two senses have been normative to the architectural expression throughout history, particular in connection to the auditorium or the theater. The setting of an auditorium or a theater generally involves a speaker that can be heard and seen by an audience. This configuration has naturally influenced the geometry of the space. The round form of the amphitheater is a classic example that focuses the attention of the audience to a single point - the center location of the speaker.

VISION
This scene illustrates the auditorium optimized for staged social arrangement and one-way communication. The space has to enhance a professional and public distance between the audience and the speaker and emphasizes visual and audio expressions.

The world largest amphitheater, Colloseum, is arranged as an ellipse form and offers the audience to be seated all around the center stage. The original activities at this stage were gladiatorial contests, animal hunts, or dramas. Very expressive and energetic kinds of entertainment that allowed the audience to watch and hear the ongoing activities independently of their position at the stadium.
But if the staged activities are more steady or verbal, the shape of the amphitheater has at a minimum to be restricted to a half circle, in order to maintain good conditions for both sound and vision. Especially if the audience has to register facial expression or hear detailed conversations or articulated singing.

The Pnyx in Athens represents an ancient example of this composition, where the audience is placed in a half circle and focus their attention to a center-placed speaker. This composition also emphasizes a certain political arrangement as well according to Richard Sennet, who examined different space of democracy. He described the amphitheater as a detection mechanism that due to its acoustic and visual conditions hold the speaker responsible for expressions on the stage. *(Sennett 1998, p. 17)*

"…its focus and duration meant to get beneath the surface of momentary impressions."
(Sennett 1998, p. 17)

The position and the maximum exposure of the speaker establish a situation like being trapped in a corner. Furthermore, the position of the speaker at the Pnyx, establishes a composition where the speaker was only object on a background of the landscape. *(Sennett 1998, p. 17)*
Another important aspect that especially influences

Speaking

ACTIONS

SENSUAL DISPOSITIONS

Sight

- Surroundings

Audience

- Potential landmarks

...

Hearing

- Sounds

Speaking

Haptic

- Contact materials

...

- Climate

...

Taste

- Food

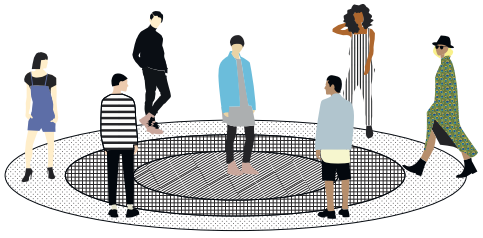
...

Odor

- Personal

...

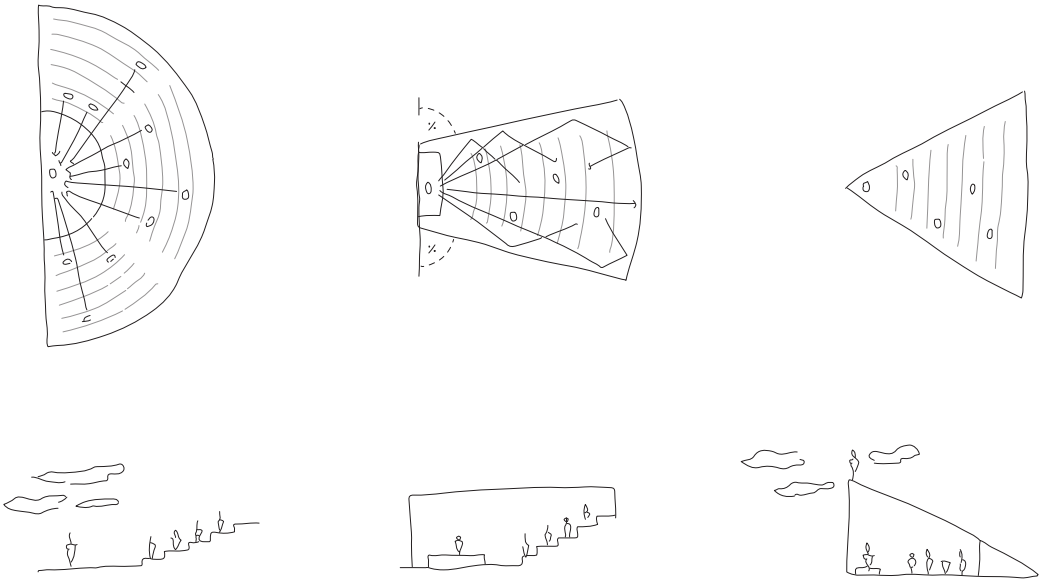
Fig. 3.18: Social space. The social and public distance to a person evokes more or less only the senses of sound and vision.



Social

Fig. 3.17: Dispositions - Auditorium

Fig. 3.19: Auditorium - space. The auditorium has to provide optimal conditions for speech and sight. a: The circular form provide a clear direction towards the center. b: To optimize the sight and the acoustic the traditional concert hall use angled walls. c: The triangle includes qualities from both scenarios and permits a viewpoint at the roof.



a. b. c.

the appearance of the theater and music center of today is the acoustics. According to advanced computer simulation and recording system, it is possible to design the space very precisely in order to establish a specific acoustic situation. Especially, the reverberation time has to be short in order to prevent echo and offer good condition for a clear and understandable speech. The size and geometry of the space are essential properties in order to secure an acceptable reverberation time. Especially, parallel walls can result in echoes. By angling the walls, the waves might be spread more equally around in the space.

The triangular form establishes a clear direction and focus the attention of the audience towards one single point similar to the Pnyx. It furthermore offers the audience an optimal view in order to observe facial and audial expressions from the speaker. The angles of the wall and the roof prevent the soundwaves to bounce forth and back at the same point, and it might furthermore establish the possibility to activate the roof as a outdoor auditorium and a viewpoint.

a.

b.

Fig. 3.20: Auditorium - inspiration. a: The triangular form directs the attention towards the speaker. b: The viewpoint up in the sky.

#SCENE*THE HALL*

This scene is focused to the hallway linking the socials areas with the private rooms. The sensual dispositions intruded by this walk in unknown, and have to be constructed as a result of the architecture. Nevertheless, an important aspect of this scene is the locomotion. As illustrated in the theory, when the sensorial inputs are monotone and uniform, and no significant landmarks are present, the egocentric information provided by movements might be essential in order navigate and understand the architectural composition.
Functions as hotels, hospitals or apartments blocks, which include a large number of similar spaces, usually deal with this situation. The rooms are often arranged parallel in two rows with a hallway in-between, due to the need of a connection to the façade in order to provide both natural lightning and a view.
This arrangement often results in a labyrinth of identical, long, and dark hallways. These conditions impair the ability to navigate, which can be seen on the typical number of signs.

In order to avoid this situation, the architecture has to provide a strong legibility to maintain good navigation in a monotone environment. Especially, the level of light, the proportions of the space, and the series of elements might be important in order to strengthen the egocentric information provided by the motions of the person.

VISION
This scene illustrates the transition between the social areas and their respective private rooms at the Landscape Hotel. The hallway establishes this connection by only providing minimal cues of distance in order to let the visitors navigate based on their own egocentric information.

Fig. 3.21: Dispostions - hall

Walking along hallway

Walking along hallway

Walking along hallway

Walking along hallway

ACTIONS

SENSUAL DISPOSITIONS

Sight

...

Hearing

...

Haptic

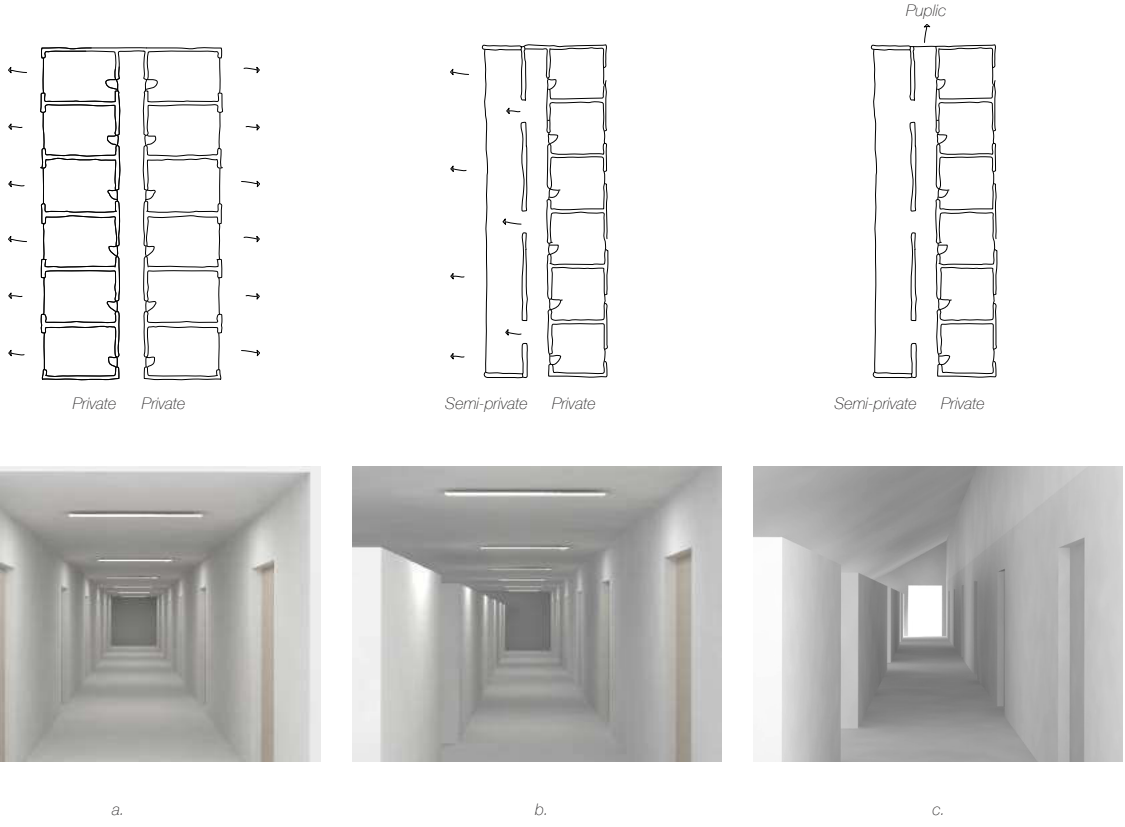
...

Smell

...

Taste

Fig. 3.22: Hall - public/private. The hallway is optimize in relation to both the social aspect and the locomotional signal. a: An ordinary hallway of hotel rooms. b: The social spaces at the rooms are integrated into the hallway. c: a continous view is establish with a window in the end of the hall.



As the Klitgård engage to social meeting and reflection among people, the private rooms have to provide enough room for private sessions and to engage socializing outside the private room. The space at the rooms is optimized to only include the essentials and semiprivate areas are located outside the room.

This opens the hallway to include a semi-private zone that provides more light and space. This can be emphasized by a higher ceiling and by introducing a window at the end of the hall. This offers a sense of direction and establishes a connection between the hallway and the surrounding nature without offering any essentials cues of local distance. Furthermore, the window establishes a view to the silo and might provide a global coherence to the rest of the area.

Fig. 3.23: Hall - inspiration. The hallway engage to motion and navigation is mainly based on egocentric information provided by locomotion.

#SCENE*THE PATH*

The natural landscape is not chosen, it is discovered, thus defined Norberg a natural place. The path towards the heathland has to emphasize this experience, and especially the different types of stimulation found along the path might establish this spatial feeling.

As previous describe in both text and pictures, Holmsland Klit has a very divers natural order with many different layers of nature and culture. Each layer represents a piece of history and furthermore different spatial expressions - a series of sensual stimulations and dispositions. In the perspective of Lynch's urban principles, the transition between the respective layers might be so defined that each piece of nature might be registered as individual districts. Not separated by roads or channels, but by the radical shift in texture, light, and height, mainly defined by the local climate conditions.

The path leads through different kinds of present and former agriculture; from controlled nature with seeded trees lined in rows and sown rectangular fields to more wild nature with sporadic trees and brushes.

Each district brings a different character. The woods are enclosed and dark, while the heartland is open and extensive. These significant shifts might represent a local landmark that provides essential information about the current location on the route. And the transition from cultivated nature, the arable, to the wild heartland might illustrate this journey from chosen land to discovered nature.

VISION

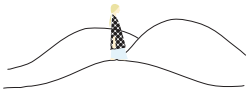
This scene establishes a series of different expressions. Each revealed at a reaction of movement along a path leading from the cultivated land to the wild nature.

Fig. 3.24: Dispostions - path

Walking along the path

Walking along the path

Walking along the path



Walking along the path

ACTIONS

SENSUAL DISPOSITIONS

Sight

- Surroundings

Arable

Meadow

Forest

Heathland

- Light

Partly shadowed

Open

Shadowed

Total open

Hearing

- Sounds

Birds

Gravel

Leaves

Ocean

Haptic

- Ground textures

Stone

Stone/grass

Grass/sand

Sand

- Climate

Partly sheltered

Windy

Partly sheltered

Windy

Smell

- Nature

Leaves

Grain

Pine

Heath

The Landscape Hotel is as a result of the initial analysis separated into a communal center integrated with the Klitgård and the huts located within the heathland.

The previous chapter presents how the social engagements at the Landscape Hotel are concentrated at the Klitgård, and how these activities offer different levels of interpersonal relations by their spatial composition and architectural treatment.

The following chapter is focused to the second part of the Landscape Hotel, - the huts.
These hut treat significantly other purposes both accordingly to location, function, and scale than the Klitgård as a result of its porous location within the heathland. Each of these aspect is treated in details in the following design process.
The included design studies are primary concerning the neurological theory, but other general studies dealing functional, technical, and aesthetical consideration are included as well in order to make the process as realistic as possible.

(iii) THE HUT

PROGRAM

The location of the hut within the extensive heathland of Holmslands Klit requires thorough analysis in order to both enlighten how this unique space within the nature has to appear for the visitors of the Landscape Hotel, but equally how to maintain the natural qualities of this magnificient landscape for the general turist in the area. These two observers and their individual interest have to be the starting point of the following design process.

Especially, the spatial properties of the existing context is important in this perspective, as the natural understanding of both observers might be a result of these. As a conclusion of the initials analysis of the area, the following four parameters are defined. These four parameters establish the primary spatial cues of this particular area, and has to be perserved and respected in a further development of the area.

(i) BOUNDARIES

The dunes represent the boundary of the area. These boundaries might stand as a essential cue, especially in close contact.

(ii) GEOMETRY

The irregularity of the area might emphasize the legibility of the space and makes it difficult to determinate distance.

(iii) GLOBAL LANDMARK

The only present man-made object, the silo, stands as a prominent landmark of the area and provides a clear reference point in order to orientate.

(iv) PROXIMAL LANDMARK

The continuity of the material, the heath, represents a proximal landmark that links the area into one large representation.

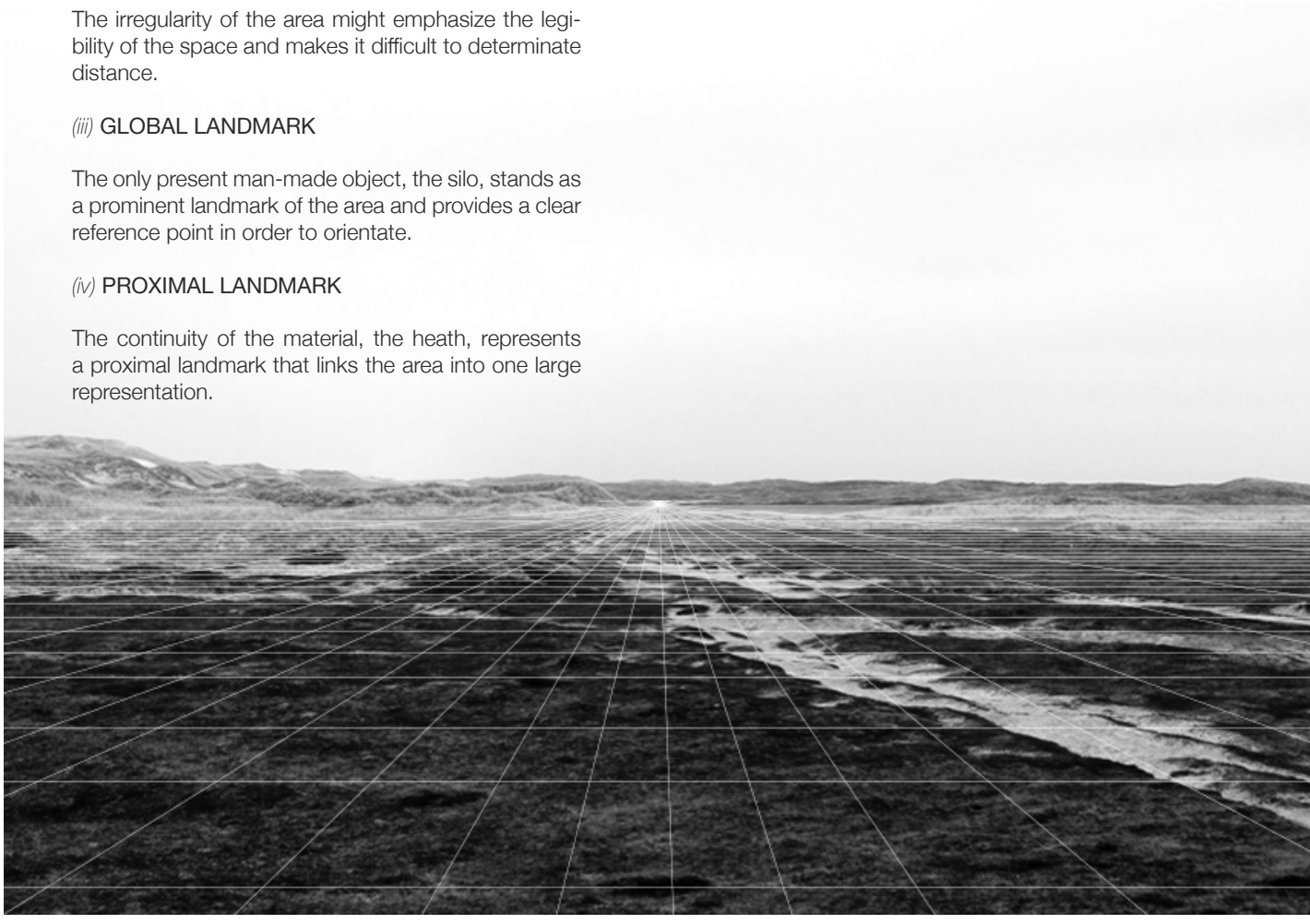
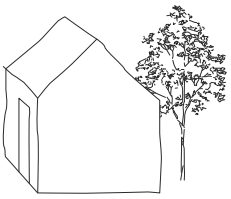


Fig. 4.01 - Heathland - Spatial elements

Visitor of the Landscape Hotel



Turist in the area

OBSERVERS

SENSUAL DISPOSITIONS

See
Hear
Feel
Smell
Taste

...

