Integrating restorative environments in high-rise buildings to improve physical and psychological well-being

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BACK TO NATURE

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This volume is part of a larger graduation project "Back to Nature". This volume specifically focusses on the existing literature, and the analysis of four precedents: Maggie’s Centre Gartnavel, Bosco Verticale, ING Headquarters Amsterdam Bijlmer, and Paley Park.

The examination of the literature discusses several psychological and physiological theories concerning mental health, stress restoration, how evolution and the sensory systems perceive nature and influence preference.

The precedent analyses uncovers and validates themes, strategies, and tools that can be used in the design of restorative environments. As such they provide valuable input for the toolbox, and the design part of this graduation project.
# Contents

## Part 1: Research Proposal 15

1 Introduction 16  
1.1 Symbiotic relation 16  
1.2 Urbanisation 16  
1.3 Evolutionary theory 17  
  1.3.1 Cultures 17  
  1.3.2 Selection pressure 18  
1.4 Biophilia 18  
  1.4.1 Biophilic design 18  

2 Research Design 20  
2.1 Main question 20  
  2.1.1 Sub-question 20  
2.2 Methods 21  
  2.2.1 Literature review 21  
  2.2.2 Case studies 21  
2.3 proposal 21  
  2.3.1 Thesis 21  
  2.3.2 Design 22

## Part 2: Effect of Nature on The Human Psyche 25

1 Introduction 26  
1.1 Ancient societies 26  
1.2 Scientific community 26  

2 Nature affects people 28  
2.1 Stress Restoration Theory 28  
  2.1.1 Experiments and studies 28  
  2.1.2 Radical study 29  
2.2 Attention Restoration Theory 31  
  2.2.1 Perception of preference 31
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2.2 Directed attention</td>
<td>32</td>
</tr>
<tr>
<td>2.2.3 Criteria for restorative environments</td>
<td>33</td>
</tr>
<tr>
<td><strong>2.3 Comparison</strong></td>
<td>35</td>
</tr>
<tr>
<td><strong>3 Causes of stress</strong></td>
<td>37</td>
</tr>
<tr>
<td>3.1 Stressors</td>
<td>37</td>
</tr>
<tr>
<td>3.1.1 Homoeostasis and Allostasis</td>
<td>38</td>
</tr>
<tr>
<td>3.2 Stress-response</td>
<td>39</td>
</tr>
<tr>
<td>3.2.1 Changes</td>
<td>39</td>
</tr>
<tr>
<td>3.2.2 Summary</td>
<td>40</td>
</tr>
<tr>
<td>3.3 Modulating effect of psychological stress</td>
<td>40</td>
</tr>
<tr>
<td>3.3.1 Modulation</td>
<td>41</td>
</tr>
<tr>
<td>3.3.2 Recommendations for design</td>
<td>42</td>
</tr>
<tr>
<td><strong>4 Effects of nature on the sensory systems</strong></td>
<td>44</td>
</tr>
<tr>
<td>4.1 Senses</td>
<td>44</td>
</tr>
<tr>
<td>4.2 Sensory systems</td>
<td>45</td>
</tr>
<tr>
<td>4.2.1 Traditional systems</td>
<td>45</td>
</tr>
<tr>
<td>4.2.2 Untraditional systems</td>
<td>45</td>
</tr>
<tr>
<td>4.2.3 Image vs Space</td>
<td>47</td>
</tr>
<tr>
<td>4.3 The visual system</td>
<td>47</td>
</tr>
<tr>
<td>4.3.1 Recognising objects</td>
<td>47</td>
</tr>
<tr>
<td>4.3.2 Recognising of coherency</td>
<td>48</td>
</tr>
<tr>
<td>4.3.3 Recognising of order</td>
<td>50</td>
</tr>
<tr>
<td>4.3.4 Colour</td>
<td>52</td>
</tr>
<tr>
<td>4.3.5 Light</td>
<td>54</td>
</tr>
<tr>
<td>4.3.6 Recommendations for Design</td>
<td>54</td>
</tr>
<tr>
<td>4.4 The auditory system</td>
<td>55</td>
</tr>
<tr>
<td>4.4.1 Silence</td>
<td>56</td>
</tr>
<tr>
<td>4.4.2 Ears</td>
<td>56</td>
</tr>
<tr>
<td>4.4.3 Contrast</td>
<td>57</td>
</tr>
<tr>
<td>4.4.4 Habituation</td>
<td>58</td>
</tr>
<tr>
<td>4.4.5 Fractals</td>
<td>59</td>
</tr>
<tr>
<td>4.4.6 Relaxation and health</td>
<td>59</td>
</tr>
<tr>
<td>4.4.7 Recommendations for Design</td>
<td>60</td>
</tr>
<tr>
<td>4.5 The taste and smell system</td>
<td>61</td>
</tr>
<tr>
<td>4.5.1 Olfactory organ</td>
<td>61</td>
</tr>
<tr>
<td>4.5.2 Categorisation</td>
<td>62</td>
</tr>
<tr>
<td>4.5.3 Aromatherapy</td>
<td>63</td>
</tr>
<tr>
<td>4.5.4 Recommendations for Design</td>
<td>63</td>
</tr>
<tr>
<td>4.6 The haptic system</td>
<td>64</td>
</tr>
<tr>
<td>4.6.1 Touch</td>
<td>64</td>
</tr>
<tr>
<td>4.6.2 Temperature and humidity</td>
<td>65</td>
</tr>
<tr>
<td>4.6.3 Kinaesthesia</td>
<td>66</td>
</tr>
<tr>
<td>4.6.4 Recommendations for Design</td>
<td>66</td>
</tr>
<tr>
<td>4.7 Basic orientation system</td>
<td>67</td>
</tr>
<tr>
<td>4.7.1 Recommendations for Design</td>
<td>68</td>
</tr>
<tr>
<td><strong>5 Image vs Space</strong></td>
<td>70</td>
</tr>
<tr>
<td>5.1 Intersensory experience</td>
<td>70</td>
</tr>
</tbody>
</table>
Ramps 175
Room height 176
Interior views 177
Entrance and exits 178
Private trail 179
Sight-lines 180