Existing conditions

Fig. 4.02 - Dispostions - huts

PLACEMENT AND PROPORTIONS

Both the number, the size, and the location of the huts in relation to the natural environment of Holmsland Klit are essential properties to consider in order to both respect the existing qualities of the natural area and to offer the ideal conditions for the visitors of the Landscape Hotel. A man-made intervention within this pristine area will undoubtedly affect the experience of the environmental setting. It is therefore highly important to investigate and identify how this new relationship do not become a conflict but rather complements the presence of each other and the collective experience.

The comprehensive scale of the site is therefore investigated and explored by digital maps, but is furthermore identified by the use of physical model in the scale of 1:2000. The three dimensional character of the physical model offers a legible spatial understanding of the topography and scale. Several studies of volume are conducted by the use of this model.

First of all, the 81 hectar of land is compared with general-known and national-known urban spaces in order establish a general understanding of site proportions.
Illustrated on the top pictures, to the left the Parc de la Villette, the three-largest park of Paris, and to the right Fælledparken in Copenhagen, the biggest park of Copenhagen, only represents in size 2/3 of the total area of the site.

The expected number, arrangement, and scale of the huts are not clarified in the vision by Norrøn, and only a few conceptual volume studies are included in their report. It is especially important to investigate the interaction between the massive landscape and the smaller huts.
This relationship is tested by introducing buildings, the black pieces, in different proportions and locations ranging from 7000 m2 in one spot to 3000 m2 divided and spread out in smaller units.

Both the large and clustered settlements might influence the natural order and directions of the landscape, and establish either a dominant center or a barrier.
In contrast, the smaller concentration of units and the scattered locations respect the exiting topography and establish a more natural hierarchy between the dominating landscape and the smaller huts.

Fig. 4.03: Studies of placement and proportions. a: The site in relation to i: Parc de la Villette in Paris, and ii: Fælled parken, Copenhagen. b: i: 7000 m2 concentrated in one spot. ii: 3500 m2 concentrated in one spot. c: 4000 m2 organized in a clustered arrangement. d: 4000 m2 spread out in the area.

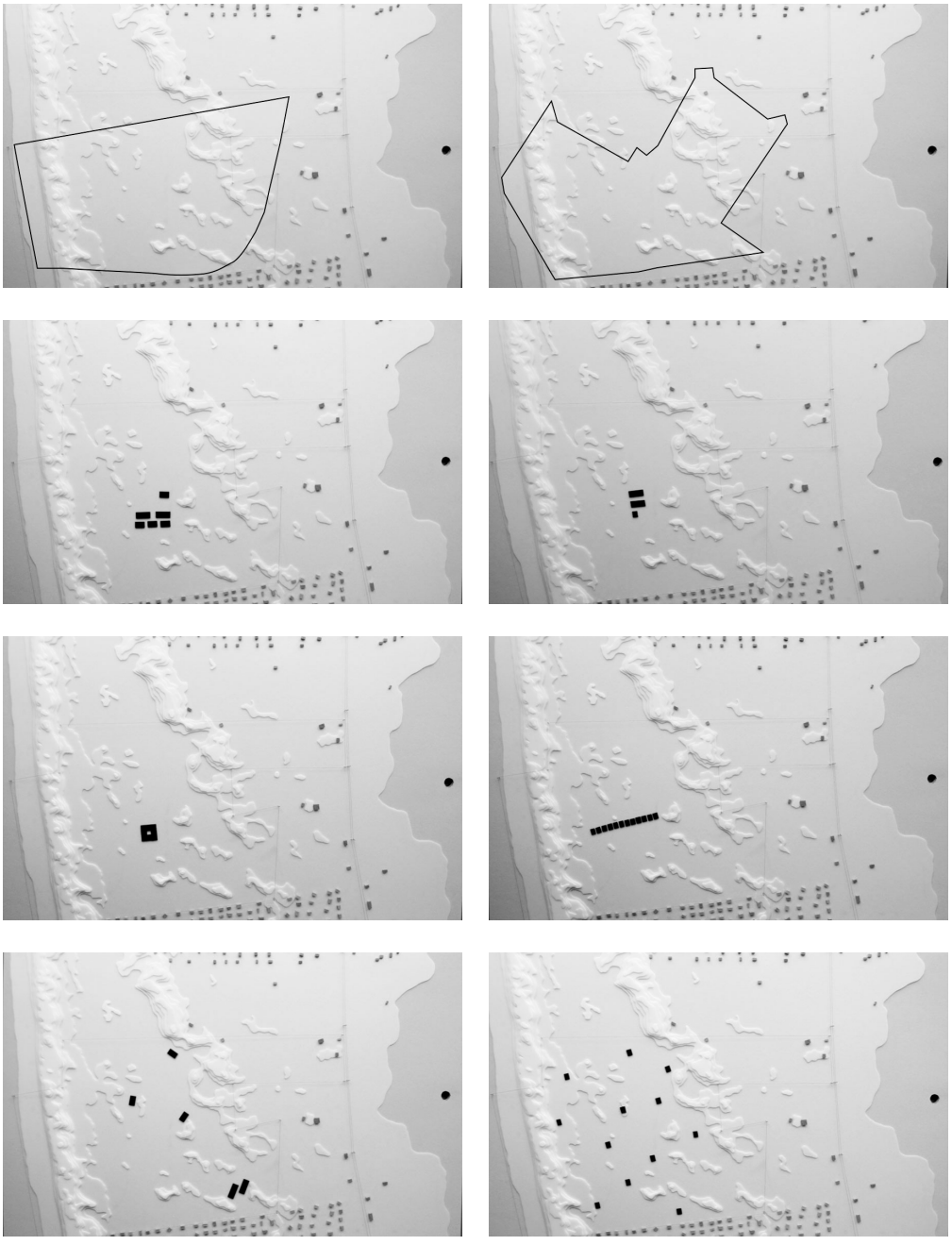

a.
b.
c.
d.
i.
ii.

Fig. 4.04: Visualizations of placement and proportions. a: Clustered versus spread arrangement. b: Part of nature versus a landmark

a.

b.

i.

ii.

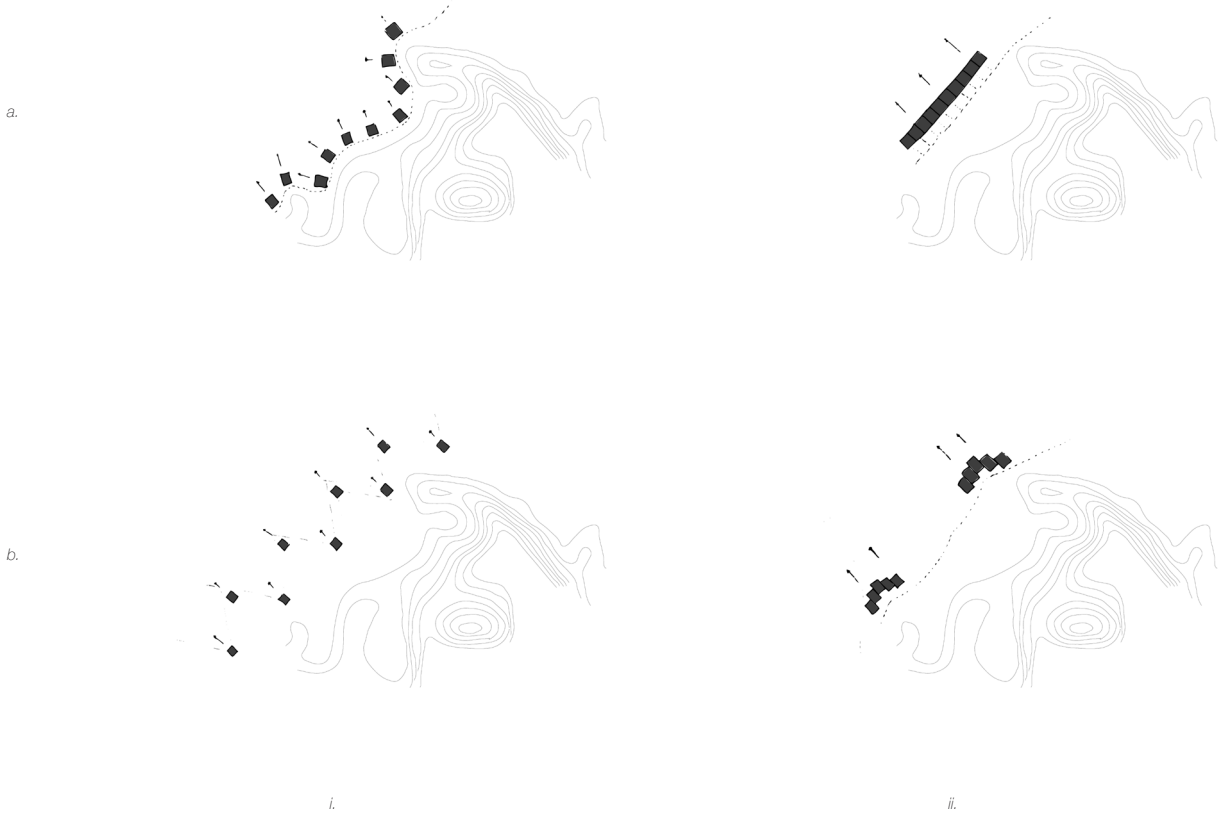
To relate these initial volume-landscape studies to the perspective of the human being, the hut are here visualizes in photos of the existing landscape. This offers a visual understanding of the huts spatial influence and appearance within the extensive landscape.

Especially two spatial aspects are present in this perspective. Firstly, the before mentioned influence by clustered arrangements are highly present, and establish focus points within the landscape that interferes with the existing neutral hierarchy of the local environment. The natural hierarchy might be respected with a more equally scattered organization with smaller units as seen in ill. a,ii. A high density of cabins influence the spatial enclosure, and especially a high density and small distance between the cabins might be registered as a boundary, which not only establishes a division between the public and private areas, but also interferes with the natural order of the environment.

Another spatial aspect that might influence especially the status of the cabin might be the relationship between the cabin, the surrounding landscape, and the human line of sight. If the silhouette of the cabin interferes with the topline of the surrounding dunes, it becomes highly visible and might be encoded as a landmark. Opposite, if the silhouette of the cabin is placed under the topline of the dunes relatively to the line of sight, it integrates with the topography and might be encoded as a part of the landscape.

This spatial registration can be used as an active tool to determinate the location or rather the problematic location for the cabins relatively to their appearance in order to maintain the natural direction and spatial understating of the environment.

Fig. 4.05: Sketch of different compositions. The plans investigate the relation to the local nature and the relationship between the individual huts.



In other to investigate how the respective huts engage with each other and the near surroundings, different compositions are tested by conceptual sketch in a specified area of the site.

To ensure and emphasize a feeling of being more or less alone in the nature, it is important to establish not only a comprehensive view to the rural environment, but also to avoid a disturbing view of the other cabins.

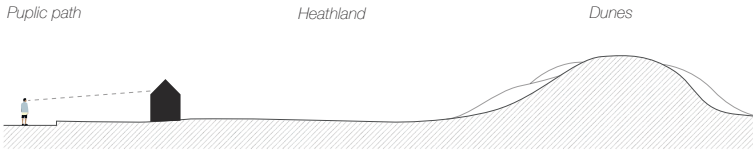
This can be accomplished by organizing the cabins in a linear row or a shifting linear grid. Such an organization offers more or less an identical and one-directional view for each cabin. Furthermore, in the perspective of the theory, the discrimination between the cabins might be decreased, because each cabin offers the same spatial information concerning orientation.

By organizing the cabins in relation to the landscape or relatively to the respective view, each cabin might be explored and perceived as individual huts to a larger degree. Furthermore, this organization respects and emphasizes the existing lines of the landscape contours and establishes an obviously relationship and hierarchy between the existing natural character and the new settlements.

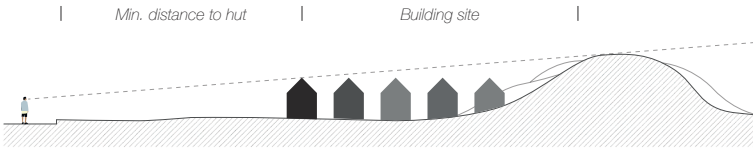
In relation to the arrangement of the huts in connection to each other, the clustered formation where the cabins are more or less physical connected to each other, establish smaller communities. This composition might decrease the feeling of being isolated in the nature.

Fig. 4.06: The status of the hut. The apperance of the hut is primary defined by both height and distance relatively to the surrounding landscape

a.



b.



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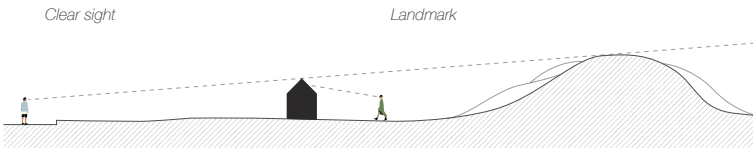

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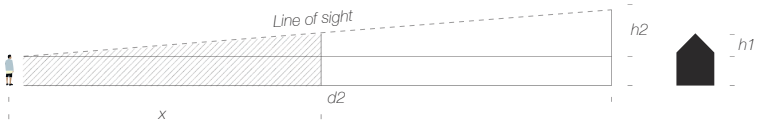
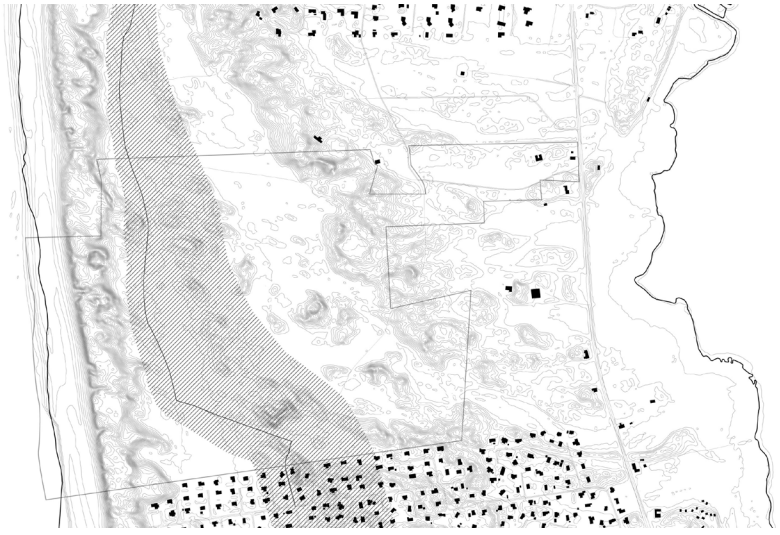


x:	*Min. distance to hut*	*h1:*	*Hut height - human height*	h1/(h2·d1) = x
d2:	*Distance to dunes*	*h2:*	*Dunes height - human height*	

Fig. 4.07: Non-building zone. The huts might stand as a landmarks in the landscape, if they are placed in the hatched area.



By defining when the cabin appears as a landmark or not, it might be possible to manipulate the experience of the cabin based on the location of both the observer and the cabin.

To maintain the experience of extensive and flat landscape defined by the heathland and the surrounding dunes, it might be important not to give a sense of direction and distance by introducing local landmarks. The public is mainly exploring the area from the public path situated on the eastern side of the dunes by the Westcoast, in shelter of the western wind and with a view of the heathland. If the height of the cabins are defined and the sight and distance to the dunes are known, it is possible to define a minimum distance to the cabin in order to maintain an undisturbed line of sight to the transition between the top of the dunes and the sky.
The cabins placed at this defined building site might therefore the public be registered as a part of the landscape, and not provide prominent information about direction and distance. On the other hand, if a guest of the Landscape Hotel get closer to the cabin or arrive from the other side, the cabin might stand as a potential landmark and reference point.

By organizing the cabins by these considerations, the cabin might be a spatial irrelevant element for the public and oppositely an essential reference point for the guest of the Landscape Hotel.

FORM

The sensitive placement in the extensive landscape demands thorough considerations of especially the interaction between the individual cabin and the porous local nature. For this purpose, several other structures that are positioned in similar natural environment are analyzed. The following three cases are highly relevant in this perspective due to both their affiliation with Holmsland Klit and their respective contact with the ground and surroundings. Furthermore, each case includes some design principles that might be relevant to integrate.