Summary & Conclusion 182

Bosco Verticale 185
Reduction 194
Site plan 194
Master plan 195
Analyses 196
  Competition vs reality 196
  Benefits of the trees 198
  Proposed benefits competition 199
  Changing sections 200
  Proposed benefits 201
  Balconies 202
  Apartments 203
  Functions 204
  Sight lines 205
  Detailed section competition 206
  Sight lines competition 207
  Detailed section 208
  Sight lines 209
  Trees on the West, North and East facade 210
  Trees on the West and South facade 211
  Apartments 212

Summary & Conclusion 214

ING Headquarters 217
Reduction 224
Site plan 224
Floor plan 225
Site plan 226
Section 227
Long section 228
Analyses 229
Site plan 229
Green spaces and rooftop gardens 230
Repetitions of volumes 232
Atria 233
Interior street 234
Natural light for way-finding 235
Functions and workspace 237
Sun light and sight lines 238
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun light and growth rates</td>
<td>239</td>
</tr>
<tr>
<td><strong>Summary &amp; Conclusion</strong></td>
<td>240</td>
</tr>
<tr>
<td><strong>Paley Park</strong></td>
<td>243</td>
</tr>
<tr>
<td><strong>Reduction</strong></td>
<td>248</td>
</tr>
<tr>
<td>Site plan</td>
<td>248</td>
</tr>
<tr>
<td>Floor plan</td>
<td>249</td>
</tr>
<tr>
<td>Section</td>
<td>250</td>
</tr>
<tr>
<td><strong>Analyses</strong></td>
<td>251</td>
</tr>
<tr>
<td>Gateway and height difference</td>
<td>251</td>
</tr>
<tr>
<td>Sight lines</td>
<td>252</td>
</tr>
<tr>
<td>Noise</td>
<td>253</td>
</tr>
<tr>
<td><strong>Summary &amp; Conclusion</strong></td>
<td>256</td>
</tr>
</tbody>
</table>
Part 1: Research Proposal
1 Introduction

Under the influence of westernisation our life expectancy has doubled, yet it has also created an imbalance between ancient and present ways of living (Maller, et al., 2005). During the twentieth century our population grew exponentially, we increased global food yield six times, as we did with our water consumption, and the production of carbon dioxide soared, and all to ensure our economic activity sky-rocketed (McMicheal, 2001, p.318). These rates of change in demography, economic activity and environmental conditions are called unprecedented (Last, 2002).