THE BUNKER

A well-known typology of the Westcoast is the historical and bombastic structures of Worldwar ll – the bunkers. These massive concrete structures are not just positioned in the landscape, they are literally a part of the landscape. They are mainly digged underground, due to their function as military fortification. These settings made the bunker almost invisible from the outside and a minimal invasion of the landscape, but it also resulted in very small, dark, and uncomfortable indoor spaces with minimal openings. The openings and form of the bunker were highly designed to offer an optimal view in a few particular directions.

FISHERMAN'S HUT

Another common typology at the nearby old harbor areas is the fisherman's hut located by either the fjord or the sea. The building form of the typical hut is mainly adapted to the harsh climate by the water, and thereby has many of the same characteristics as the Klitgård. This includes for instances the low volume and the pitched roof in order to minimize the critical windload. The hut is furthermore placed on the ground, and becomes a staple and static part of the landscape.

HUNTING TOWER

The large natural areas of Ringkøbing-Skjern municipality permit several hurting areas. A common typology for the hunter is the hunting tower. A smaller platform raised from the ground offering a overview of the surroundings. This typology only interferes the ground by a few posts that support the slender structure and the elevated platform. The natural conditions continues underneath the tower, and are not interrupted by its presence.

Fig. 4.08: Buildings of the area. Inspiration can be found in the existing buildings placed in the area. a: The Bunker. b: The Fisherman's Hut. c. The Hunting Tower

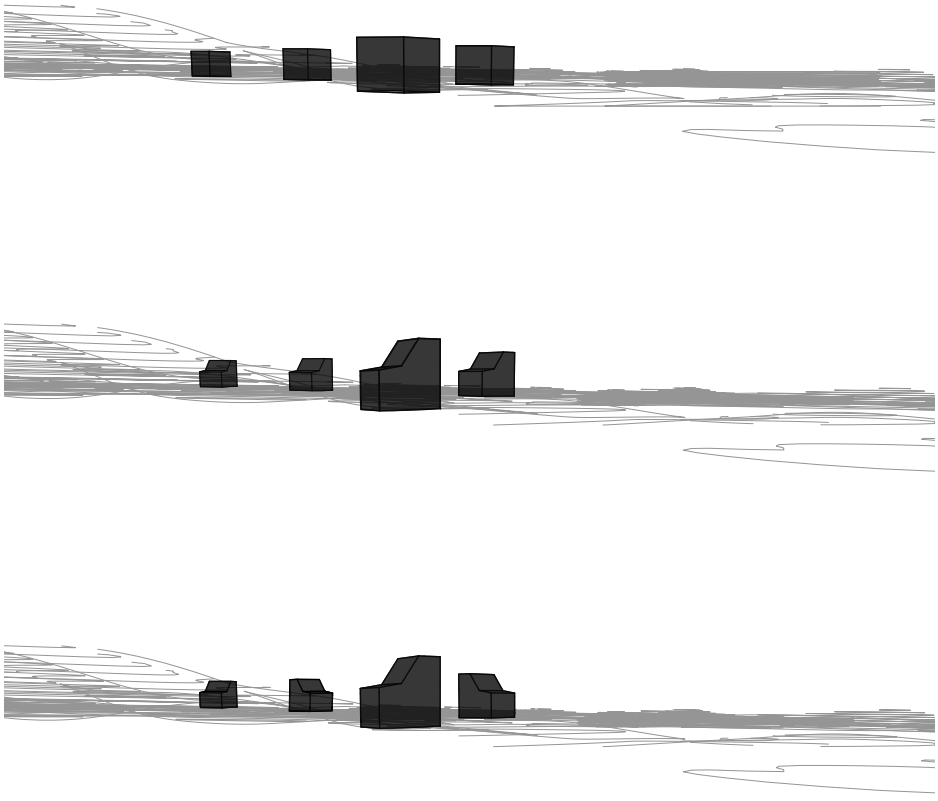
a.

b.

c.

Fig. 4.09: The appearance - huts. The asymmetric form emphasize a certain individualism.

Fig. 4.10: The appereance - form. The experiment investigate the appereance of different form in different angles.



The orientation might be an important aspect in order to individualize the cabin, both in the perspective of the theory, but also because of the customized appearance each cabin might establish due to its orientation.

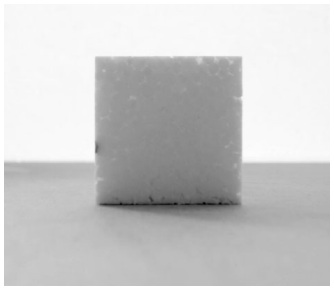
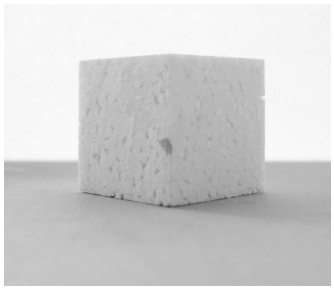
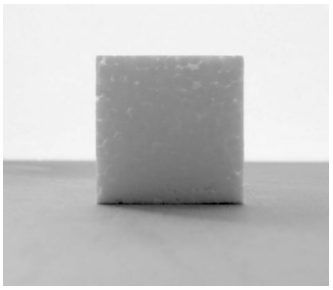
In order to investigate this aspect, a volume study is conducted that includes different volumes from simple geometries to more prismatic figures visualized from three different angles.

Especially, the silhouette of the given form is very important in this aspect. The simple cube and the prismatic form offer the more or less same expression, despite their difference in form and persepctive, see a. and f..
The volumes with a pitched roof are similar in expression as the square, when seen from one perspective, but reveals the archetypal form from other perspectives, see b. and e..

The asymmetric volumes establish a varying expression relatively to the orientation of the cabin. The asymmetric volume goes from a very dynamic form to a more static, and change totally character from each view, see c. and d.

This changing character is important in relation to other cabins and might make it easier to recognize the respective cabins from each other. To illustrate this, some of the volumes are visualized positioned in the landscape above. The scale of the cabin helps to discriminate the cabins, but locomotion in-between the cabins might eliminate or increase this spatial information, which is the only information at the first figure.
Nevertheless, the significant asymmetric silhouette offers individual appearance besides only the scale. Despite the equally form, the orientation gives each cabin an unique character.

a.

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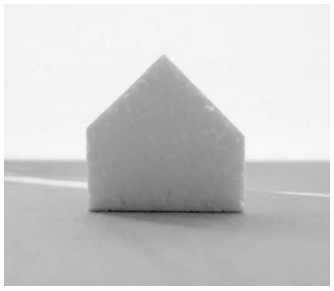
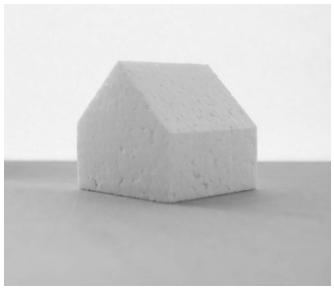
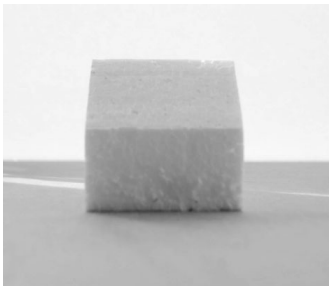
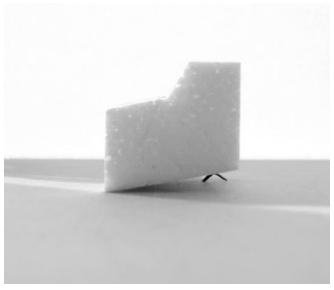
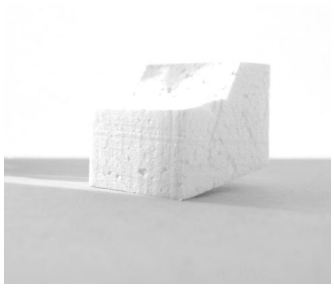
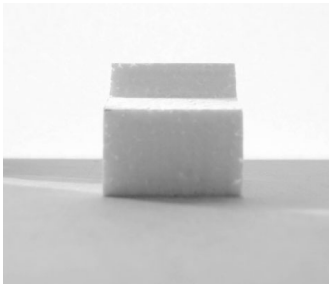




c.

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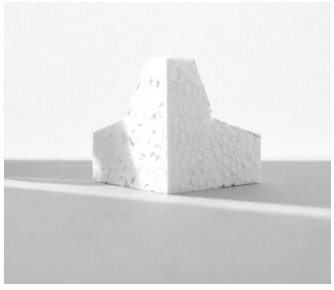
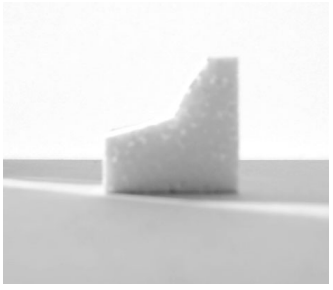
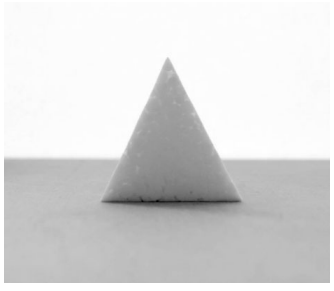
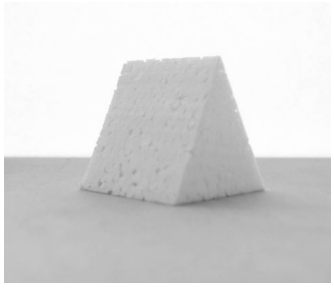
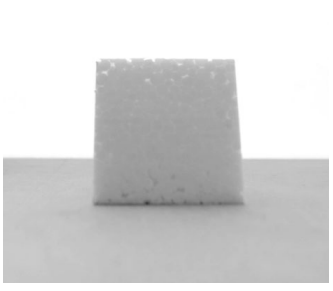



e.

f.

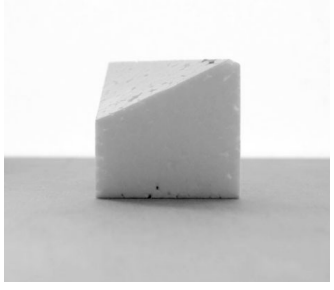
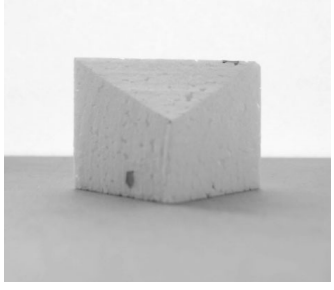
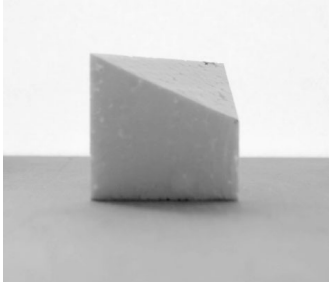
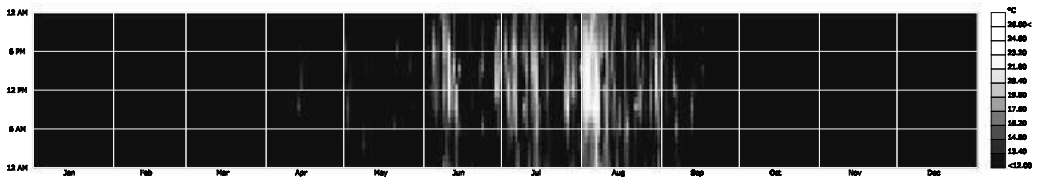
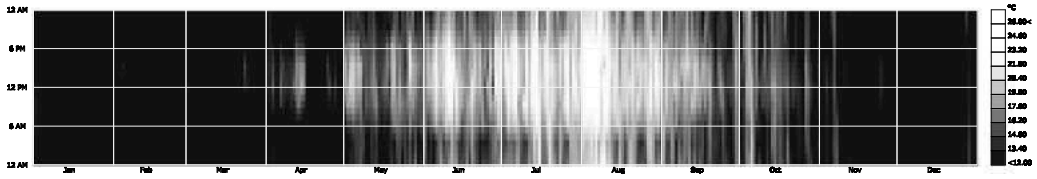




Fig. 4.11: Temperature diagram. The white spots mark when the temperature is comfortable for longer stays outside. a: Without shelter. b: Sheltered.

a.



b.



TEMPERATURE AND TIME

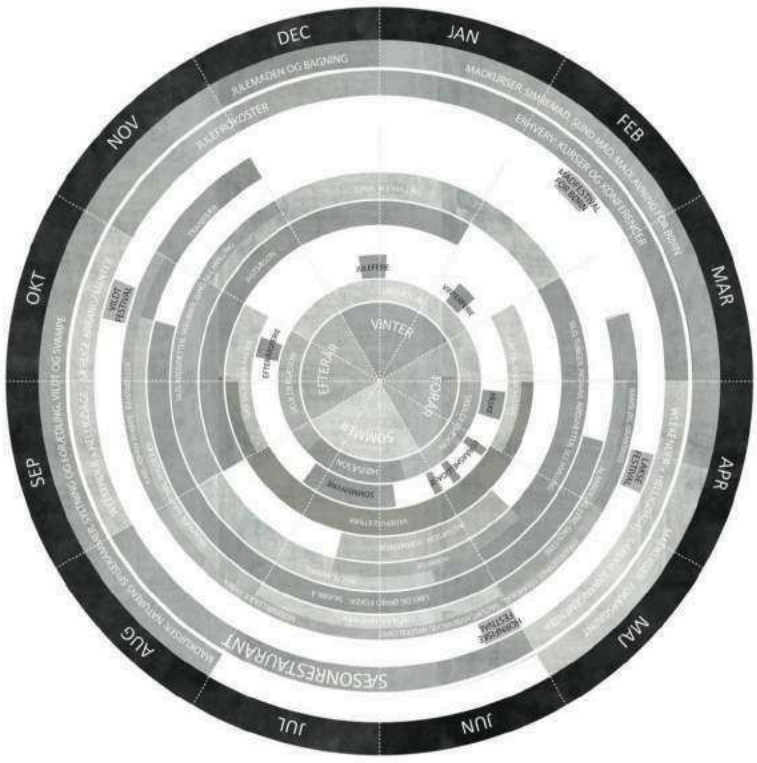
As illustrated in both the inspections of both the Klitgård and the cases, the influence of the climate is an important aspect in terms of location and appearance of the building, when minimizing the climatically impacts, but also when exploiting the opportunities of it. The primary natural force at Holmsland Klit is the wind. The dominating wind from west is highly present especially in the wintertime, and only the dunes reduce its power by the ground.
Especially the windload has to be considered, in order to minimize the impact on the individual building parts.

As a result of the Danish weather, longer stays outside are only pleasant occasional. The windy condition at the site almost only permits walks and temporary stays. Only in about 15 % of the year, the weather conditions is considered comfortable (when universal thermal climate index is between 9-26 celcius degrees) for outdoor stay. If the wind power were subtracted from this calculation about 50 % of the year would be characterized as comfortable for outdoor stays, because the cooling effect by the wind increase exponentially by increased windpower. In other words, if the building can provide shelter for the wind, it will prolong the outdoor season significant and give the opportunity for outdoor stays from April to October.

To prolong the outdoor season further more could be to accumulate the heat from the sun during the day. This might be possible by the usage of hard materials as bricks or concrete that by their individual high heat capacity are able to store energy from especially the sun. This can be utilized by posistioning a bench or similar by a wall oriented towards south and might prolonging the outdoor possibilities furthermore, and especially to include parts of the evening.

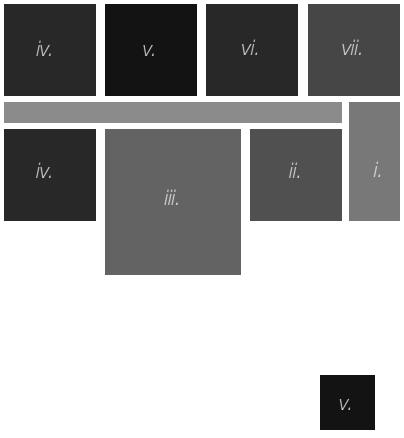
Another aspect in order to prolong the season to especially include the winter period is the different local activities. Norrøn has suggested different scenarios that might activate the area for almost the whole season in the timewheel on the following page. These activities are intended to serve the Landscape Hotel in general, and are mainly addressed to the public segments of the hotel. The hut has to symbolize and establish a space independently of social arrange-

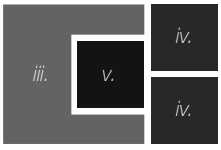
Fig. 4.12: Timewheel of activities. The activities at the Landscape Hotel proposed by Norrøn.



ments and staged stimulations. The location is the nature should stand as the primary source to activity, or rather inactivity, and offer the optimal space for reflection and recreation.

i. Entrance
ii. Utility room
iii. Kitchen
iv. Bedroom
v. Toilet
vi. Sauna
vii. Activity Room





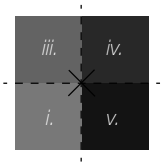


Fig. 4.13: Programs - hut. a: the traditional holiday home is characterize by a complex and divers roomprogram. b: The Venligboliger only includes a few functions. c: The combination and organization of the program are important in order to reach a compact and legible volume.

FUNCTION

The hut has to only provide the essential elements. Not understood in the sense of being primitive and only offering the essentials in order to survive, but to function as a meaningful space in a modern society of today.

The ordinary holiday home at the area includes typically a complex roomprogram with several different practical functions, as kitchen, bedrooms, bathroom, etc. and additional spaces for indoor entertainment as billiard room, sauna, swimming pool, etc. Functions which only benefit entertainment, and are totally independent of the spectacular location in the nature. Furthermore, the number of functions encourages to indoor activities and result in enormous house that are more expensive to heat, filled with daily chores for both guests and owner, and becomes more or less just a replication of the everyday life, people are trying to escape from.