“As more people survive to older age, and as patterns of living, consuming and environmental exposures change, so non-communicable diseases such as coronary heart disease, diabetes and cancer have to dominate” (McMicheal, 2001, p.2). Mental, behavioural and social health problems have been shown to increase in a similar pattern (Desjarlais et al, 1995). Moreover it is expected that by 2020 mental health disorder will rise to 15% of the global burden of disease (Maller et al., 2005, p.45-46).

1.1 Symbiotic relation
It is apparent that the difference in our way of living has greatly influenced our mental health and that these lifestyle changes correlate with increased stress (Norgaard, 2006). It can even be argued that our physical environment and its effects on us are harmonious with our social environment (Radmore, 2014). Central to this argument is the harmonious relation between humans and nature, a relation which is the foundation of biophilia (Kellert, 2008). Furthermore, this harmonious or symbiotic relation concerns our entire environment both natural and built. It is asserted that an immense loss of biodiversity will negatively affect our innate biophilic need for biodiversity for human mental health (Wilson, 1993).

1.2 Urbanisation
All of this can be distilled back to how we live our modern day lives. The urban environment has only been our home for around three hundred years, while the natural environment has been our home throughout our evolutionary history (Clancy, 2014, p.38). First we lived forests then in grasslands and later in small
farming communities which still had a close association to nature. (Radmore, 2014)

Yet it is predicted that more than two-thirds of the world population will live an in urbanised area by 2050 (Adli, 2011, p.1; Department of Economic and Social Affairs, 2014). The concentration of economic activity, commerce, government, and transportation draws people towards the urban agglomerations we call cities with promises of jobs and social interaction (Abott, 2012, p.162; Adli, 2011, p.3). As such, space within cities becomes more expensive leading to a densification of the population with less recreational space due to high land value.

In terms of implications, we can see that people who spend too much time in urban environments seek contact with nature and in receiving this contact, it acts as a balm for their mental well-being (Clancy, 2014, p.38-40; Maller et al, 2005). If as Wilson (1993) fears we lose the “biophilic part” of our mind through under stimulation, we lose one of the ways through which we cope with reduced mental well-being.

It has been suggested that these observations can be used in a joint effort as a way of training our biophilic tendencies through creating more open and green spaces in the fabric of the city (Maller et al., 2005).

1.3 Evolutionary theory
Whilst biophilia is a primary concept in ecopsychology, there are arguments against it (Bone, 2009). Since biophilia can be seen as biologically predetermined, it is in conflict with our social environment (Kahn, 1997, p.7). Some of the most important examples are behaviourism and the theories of conditioning (Bone, 2009). In other words, what is nature and what is nurture.

1.3.1 Cultures
Over the course of decades many accounts detailing the preference for nature have been gathered. Not just in the field of psychology but across different fields (Kellert, 2008; Maller, et al., 2005; Malnar and Vodvarka, 2004; McMicheal, 2001, p.2; Wilson, 1993; 2008). This information is not based on a single demography, country, or culture and while there are still cultural differences in these preferences there are remarkable similarities across cultures in what people prefer.

Kellert (1996) finds that each culture treats nature differently and as such the relation they have with nature differs as well. From his extensive research he distils that German people scored high on moralistic and ecologistic value while the Japanese people scored high on a dominionistic value of nature and wildlife. This means that where the German people are willing to put aside practical needs to maintain pristine and wild nature, the Japanese people often seek to manipulate nature and prefer cultivated natural elements. (Kahn, 1997, p.9-10)
1.3.2 Selection pressure

One explanation for these general preferences is how our evolutionary history predisposed us to like certain elements or features (Kahn, 1993). It was found that simply adding a water feature to an environment, the environment received a lot more preference (Kaplan, 1992; 1995; Kaplan & Kaplan, 1989; Kaplan, Kaplan & Ryan, 1998; Ulrich, 1979; 1981). Ulrich (1993) offered that advantages by specific natural settings during our evolutionary history could have been so central to survival that natural selection favoured those who acquired and retained positive responses to those settings.

As such the universal preference for water dates back to when its presence heightened the possibility of human survival (Kahn, 1997, p.5). Natural selection of course favoured those individuals who were able to find and use water, eventually leading to a genetic disposition towards water. This evolutionary or genetic predisposition for the presence or absence of certain elements is called “selection pressure” (Kaplan, 1992, p.587).

1.4 Biophilia

In essence biophilia is an all encompassing theory trying to find a universal denominator explaining preference for natural elements in everything, as such, in architecture as well (Kellert, 2008; Wilson, 1993; 2008). Although the biophilic theory is controversial in it trying to explain all aesthetic preferences, thus much too broad for the scope of this thesis as well, there is some merit to parts of the theory.

It must be said that there are other architectural styles that treat the connection people have with nature in a similar matter. However where biophilia is too broad, vernacular architecture, sustainable architecture, green architecture and biomimicry, examples of similar architectural styles, are too narrow to determine strategies for the integration of restorative environments in high-rise buildings. Since Biophilia is an umbrella theory it deals with all the relevant aspects of these architectural styles.

1.4.1 Biophilic design

As Biophilia is such a broad and new theory its definition is quite fluid. This is apparent not only in the literature regarding the concept of Biophilia but in the critiques as well (Bone, 2009; Kahn, 1997). For the purpose of this thesis, Biophilia as Stephen R. Kellert (2008, p.3) defined it will be used. According to his writings “biophilia is the inherent human inclination to affiliate with natural systems and processes, especially life and life-like features of the non-human environment.”

He further argues that although our biophilic tendency has been shaped by thousands of years of natural selection it remains a “weak biological tendency”. It is subservient to human choice and as such biophilic values are variable yet bound by biology. Thus concluding that biophilia is the result of both nature and nurture. (Kellert, 2008, p.3-4)
Dimensions
The definition that Kellert (2008, p.3) uses can still be interpreted quite broadly and fluidly. Therefore Kellert identified additional components that limit and clarify the scope of Biophilia in the field of architecture. Biophilia deals with two dimensions: an organic or naturalistic dimension, and a place-based dimension.

Organic dimension
This dimension can be interpreted to be directly, indirectly, or symbolically reflected in design. Direct experience of the organic dimension is relatively unstructured as it deals with self sustaining features of nature such as: daylight, vegetation, animals, bodies of water, natural habitats and climate. (Kellert, 2008, p.5-6)

Indirect experience is more structured since these features require human maintenance such as: potted plant, aquaria, and fountains. (Kellert, 2008, p.5-6)

Symbolic experience of the organic dimensions does not actually involve natural elements but rather the representation of nature through different media such as: paintings, photographs, and films. (Kellert, 2008, p.5-6)

Place-based dimension
This second dimension concerns itself more with ingraining buildings and landscapes in the individual and collective identities of people. This is accomplished through culture, history and local materials to bring buildings and landscapes alive in the minds of people. (Kellert, 2008, p.5-6)

Ingraining buildings and landscapes in the collective identities of people also ensures that people will take better care of those buildings and landscapes as they are part of the place they call home. (Kellert, 2008, p.5-6)
2 Research Design

It is clear that in spite of the controversy of the biophilic theory there is evidence supporting that nature has a positive influence on the mental health of people. It has become clear as well that our modern society largely ignores this influence and is slowly distancing itself from the influence of nature, running the risk of losing the “biophilic part” of our brain (Wilson, 1993).

2.1 Main question
The main focus of this thesis is thus:

How to integrate nature with the architecture of interior and exterior spaces in buildings with high stress environments in order to harness the positive effects on the human psyche.

As such architecture can reconnect society with nature by not only making cities concentrations of economic activity, commerce, government, and transportation but of nature as well.

2.1.1 Sub-question
In order to fully understand the intricate symbiotic relation between people and nature, this thesis will focus on two sub-questions in order to answer the main query.

How does nature influence psychological and physiological well-being?
As stated before, nature influences both psychological and physiological well-being. By answering this question, knowledge is gained on how nature exacts this influence and how these effects can be translated into architecture. This question focuses on several interrelated topics:

- Restoration from stress through nature;
- Stress and its cause;
- Perception of the surrounding environment by the sensory systems;
- The influence of the prospect refuge theory on modern life.