The hut has to secure a standard of luxury and convenience by only intruding the essentials, and through simplicity and efficiency offer space for intimacy and reflection and emphasize the qualities of being isolated in the nature.
For instance, to provide luxury do not necessarily means spa, swimming pool, or widescreen TV, but can be received by alternative interventions. As mentioned in the beginning of the report, Svinkløv Badehotel, is an classic example of this. Stays at the hotel were considered to be pure luxury and benefits well-being, despite the hotel had small and poor isolated rooms, outdated technical equipment, and shared bathroom in the hallway.

"…to connect the architecture to feelings and fascination, to reinforce the relationship between the outside and inside and enhance the experience of light and colors, weather, wind and temperature differences. This sensuality isn't strengthened by how many square meters of floor space you have – it's more the opposite" (Berg 2017)

In the perspective of this, this number of function and the organization of them according to the surrounding seem important in order to reach a meaningful space.

Fig. 4.14: Plan - the hut. These plans investigate which functions that should be included and the organization of them

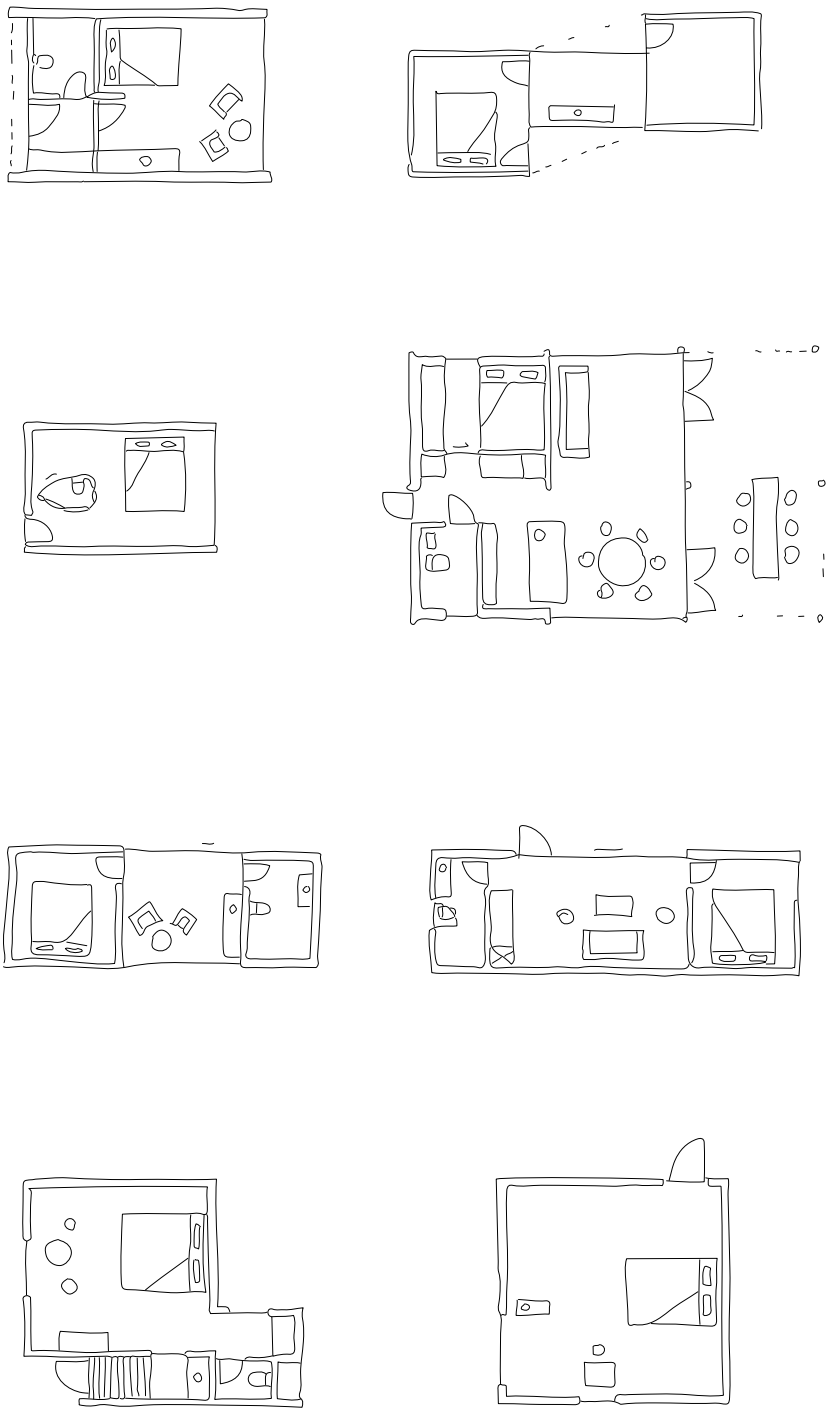


Fig. 4.15: Spaces defined by levels. The different levels seperate the hut into individual spaces. Connected by stair that might act as furnitures as well. Final Wooden House (2006) by Fujimoto

For instance, this aspect of minimal space that only include the essentials has been discussed heavily the last years as a reaction to urbanization, but also recently as a reaction to the refugee crisis. An result of this discussion is the minimal dwelling called Venligboliger. These houses, inspired by the tiny house movement, only included the absolute necessary functions for a smaller family to live temporally in the modern society of Denmark. This home includes a kitchen, a living room, a bathroom, and one or a few bedrooms corresponding to the members of the family.

Especially, the compactness of this type of house minimizes the space of waste and creates a coherent and legible space. This creates synergies between individual functions, and individual rooms as kitchen and living room merge together and bedrooms become useable in daytime. By that, the individual functions use the qualities of each other to a certain degrees.

Especially, the boundaries between the spaces are important in this situation, and the findings concerning boundary cells might let us understand how compactness can be reach with alternative boundaries. Because according to the theory, a boundary might not only be represented by a wall, but a ridge or a drop might be encoded as a boundary as well.
The individual functions of the hut can be organized as one representation, but separated by the use of different levels. This scenario is tested and illustrated in the section of the hut on the following page.

This establishes a vertical direction of the house, and creates a up/down orientation. The vertical configuration connected by stairs establishes an alternative separation between the functions, than normally registered by entering a door. Kent C. Bloomer and Charles W. Moore describe the properties of an up/down composition in their book Body, Memory, and Architecture to ***"embody aspirations and hesitations silently" And describe the situation as "a child sitting halfway up the staircase tacitly announcing that he is either going to make a run for it or return to the formalities of a family gathering".*** *(C. Bloomer & W. Moore 1977, p 48)*

Fig. 4.16: Section - hut. Experiments with different levels.

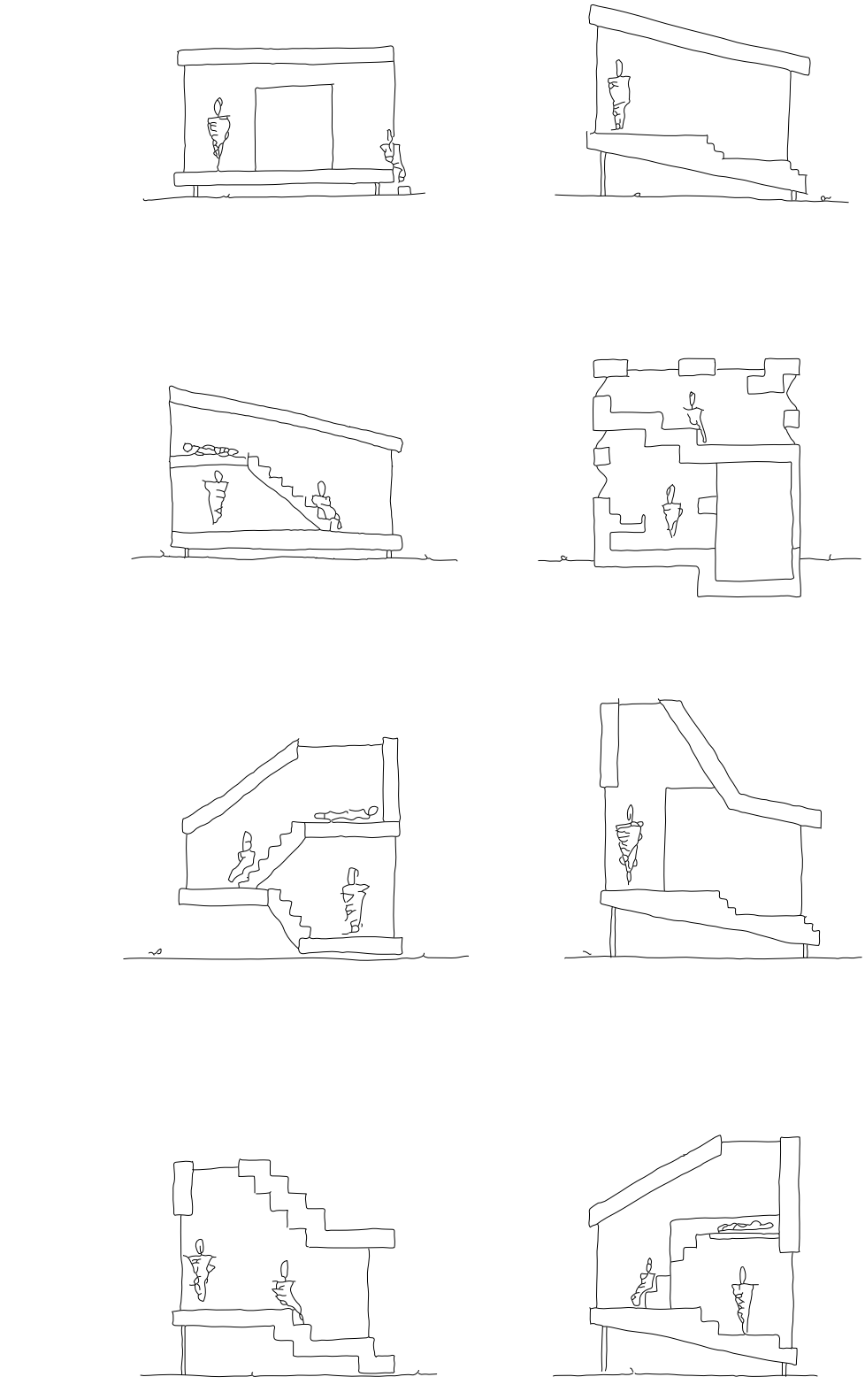
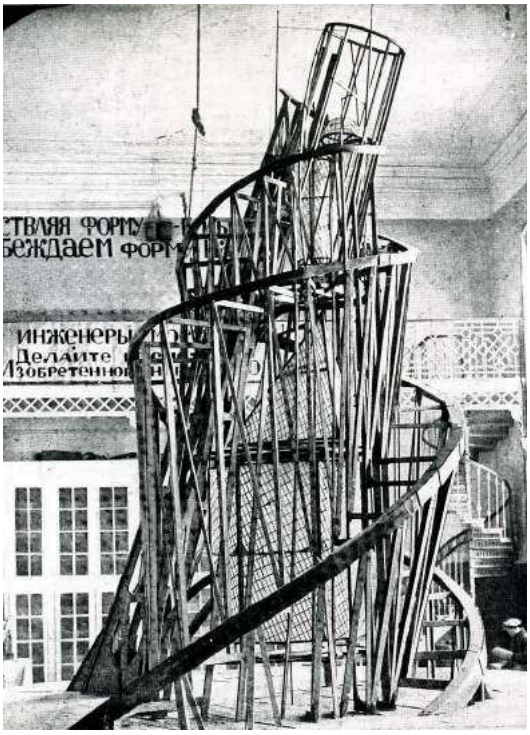


Fig. 4.17: Monument to the Third International. (1919–20). By Vladimir Tatlin. The sculpture symbolize movement and dynamic.



The relationship between the respective functions might be essential in this perspective, and have to be legible and strong in order to prevent an ordinary separation between the spaces as individual floors and to exploit the individual qualities of the spaces.
A proximal and local landmark might potential strengthen the relationship between the individual functions, and act as a common reference point for the hut.

The hut becomes a centerplace both locally and globally manifested in the reference point.
The center-placed landmark might furthermore emphasize a spiral flow of the hut that encourages to movement and a bodily reaction in order to explore the different facets of the hut. This might reveal another sensory activity than the ordinary house.

"The centerplace of the house, like the body, accumulates memories that may have the characteristics of "feelings" rather than data."
(C. Bloomer & W. Moore 1977, p 49-50)

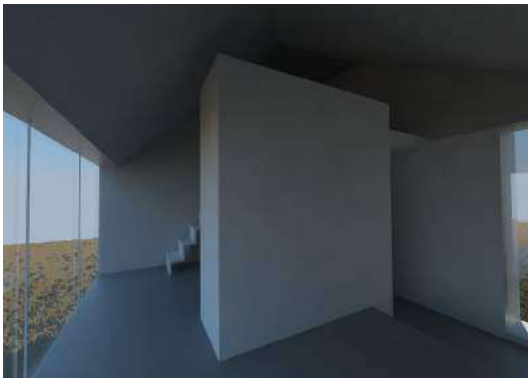
The status and appearance of the landmark is investigated in term of proportions and materials in a three dimensional model, where especially the spatial understanding of the hut has been an important aspect.

As illustrated on the following page, the level of light is essential to the spatial understanding. The window in the roof and the pitched roof emphasize the up/down orientation and provides natural sunlight to the whole hut.
This is emphasized by the choice of material, where the level of reflection and the coherence in color might tie the space together to one representation.

Especially, the combination between the warm wooden material and the cold concrete establish a clear hierarchy between the landmark and the rest of the hut.

Fig. 4.18: Materiality - hut. Experiment with texture and light.

a.



b.

c.

d.

Fig. 4.19: Materiality - hut outdoor.
a: Bricks. b: Wood. c: Polycarbonate. d: metal

MATERIALITY

The presence of the hut in the rural landscape has been dicussed in terms of form and scale, but also the choice of material might be an important aspect in this discussion as well.
As illustrated on the following page, different types of material are tested in relation to the nature of the area, the heathland.
The asymmetric form of the huts offers a dynamic experience depending on the placement of the observer. This character might be emphasized by the texture of the hut.

Especially, the colors and the levels of reflections in the material are important properties in relation to the wild and colorfull nature. The wood and the stone appear very static and monotone in relation to the vivid nature and creates a clear contrast between the textures. On the other hand, the reflective materials as the transperent polycarbonate and the steel establish a correlation between the materials.
The heterogeneous texture of the corten steel represent, in some way, this effect as well, and appears vivid as the nature.

The reflective materials are furthermore more addaptable to both change in weather and to movement of the observer. It change as the point of view changes. This might emphasize the dynamic appearence of the hut, and make it variable according to the placement of the observer.

a.

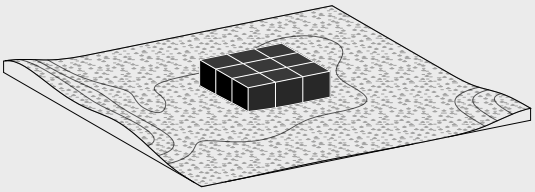
b.

c.

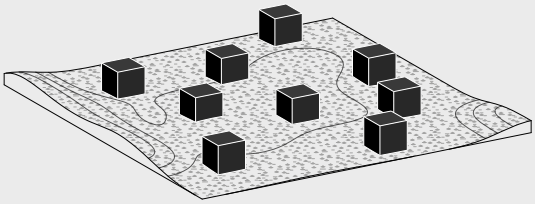
d.

CONCLUSIONS*THE HUT*

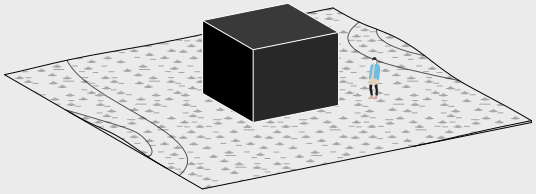
The following steps illustrate the essentials aspect of the previous presented design process.



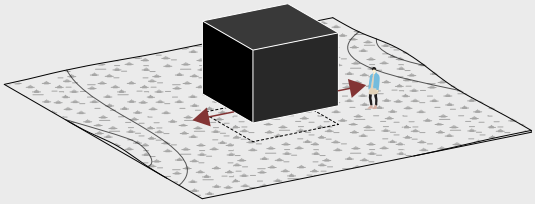
- Maximum total area of 3000 m2 in total
- Organised in smaller clusters by 5-10 units



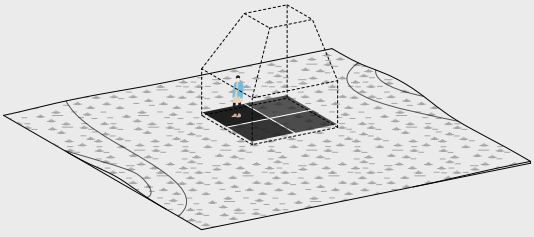
- Spread out to estalbish a private sphere
- Placed in relation to contour lines



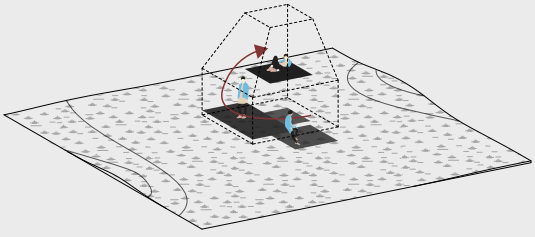
- Unit placed in landscape



- Lifted up in order to let the heathland continue underneath the hut
- Protect the construction from the ground
- Offers more privacy

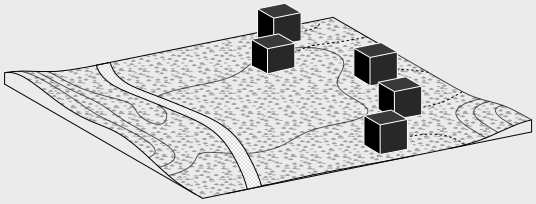


- Simple plan with four essential functions
- Defined by a familiar squared form

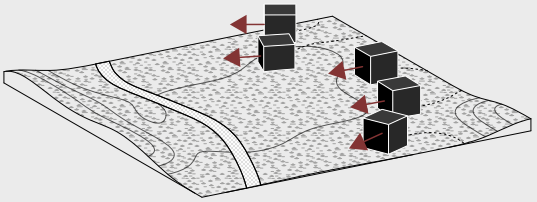


- Separated by levels
- Spiral flow

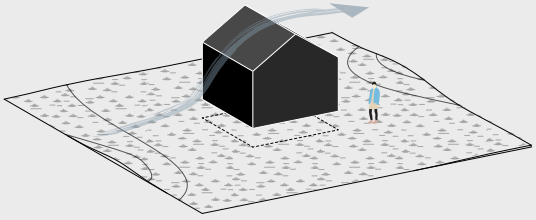
Fig. 4.20: Hut - diagram



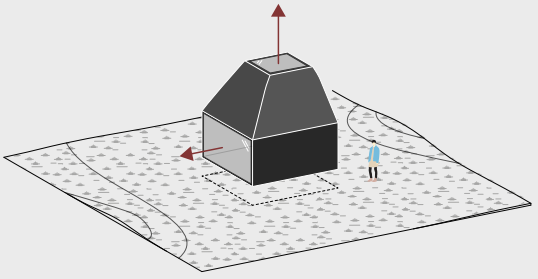
- *Certain distance from puplic path*
- *Landmarks from private path*



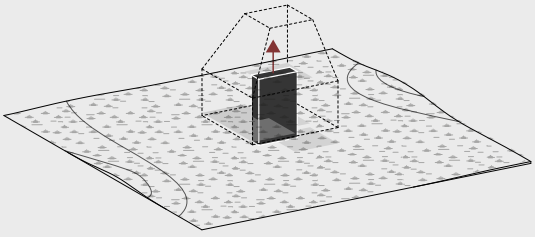
- *Orientated towards optimal view*
- *Invidualized by direction*



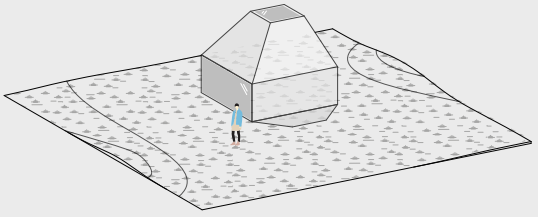
- *Adjusted to the wind*
- *Natural ventilation*
- *Association to the typical hut*



- *View to both heathland and sky*
- *Asymmetric form*



- *Central landmark connecting different levels*
- *Technical core*



- *Final hut*

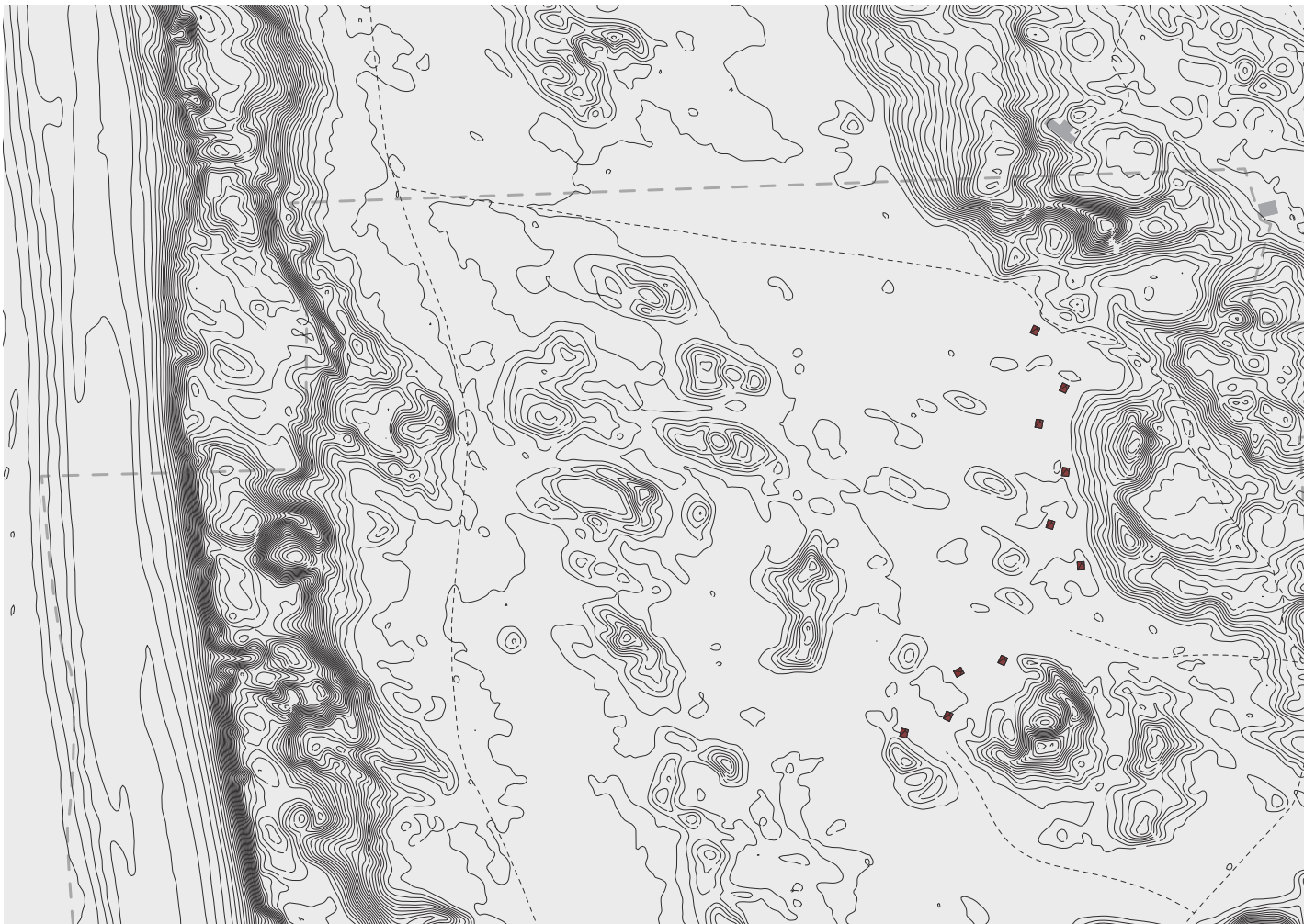
The location within the extensive heathland emphasize the essential purpose of the huts to provide a unique space in synergy with nature isolated from the over-stimulated everyday life, but it furthermore sets critical demands to their appearance within the rural landscape. The individual hut acts for the respective guest of the hotel as a significant reference point and a stable domestic safe within the nature, while it for the common tourist in the area appears elusive and dynamic.

The following chapter presents the final design solution based on previous chapters analysis and investigations. As each aspect of the project has been discussed and thorough described in the design process, the following chapters are primary presenting the final result through short descriptions, visualization, and technical drawings.

The project is furthermore finally concluded and reflected.

(iv) PRESENTATION

Fig. 5.01: Site plan. 1:5000



SITE PLAN SCALE 1:5000

0 25 50 100 250 500 m

Fig. 5.02: The hut - axonometric.

1#SCENE*THE HUTS*

The hut represents an isolated space in sympathy with nature substrated from an over-stimulated everyday life. The hut establishes luxury in a sensual contact with the magnificient surrounding nature, simplicity, and by only providing the essentials.

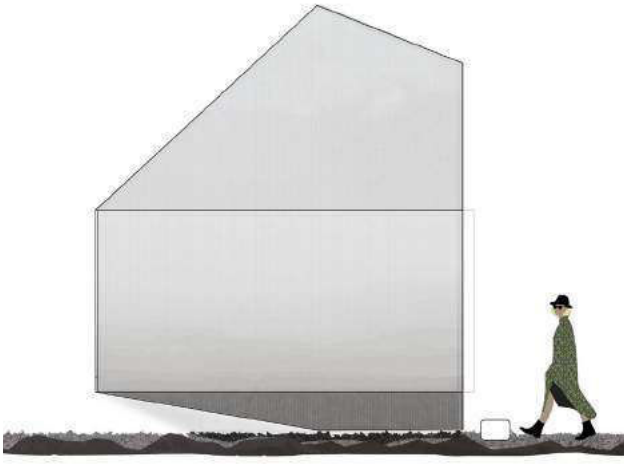
The appearance of the huts in both form and materiality seems volatile and uncertain. The slightly transparency and reflections of the skin chance accordingly to the weather and colors of the heath and let the huts disappear into the landscape on a temporal basis. These properties furthermore provide a dynamic look in relation to distance and offer changing character depending on the location of observer.

This mutability is furthermore emphasized by the asymmetrical form and their individual orientation that, despite identical design, offers an certain individualism and personality, which makes them easier to recognize and familiar for the respective guests.

Fig. 5.03: The hut - outdoor visualization. The appearence of the huts in the extensive heathland.

Fig. 5.04: The hut - Elevations.

ELEVATIONS SCALE 1:100



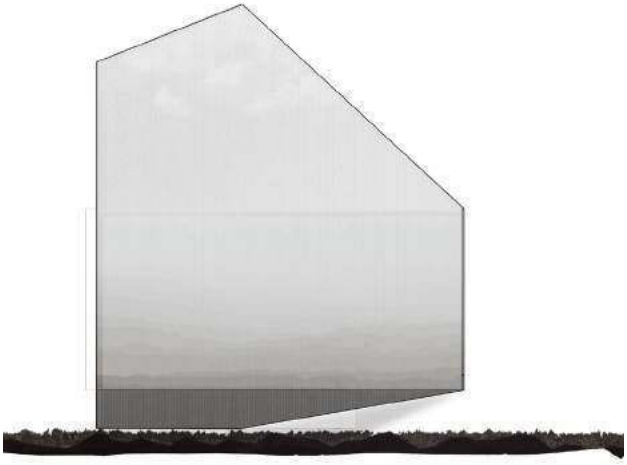
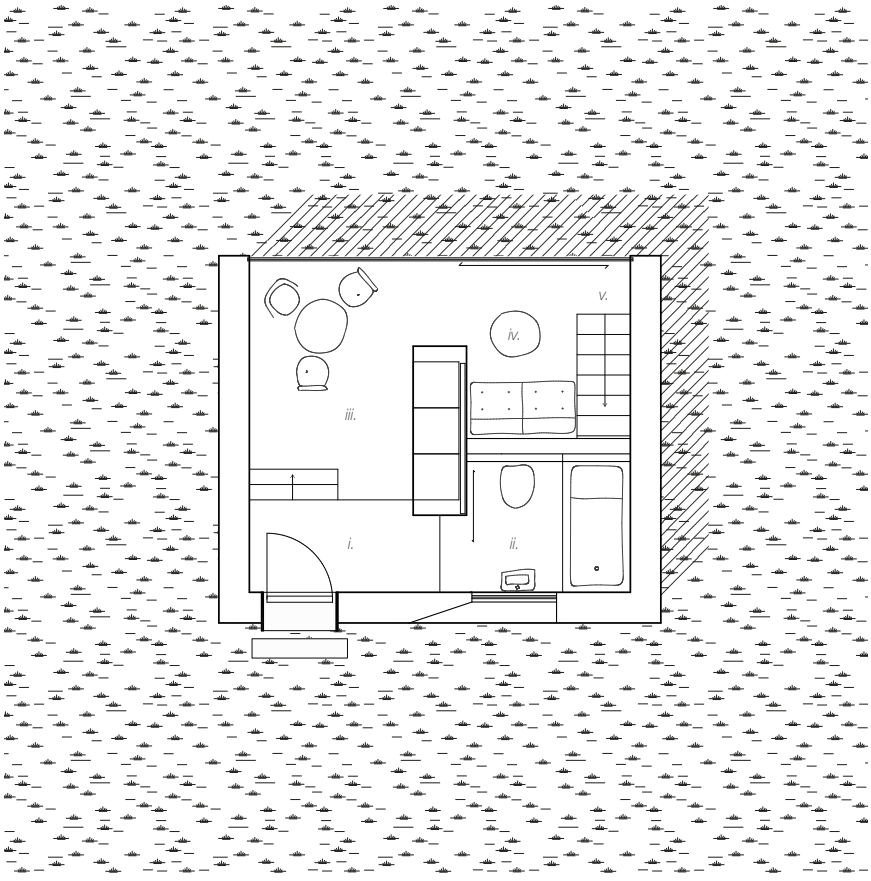


Fig. 5.05: The hut - Site plan.

Fig. 5.06: The hut - plan.



i. Entrance
ii. Bathroom
iii. Dining area
iv. Living room
v. Stair to bedroom

PLAN SCALE 1:100

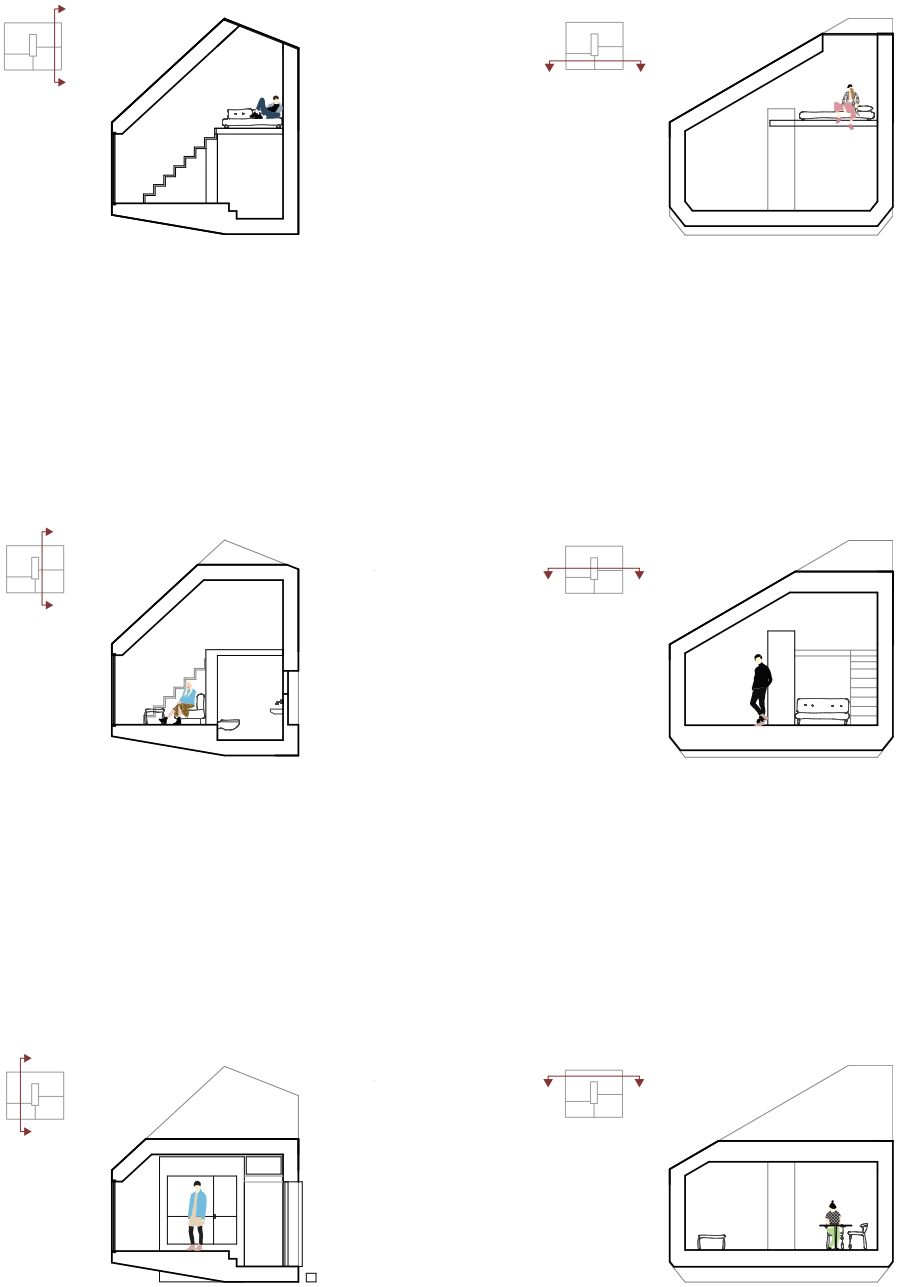
The 25 m2 simple plan of the hut includes four functions in one coherent and legible space, only separated by their vertical placement. Each space is carefully positioned and organized relatively to the movements of the body, the connection to outside, and their individual technical requirements.The entrance welcomes the guest by its placement by the ground, and establishes together with the bathroom, the cold and dirty functions by the door. The dining and living room are placed by the enormous front window, and provides a space with both optimal natural light a spectacular view. A stair leads from the living to the top of the hut, where the bedroom is placed in close contact with the dynamic sky.

The centerpiece of the hut stands as a stable reference point in order to both emphasize the spatial correlation between the respective spaces, but furthermore to establish a stable domestic point in contrast to the extensive and ever-changing outside world.

The overall constellation of the hut, manifested by the floorplan layout and the geometric form, enhances a helical and three dimensional spatial experience that both offers the near relationship with the static ground, and the possibilities of being in contact with the dynamic sky.
The position and the scale of the windows areas comprehend this. The large front window provides an uninterrupted and extraordinary view to the extensive landscape and blurs the border between outside and inside, while the top window frames the sky and offers a view of both the vivid clouds and the lighting stars.

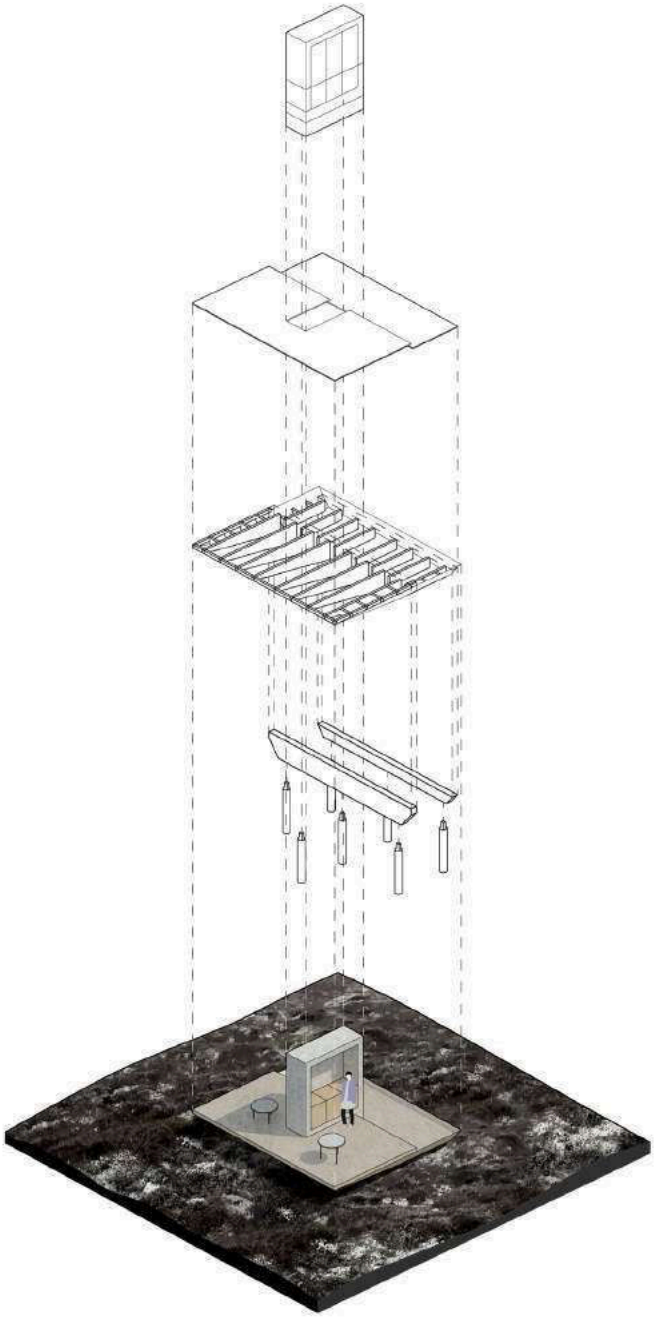
Besides comprehending the self-motion signals provided movements, the hut furthermore offers a numerous of situations carefully designed to the proportions of the human body. This includes not only the upright position when standing or walking, but furthermore consider the position of sitting or lying. Especially, the change in levels of the hut is used actively in this purpose, and the stairs becomes important furniture of the hut.

Fig. 5.07: The hut - sections.



SECTIONS SCALE 1:200

Fig. 5.08: The hut - Axonometric of platform.



THE CORE

As mentioned before, the core represents the stable spatial reference point of the hut, but it further acts as the statically and technical core as well. The core is connected to the foundation point and establishes a stable center point for the lifted construction. The center-position makes it optimal for technical supplements as heat, electricity, water, and sewage, and the bottom of the core provides space for a 500 liters tank for water supple and sewage, a rainwater filter, and a battery for solar panels.

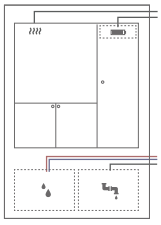


Fig. 5.09: The technical installations implemented in the core.

THE CONSTRUCTION

The floor construction is structured by two primary lateral timber beams supported by both the core and the foundation. A layer of rafters establishes the hanging floor platform and transmits the general forces to the primary beams and the core. The floor is made of sandstones supported by a layer of chipboard.

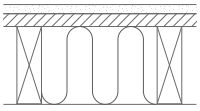


Fig. 5.10: The floorsandwich

THE FOUNDATION

To minimize the influence on the landscape, the hut is placed on top of a series pillars. The primary beams and the core are fixed to the seven pillars that are dug into the ground and casted into a foot of concrete.
The pillars seperate the hut from the ground and protects the construction from moisture, and furthermore let the heath underneath get both natural light and air in order to continue growing.

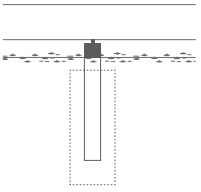


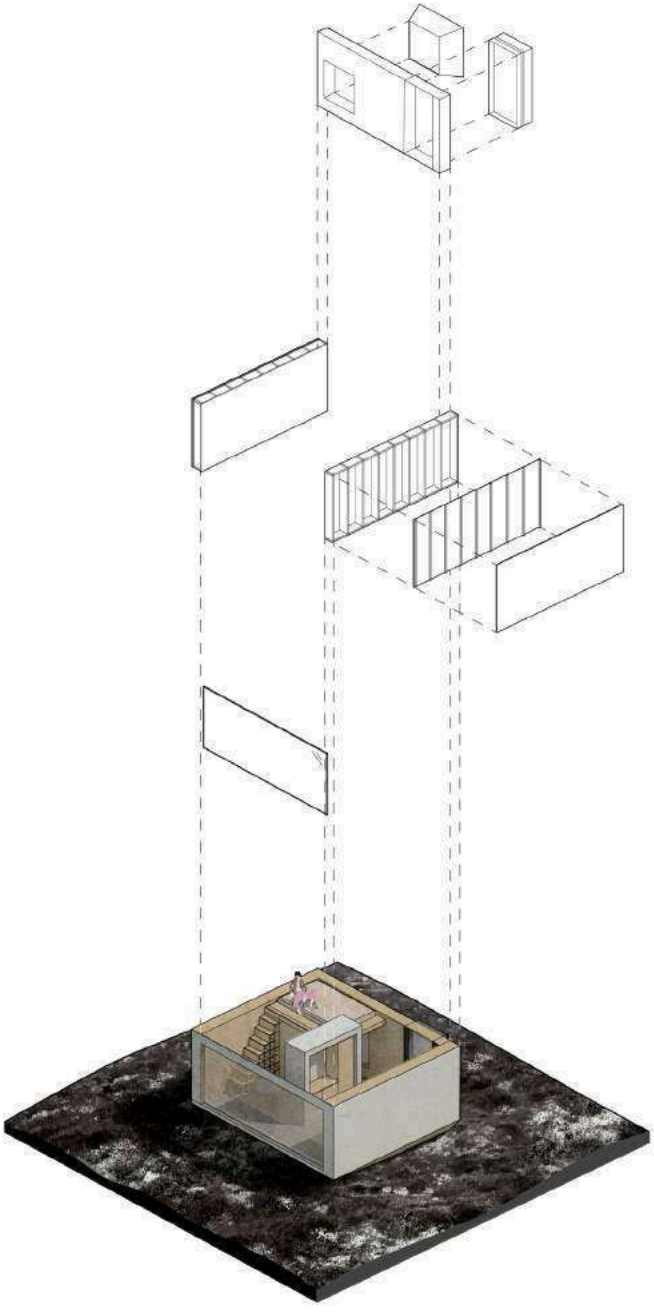
Fig. 5.11: The foundation

Fig. 5.12: The hut - Visualization of living room.

CENTERPIECE AS LANDMARK

The hut is gathered around the centerpiece, the core, which represents a local landmark for each function of the hut from the bathroom to the bedroom. Its placement, proportions, and materiality discriminate from the rest of the hut, and stands as a reference to the massive and stable bunkers of the area.

Fig. 5.13: The hut - axonometric of envelope.



THE ENTRANCE

The hut has only opening in two sides in order to secure privacy between the huts and to optimize the view towards the most important area of the landscape. The openings towards south/east include the door and a smaller window. The smaller window is extracted into the facade so it offers maximal natural light and a view from the bathroom inside, but simultaneous provide a small sheltered area outside. The walls of this niche are furthermore made out of concrete, so they accumulate the solar energy during the day, and allow the guests to sit outside in long periods of the year.

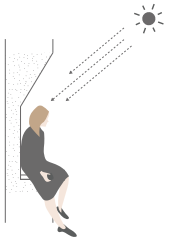


Fig. 5.14: Integrated concrete bench heated by the sun.

THE WALL

The hut is a light weight structure both in construction and appearance. The walls are established by sandwich elements made of different layers attached to a structure of timber posts. Inside, the structure is cladded with pine plates. Outside, it constitutes of respectively a weatherproof membrane, a layer of treated pine lamellar, and a layer of transparent polycarbonate as finish. The polycarbonate might be produced by the hundreds of recycled bottles that are found at the beach every day, as a sustainable approach but also to restore the old idea from the Klitgård to build of the waste from the ocean.

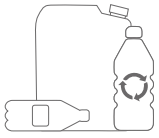


Fig. 5.15: Recycled polycarbonate from wasted plastic bottles at the beach

THE WINDOW

The front window is made of one consistence piece of glass spanning from floor to ceiling and from wall to wall. The window offers a brilliant view out, but it furthermore invites the heathland inside and emphasizes the feeling of being alone in the nature. The lifted character of the hut offers certain privacy despite the large amount of glass.

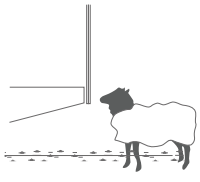
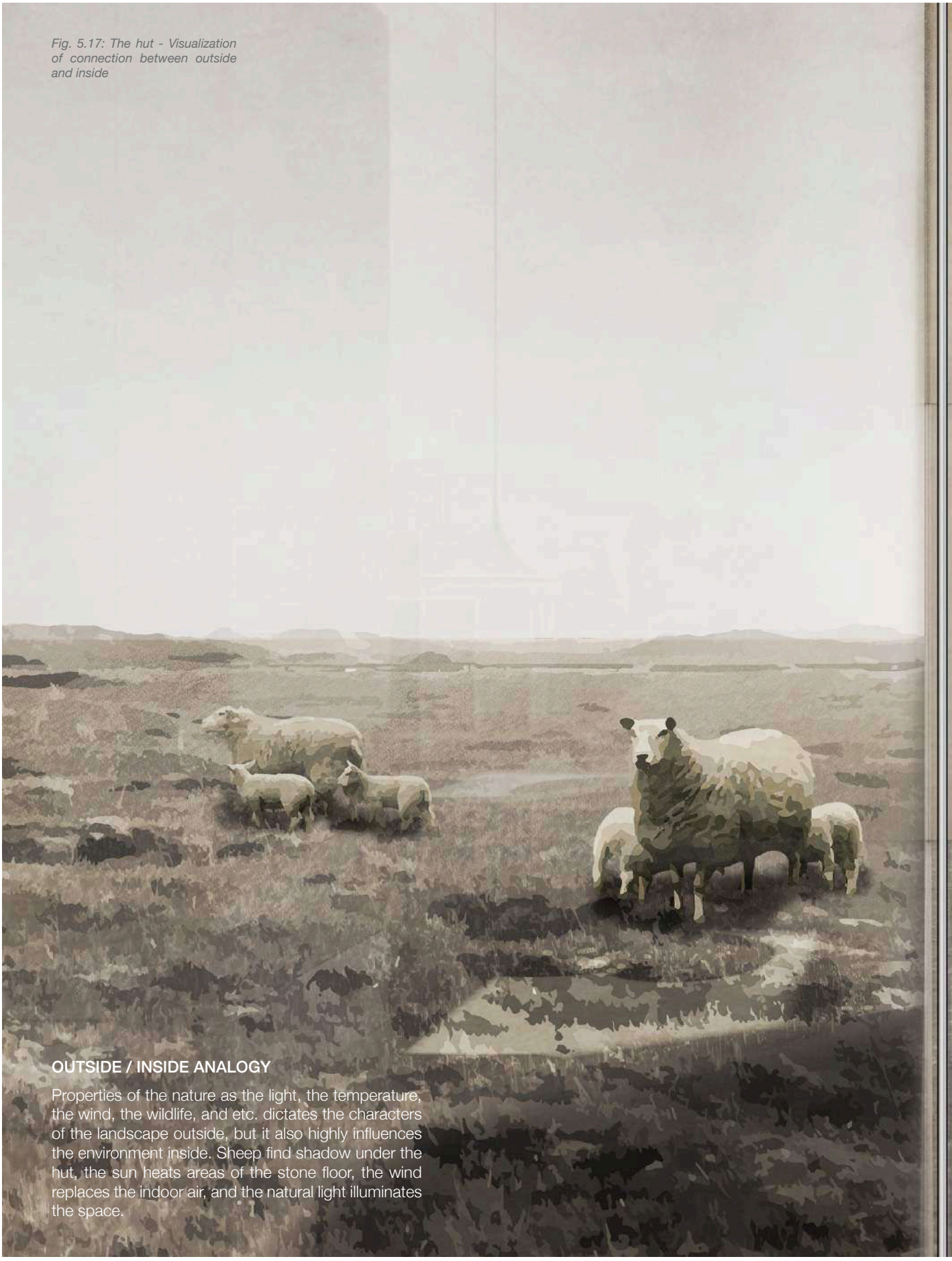


Fig. 5.16: Lifted from the ground to secure privacy.

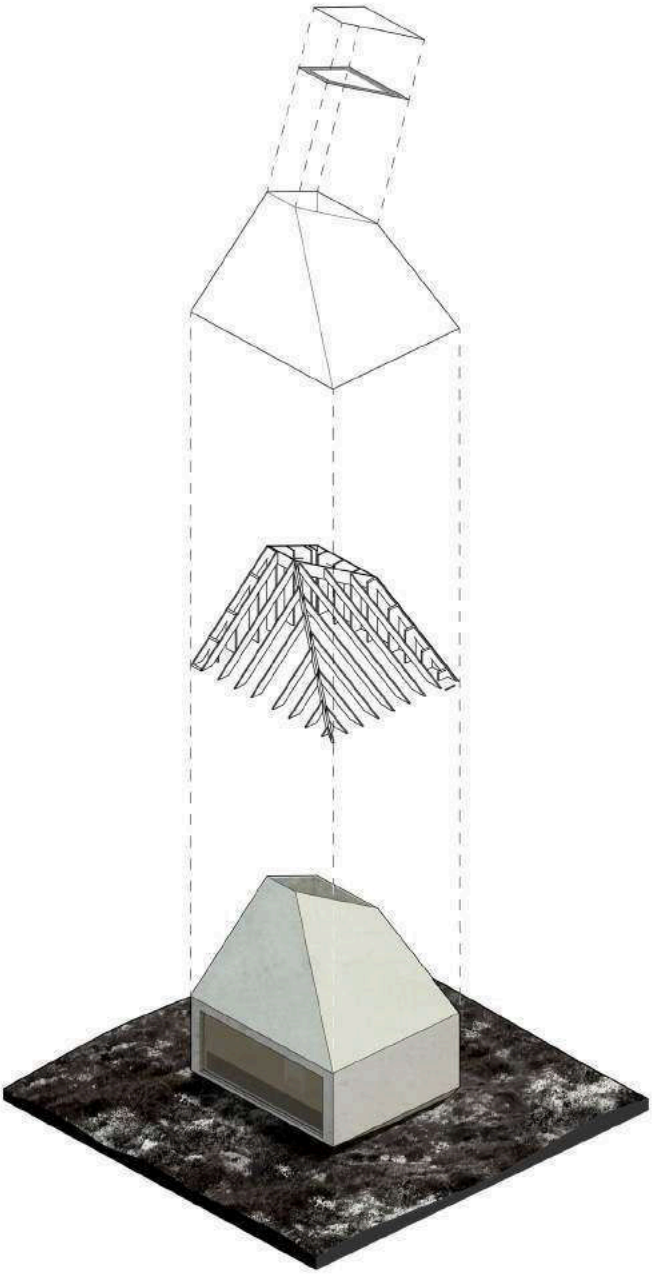
Fig. 5.17: The hut - Visualization of connection between outside and inside



OUTSIDE / INSIDE ANALOGY

Properties of the nature as the light, the temperature, the wind, the wildlife, and etc. dictates the characters of the landscape outside, but it also highly influences the environment inside. Sheep find shadow under the hut, the sun heats areas of the stone floor, the wind replaces the indoor air, and the natural light illuminates the space.

Fig. 5.18: The hut - Axonometric of roof.



THE SKYLIGHT

The top window provides a view to the dynamic sky, but it furthermore stands as an important light source of natural light to more or less every space of the hut. As the glass of the skylight is extended to the edges of the top window, the frame provides enough space for 2,5 squaremeters of integrated solar panels.

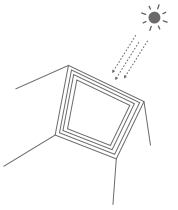


Fig. 5.19: Integrated solar-panels in the window frame

THE ROOF

The structure of the roof is established by a construction of timber rafters. The elements are cladded in similar way as the walls with pine plates inside and polycarbonate outside. The pitched form of the roof allow a certain thermal buoyancy and can be used a natural ventilations system for the hut. The generally strong windspeed at the coast might emphasize this process, as the roof creates difference in pressure by its relatively exposed and tall geometry.

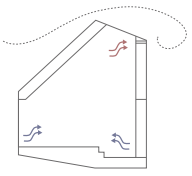


Fig. 5.20: Natural ventilation by thermal buoyancy

TRANSPORTATION

As the structure is both a light-weight construction and assembled in sections. It is possible to establish the hut as prefabrication in a local and controlled environment. Only the pillars have to be positioned at site, while the rest can be produce and assembled off-site.
This also offers the possibility to move the huts in order to relocate them in the summer season or to spare the nature in specific periods.

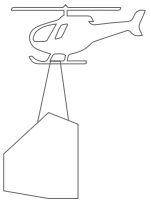


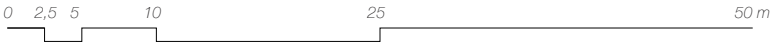
Fig. 5.21: Prefabrication off-site.

Fig. 5.22: The hut - visualization of skylight

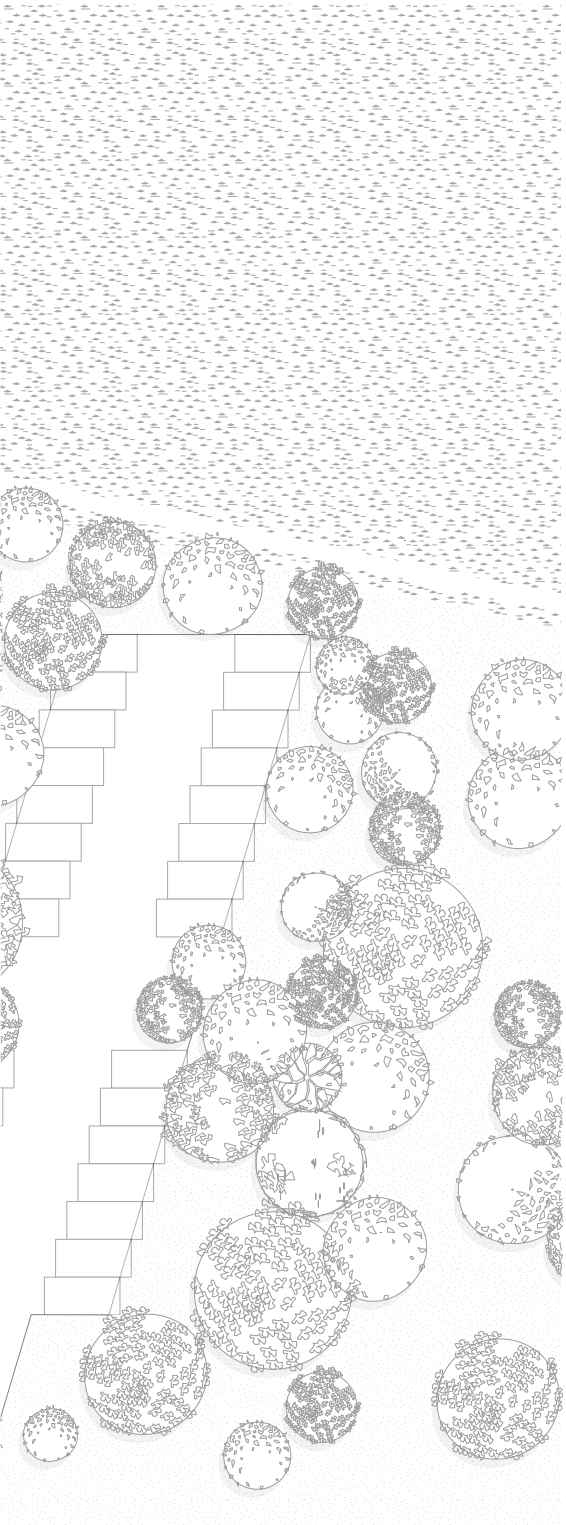
REFLECTIONS

The hut becomes an escape from the overwhelming stimulations of everyday life and offers a temporary space for egocentric reflections.

Fig. 5.23: The Landscape Hotel - Site plan.



PLAN SCALE 1:500



THE LANDSCAPE HOTEL

The communal center of the Landscape Hotel consists of the three primary social functions; the restaurant, the bath, and the auditorium, and two wings including a variety of hotel rooms; the ordinary room, the social huts, and handicap friendly rooms.
The wings establish together with the Klitgård a enclosed and semi-private piece of controlled landscape. Here is both the bath and auditorium located as smaller pavilions, which together with the restaurant included in the Klitgård are available the whole season for both the guest of the hotel and the general public.
Each function enhances a individual and unique experience, both established by its program and by its spatial composition.

LIST OF PROGRAMS

Communal center:

	General functions:	Quantity	Size	
i.	*Ordinary rooms*	*5*	*15*	m^2
ii.	*Ordinary rooms as huts*	*6*	*25*	m^2
iii.	*Handicap friendly rooms*	*2*	*32*	m^2
	Social functions:			
iv.	*Restaurant/Food laboratorium*		*110*	m^2
	Courtyard		*38*	m^2
	Kitchen		*27*	m^2
	Entrance		*12*	m^2
	Reception		*7*	m^2
	Restrooms		*15*	m^2
	Administration office		*10*	m^2
v.	*Bath*		*32*	m^2
	Dressing rooms	9	*8*	m^2
	Technical room		*8*	m^2
vi.	*Auditorium*		35	m^2
	Meeting room		12	m^2
	Entrance		6	m^2
	Restrooms		6	m^2
	Technical room		4	m^2
	TOTAL		683	m^2

Other:

vii.	*Storage yard*		
viii.	*Parking*	30	pcs.

Fig. 5.24: Restaurant - diagram

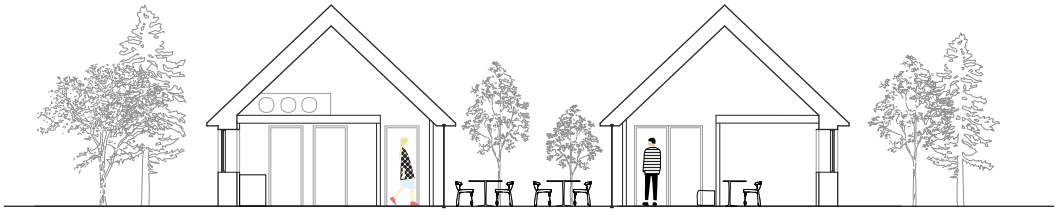
2#SCENE*THE RESTAURANT*

The Klitgård represents the historical as well as social center of the Landscape Hotel. Its courtyard represents an protective enclosure that offers multisensual experiences through social interaction and comfortable dining facilities available during the whole year.

The Landscape Hotel is grounded in memories - memories of the magnificent nature, memories of the pioneering Danish agriculture, and memories of the focal point of them both - The Klitgård. The Klitgård represents a piece of history that is emphasized and revitalized in the new function as center for the Landscape Hotel. This includes essential functions as the entrance, the reception, and the restaurant that together promotes social engagement involving every sense, from the light, acoustics, and materiality of the environment to the taste and smell of the food.

Fig. 5.25: Restaurant - Collage of dining space.

Fig. 5.26: Restaurant - section.

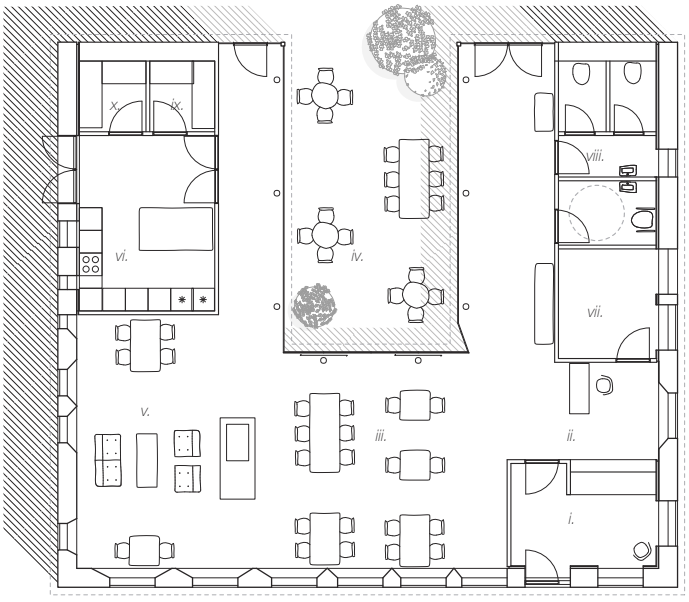


SECTION SCALE 1:200

Grounded in the original circumstances of the protective four-winged typology and inspired by modern interpretations of the courtyard, the restaurant offers a legible and open space that interweaves the qualities of both the courtyard and indoor spaces into one representation. A space that is correlated to the activities, but furthermore established by the use of floor textures and the presence of a local landmark represented by the red-tiled fireplace.

The physical connection to the courtyard is established by a continuous window section that allows full visibility to the activities of the courtyard, but furthermore brings light into the surrounding indoor spaces. The outer walls become the boundaries of the restaurant and stand stable and defined as before. The additional functions as kitchen, toilets, storage, and etc. are placed as boxes inside the floating space of the restaurant. On top of each box is the technical supplement for ventilation positioned.

Fig. 5.27: Restaurant - plan.



i. Entrance
ii. Reception
iii. Restaurant
iv. Courtyard
v. Living room
vi. Kitchen
vii. Restrooms
viii. Office/tech
ix. Fridge
x. Freezer

PLAN SCALE 1:200

Fig. 5.28: Bath - diagram.

3#SCENE*THE BATH*

The bath composes a space for contemplation and well-being in a social context. The environment in its entirety establishes an intimate space that exclusively represents refined sensual expressions related to being in water.

The bath of the Landscape Hotel comprehends a social intimacy. The circular form encloses a very defined space isolated from the stimulations of the world outside. Only the sky is in focus and emphasized both by the framing overhang of the bath, but also by the reflections in the water. The proportions of the space and the use of materials do not enhance clear speech or verbal communication, and the shadows of the overhang and the fog decrease the visibility. Almost only the sense of feeling is highly stimulated in this context by both the touch of the water and the distanced touch of the people in the same bath.

Fig. 5.29: Bath - Collage of bath

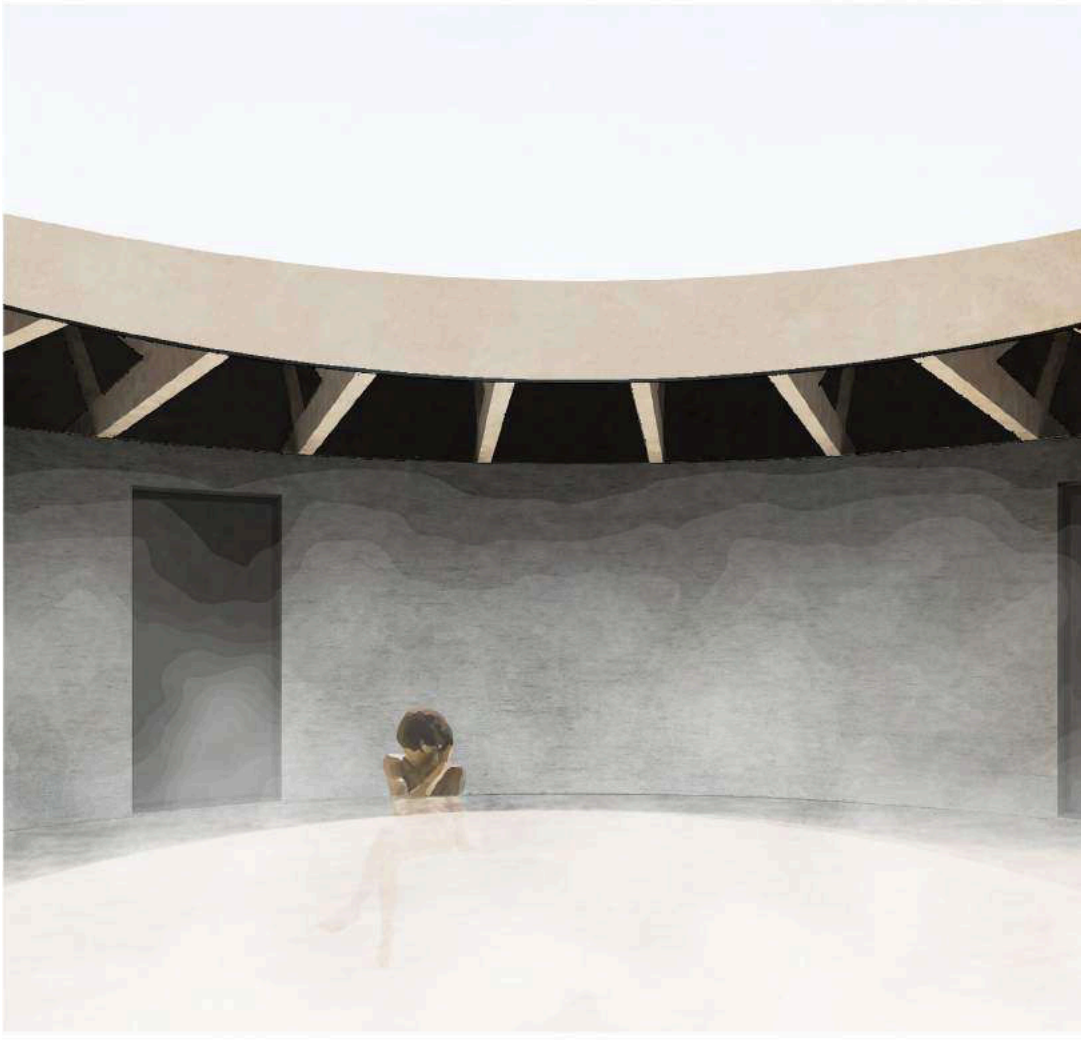
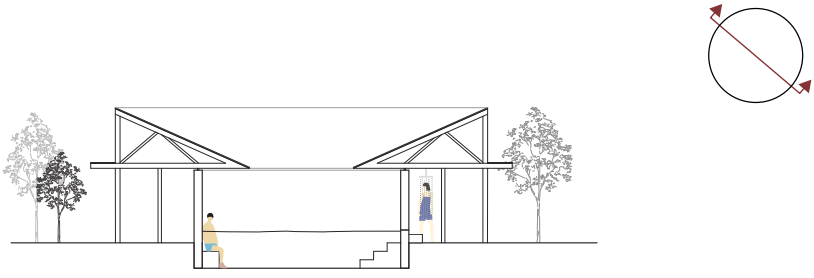


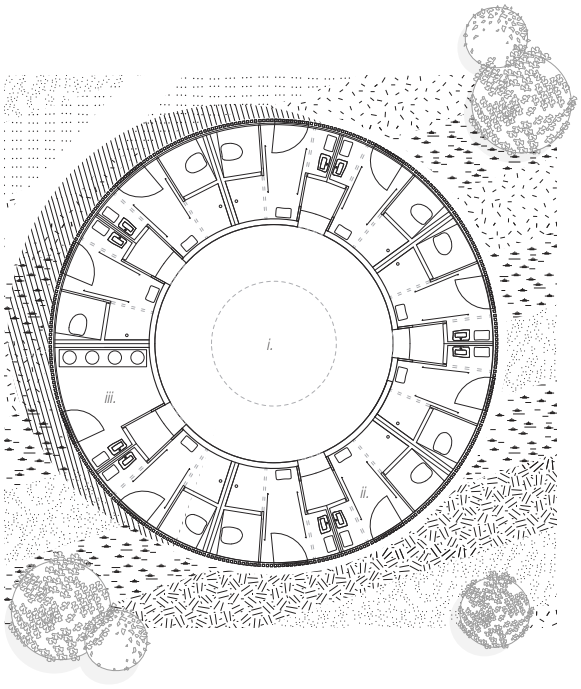
Fig. 5.30: Bath - section.



SECTION SCALE 1:200

The bath contains several different layers from the outside envelope of wooden lamellas to the concrete wall of the basin. The private dressing rooms are organized in the perimeter of the circle and include a toilet, a shower, and a sink. Between the dressing room and the bath is a small dark hallway that offers the possibility to overlook the bath before entering.
As the dressing rooms and the entrances are more or less identical and offer no directional cues, it is up to the egocentric information of the individual to navigate back to the correct dressing room. The user of the bath would stay close to their respective entrance and thereby keep a certain distance to the others in the bath.

Fig. 5.31: Bath - plan.



i. Bath
ii. Dressing room
iii. Technical room

PLAN SCALE 1:200

Fig. 5.32: Auditorium - diagram.

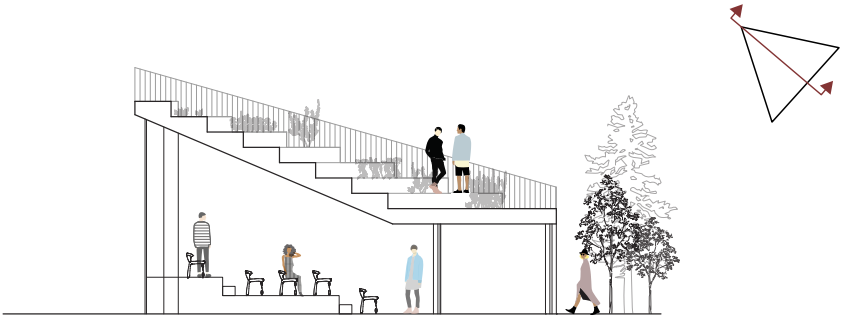
4#SCENE*THE AUDITORIUM*

The auditorium are optimized for staged social arrangement and one-way communication. The space enhances a professional and public distance between the audience and the speaker and comprehend clear visual and good acoustics for verbal gesticulation.

The auditorium forms a physical stage for conferences, lectures, or public speeches both outside and inside. The triangles breaks up from the ground and stand as a pompous and extravagant sculpture. A character that enhances a certain distance and attention and emphasizes the staged activities that takes place both inside and outside of the place. The triangular geometry encloses an interior space that directs the attention towards the position of the speaker and offers an ideal angle of sight for every person in the audience in order to follow both facial expression and detailed speech. The angles of the triangular geometry offer furthermore ideal acoustic properties in order to prevent echoes.

Fig. 5.33: Auditorium - Collage.

Fig. 5.34: Auditorium - section.

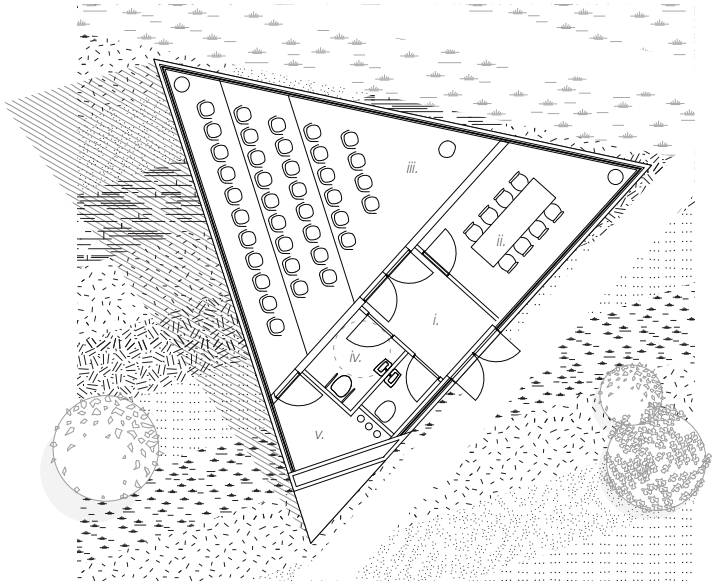


SECTION SCALE 1:200

The spectacular background of the speaker represented by a view to the extensive heathland automatically puts some expectation on the speaker to hold the attention of the audience.

The uplifted form of the building establishes space for an exterior amphitheater that besides allowing large gatherings to take place also offers a viewpoint on the top. The height of the viewpoint establishes both a global reference point for the individual functions of the hotel, but it furthermore offers a view to the prominent landmark of the area, the silo. A view to the silo furthermore provides a spatial coherence to the huts located at the heathland, as they also have the silo as a salient reference point.

Fig. 5.35: Auditorium - plan.



i. Entrance
ii. Meeting Room
iii. Auditorium
iv. Bathrooms
v. Technical Room

PLAN SCALE 1:200

In conclusion, this project demonstrates how scientific findings derived from the field of neuroscience can enrich and refine the process of architectural design and represent essential instruments in order to reach more humanistic architecture.

Due to the findings of the included studies, this project exemplifies how evidence-based knowledge can verify how individual architectural properties influence our spatial understanding and facilitate our ability to navigate. By manipulating and defining the present sensory inputs of our physical environment, we might be able to provoke a certain experience and establish the optimal platform for the recreation of memories.

The project concerning a Landscape Hotel by the Weastcoast at Holmslands Klit is object to the application of the neurobiological principles in practice. It includes a thorough investigation of how basic architectural interventions in terms of form, scale, position, and materiality might be perceived and understood on a neurological basis by the users.

The function as a landscape hotel is associated with vacation. Vacation represents an escape, - an escape from the regular stimulation of our everyday life, and an escape that offers new memories. Previous vacations act as an important part of the memories of the most, simply because being on holiday provokes different experience than we normally are used to. The Landscape Hotel primary task it to set a proper stage for these unique experiences to take place.

By carefully refining the stimulations and balancing the egocentric and allocentric sensual information of every situation, the scenes, each and every space is focused and intensified to provoke a certain experience. The hut sets the stage for reflection and contemplation in contact with oneself and nature, while the Landscape Hotel provides spaces for social and interpersonal engagement. The architectural properties of both comprehend the function of it, and set the optimal conditions for the guest in order to establish their own experiences and memories.

REFLECTION

We are today experts in measuring our buildings in relation to a numerous of aspects as indoor climate, energy efficiency, daylight conditions, heat loss, and etc. Calculations that were almost impossible for just 20 years ago are now done in seconds by our advanced digital tools, and quantitative data have nowadays become a naturally helpful indicator of the impact of an architectural decision. We know much more about our buildings, than we have ever done.

It is difficult to oppose such an evolution, if we simply are aware of the true value of it. But if we begin to take the result of the technical instruments for granted, and let the data stand as the ultimate answer of quality, the value of it becomes an obstacle instead of a helpful instrument.

"Today it is common to give more importance to the tools than our life-world"

(Norberg-Schulz 1980, p. 6)

A building is not built in order to satisfy the data, but to satisfy the people who it is built for. The experience of the people would and shall stand as the ultimate indicator of our architecture. The quantitative data cannot dictate how this experience appears, but it might tell us how the experience can emerge. Our instruments might stand as dynamic indicators that collective offer sufficient insight of how the human in general might react to the physical environment considering both the specific social, cultural, and geographic context.

Universal regulations seem therefore more or less pointless in this perspective, and might by their normative basic be in favor of the measureable means than the human experience. This phenomenon might be characterized as Instrumentalized Architecture accordingly to the denotations of Brinkmann and his analysis of the similar tendency in society of today.

To prevent this, the present study took its starting point at the focal point of this discussion, - the human physiology, and questioned whether knowledge of the underlying human mechanism of spatial memory can be applied as a useful tool in order to design meaningful architecture.

The principles derived from neuroscience represented the theoretical basis for this task and enlightened how the spatial composition might influence our ability to form new memories. Especially, the existing site-specific properties were an important aspect in this perspective and established the primary groundwork of an architectural decisions.
The combination between the theory and the local conditions at site were important in order to utilize the neurobiological principles as an instrument in the process of both analyzing and designing a Landscape Hotel for this particular area. This approach influenced especially the focus of the project from being an overall composition to instead being concentrated on the individual sensual dispositions. This adaption naturally took some time to customize and integrate into an applicable methodology and required several experiments in order to both define and fulfill.

The methodology was primary a matter of simplification and constriction, and a restriction to the influence of the specific architecture element in every individual situation. This resulted in very refined stimulations for each and every local environment, but it might also result in an indistinct correlation between the individual situations.

All this together, the neurological theory and the methodological application of it in practice have naturally affected the project. Present project has to be considered as, a study of how neurological principles influence architectural design, and not as general design proposal. Several other aspects as technical, aesthetical, and functional can furthermore be included to specify the project in detail even more. Nevertheless, the project exemplifies how a deeper knowledge into the mechanism of the human brain might establish architecture to remember.

Fig. 5.36: Auditorium - viewpoint

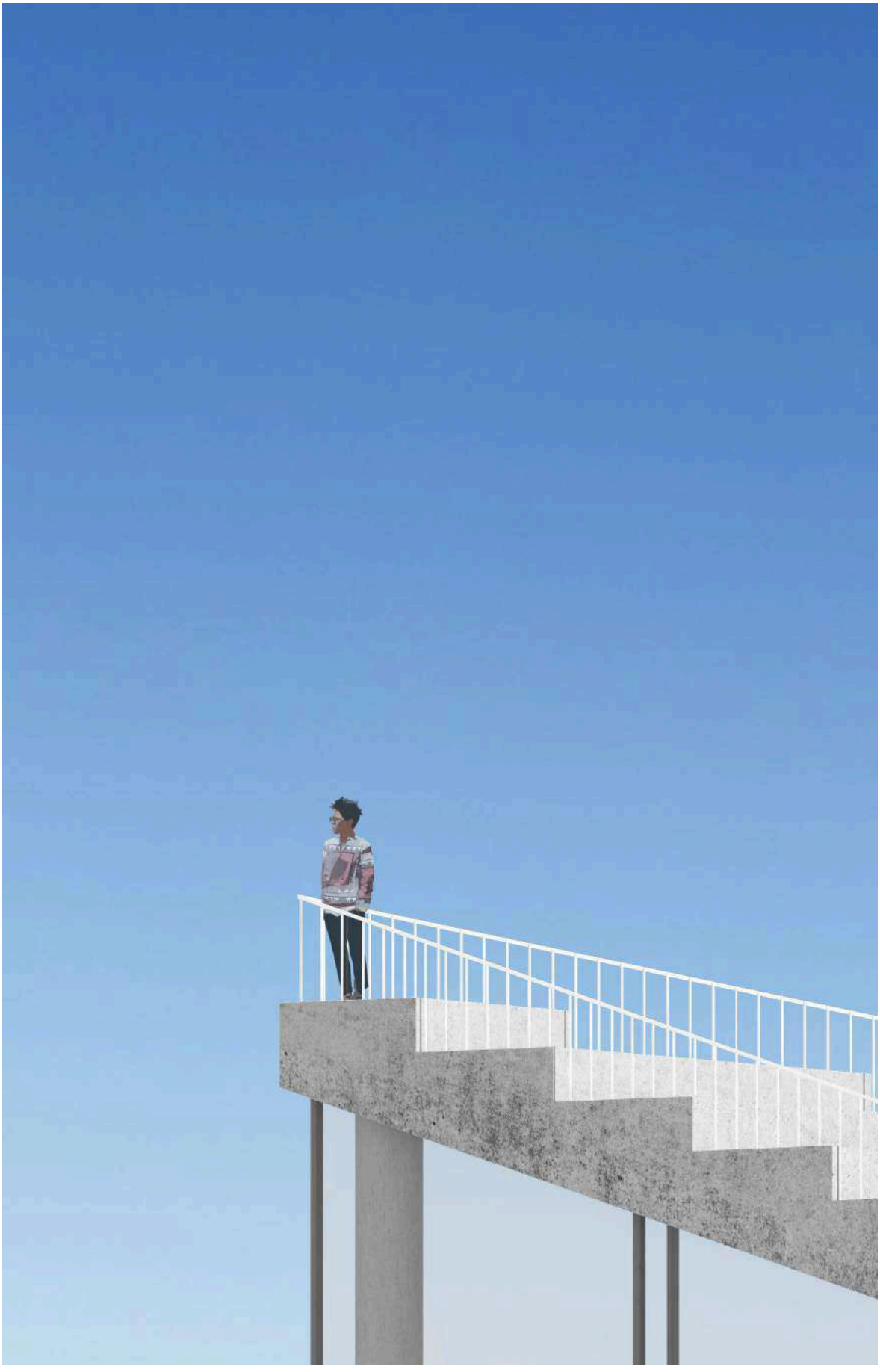


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Fig. 0.01: Huts in the fog.
Own illustration

Fig. 0.02: Japanese Shinto Shrine
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Fig. 0.03: Meaningful Architecture
Own illustration

Fig. 0.04: Process flow diagram of practical part
Own illustration

Fig. 1.01: Contrast between nature and holiday home
Own illustration

Fig. 1.02: Location - Ringkøbing-Skjern.
Own illustration

Fig. 1.03: Proposed function diagram.
https://www.rksk.dk/edoc/dagsordenspublicering/økonomi-%20og%20erhvervsudvalget/2016-06-21%2008.00/dagsorden/referat/hjemmeside/2016-06-21%2010.26.49/attachments/1098415-1374556-1.pdf
[Assessed 5 January 2017]

Fig. 1.04: Site area.
Own illustration. Background map from https://sdfekort.dk/spatialmap?
[Assessed 10 January 2017]

Fig. 1.05: Area of nature.
Own illustration

Fig. 1.06: Nolli map.
Own illustration

Fig. 1.07: Childhood memories.
http://imagens.mdig.com.br/fotografia/Summertime_lzabela_Urbaniak_25.jpg
[Assessed 3 Marts 2017]

Fig. 1.08: En jysk fårehyrde på heden.
https://da.wikipedia.org/wiki/Fil:En_jysk_fårehyrde_på_heden.jpg
[Assessed 16 Marts 2017]

Fig. 1.09: The history of heart area
Own illustration

Fig. 1.10: The location of the Klitgård.
https://sdfekort.dk/spatialmap?
[Assessed 16 Marts 2017]

Fig. 1.11: The Klitgård - form.
a: Dunn Andersen, P., 2000. Den Vestjyske Klitgård. b: http://www.lilienhoff.dk/liebhaver/Soender-Klitvej-230-Bjerregaard-6960-Hvide-Sande
[Assessed 20 April 2017]

Fig. 1.12: Diagram of supportive theories.
Own illustration

Fig. 1.13: Windrose.
http://www.lwo.dk/NG/vindrose_hvide_sande.jpg
[Assessed 1 Marts 2017]

Fig. 1.14: Natural order.
Own illustration

Fig. 1.15: Section of site.
Own illustration

Fig. 1.16: Natural order - pattern.
Own illustration

Fig. 2.01: Westcoast.
http://eyeswideopen.dk/wp-content/uploads/2012/09/vesterhavet.jpg
[Assessed 11 Marts 2017]

Fig. 2.02: The beach.
Own illustration

Fig. 2.03: Dunes.
Own illustration

Fig. 2.04: Straw.
Own illustration

Fig. 2.05: Silo.
Own illustration

Fig. 2.06: Heathland.
Own illustration

Fig. 2.07: Heathland close-up.
Own illustration

Fig. 2.08: Forest.
Own illustration

Fig. 2.09: Arable.
Own illustration

Fig. 2.10: Visions of the landscape hotel.
Own illustration

Fig. 3.01: The story.
Own illustration

Fig. 3.02: The existing Klitgård.
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[Assessed 20 April 2017]

Fig. 3.03: The arrival - dispositions.
Own illustrations
Fig. 3.04: The arrival - boundaries.
Own illustrations

Fig. 3.05: The porch – materials and proportions.
Own illustrations

Fig. 3.06: Proximics
Own illustrations

Fig. 3.07: The restaurant – Dispositions.
Own illustrations

Fig. 3.08: Personal space.
Own illustrations

Fig. 3.09: Courtyard - florrplans.
Own illustrations

Fig. 3.10: The courtyard – inspiration.
a: https://s-media-cache-ak0.pinimg.com/originals/5a/38/3b/5a383ba6950789e18be49ad89e25adac.jpg
[Assessed 2 April 2017]
b: http://images.adsttc.com/media/images/54c6/a195/e58e/ced6/7000/0007/large_jpg/Mies4.jpg?1422303611
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Fig. 3.11: Connections - courtyard.
Own illustrations

Fig. 3.12: Proximal landmark – inspiration.
a: http://www.wikiwand.com/en/Kingo_Houses
[Assessed 2 April 2017]
b: http://www.dinfo.gr/αυτό-είναι-το-καλύτερο-κτίριο-που-σχεδ/
[Assessed 2 April 2017]

Fig. 3.13: Dispositions - Bath.
Own illustrations

Fig. 3.14: Intimate space.
Own illustrations

Fig. 3.15: Bath - properties.
Own illustrations

Fig. 3.16: Bath - inspiration.
a: http://noeassociates.com/img/5601cda36d17c-_A5B1008.jpg
[Assessed 14 Marts 2017]
b: http://www.huftonandcrow.com/projects/gallery/serpentine-pavilion/
[Assessed 14 Marts 2017]

Fig. 3.17: Dispositions - Auditorium.
Own illustrations

Fig. 3.18: Social space.
Own illustrations
Fig. 3.19: Auditorium - space.
Own illustrations

Fig. 3.20: Auditorium - inspiration.
a:http://images.adsttc.com/media/images/52f3/c8eb/e8e4/4e1a/2200/002e/large_jpg/BIG_Danish_Maritime_Museum_©Hufton_Crow_17.jpg?1391708387
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b: https://s-media-cache-ak0.pinimg.com/564x/75/82/6c/75826c27de8c51aa80020b9b5e5fcd6e.jpg
[Assessed 21 Marts 2017]

Fig. 3.21: Dispositions- hall.
Own illustrations

Fig. 3.22: Hall – public/private.
Own illustrations

Fig. 3.23: Hall - inspiration.
Own illustrations edited by http://archinew.altervista.org/category/john-pawson/ and https://s-media-cache-ak0.pinimg.com/736x/c3/a7/2e/c3a72e4b-16336706d52c2d04cc6671b9.jpg
[Assessed 3 Marts 2017]

Fig. 3.24: Dispositions - path.
Own illustrations

Fig. 4.01: Heathland – Spatial elements.
Own illustrations

Fig. 4.02: Dispositions - huts.
Own illustrations

Fig. 4.03: Studies of placement and proportions.
Own illustrations

Fig. 4.04: Visualizations of placement and proportions.
Own illustrations

Fig. 4.05: Sketch of different compositions.
Own illustrations

Fig. 4.06: The status of the hut.
Own illustrations

Fig. 4.07: Non-building zone.
Own illustrations

Fig. 4.08: Buildings of the area.
a: http://www.euro-t-guide.com/See_Coun/Denmark/Jut-N/DK_See_Hanstholm_Bunker_2-1.htm
[Assessed 5 Marts 2017]
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c: http://www.scamgallery.com/product/akay-fredric-jakttorn-korall-2013
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Fig. 4.09: The appearance – the huts.
Own illustrations

Fig. 4.10: The appearance – form.
Own illustrations

Fig. 4.11: Temperature diagram.
Own illustrations

Fig. 4.12: Timewheel of activities
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Fig. 4.13: Programs - hut.
Own illustrations

Fig. 4.14: Plan - hut.
Own illustrations
Fig. 4.15: Space.
goo.gl/mhlw4L
[Assessed 20 April 2017]