The outcome is used to define the scope of the project and thesis and helped to identify possible directions for the themes, strategies and tools for the toolbox. The methodology used to answer this question is a literature study.
What are the physical and spatial characteristics of restorative environments
To be able to formulate themes, strategies and tools for the toolbox it is important to understand the physical and spatial characteristics of restorative environments. This question has two different focal points:

- What can be learned from existing pattern languages;
- and how are the restorative qualities integrated in architecture.

The outcome forms the framework for the toolbox, providing insight into how the abstract theoretical finding can be translated in viable tools that can be used by architects. The methodology used is twofold: a literature study, and a series of case studies.

2.2 Methods
Two different methods are used to answer the main and sub-questions. An elaboration on these methods can be found in the paragraphs below.

2.2.1 Literature review
The literature review will focus on psychological and neurological literature dealing with stress, the neurological processes related to stress, and the sensory systems. Important in this review are the stress restoration theory by Ulrich (1979) and the attention restoration theory by Kaplan & Kaplan (1989). This will be complemented by architectural theory on the sensory systems in which the works of Malnar and Vodvarka (2004), Pallasmaa (2005), and Sternberg (2009) are important.

2.2.2 Case studies
The case studies are performed to find out how reference projects deal with similar issues. These case studies are selected based on their restorative capacity, while ensuring a range of different topologies, functions and sizes are chosen. The themes, strategies and tools used to design the restorative environments are derived by combining the results of a morphological analysis of the precedents with the results of the literature studies.

2.3 Proposal
This thesis is part of a larger project. As such the proposal has two parts, the thesis and the design. The conclusions of thesis, in the form of a toolbox, will be the backbone for the project, whereas the design will be used to test the toolbox in a larger context and thus provides feedback on the conclusions of the thesis.

2.3.1 Thesis
Given the knowledge that perceiving nature positively affects us and the dismissal of this knowledge by the scientific community due to its controversy a theoretical framework is proposed. This framework connects intuition and neurological evidence, grounding the effects of perceiving nature as a hard science.
This chapter will start out by examining the environmental researchers that first attempted to generate evidence detailing the effects of nature on people. These studies however were concerned with proving the effects of nature rather than how nature can affect people.

In order to understand how nature affects us, the physiological effects of the stress response will be introduced as a basis for how the world around us can affect both our mental and physical state.

Following the stress response, the neurological workings of the senses and the role they play in perceiving the world around us are discussed. Providing the first notion on how nature and by extend architecture can influence our physical and mental state.

The theoretical framework will used to morphologically analyse four case studies in order to gain insight in different ways to translate the framework into themes, strategies and tools. Each of the case studies deals with different focal points, such as high-rise, landscape, offices, dwellings, noise pollution, nature and water.

The conclusions of both the literature and the case studies will be compiled in a toolbox detailing themes, strategies and tools that can be used to design restorative environments. The toolbox is not limited to a specific typology but will rather be non exhaustive general collection applicable to a multitude of different scenarios.

During the course of the thesis each section will be concluded with a paragraph for restorative design. In these paragraphs recommendations for design will be provided, casting forward to the proposed toolbox. The references towards design strategies will be identified with (a letter), while the references to the design tools can be recognised by (a number).

2.3.2 Design
The design will function as a test case for the toolbox defined in the thesis. It will constitute a mixed-use high-rise building in centre of Rotterdam, the Netherlands. The different aspects of the design will test the versatility of the toolbox and seek for its limits providing valuable feedback.
Part 2: Effect of Nature on The Human Psyche
The concept of restoring through nature is both ancient and modern (Marcus & Barnes, 1999, p.1-3). As a species we have lived the majority of our evolutionary history in a natural world. During this time our minds and bodies came of age and as such we depend on nature for our physical and psychological well-being. (Clancy, 2014, p.38-40)

Since the earliest construction of dwellings healing places were always found in local natural environments. Among the oldest of these healing places were, springs, groves, caves or simply a rock with special meaning. Long after the first dwellings were constructed, places of healing began to change. In the western civilisation stands of groves, caves, and healing springs were turned into the predecessors of hospitals and infirmaries in the form of temples. (Kahn & Hasbach, 2012, p.1-12; Marcus & Barnes, 1999, p.1-3; Sternberg, 2009, p.2-7)

1.1 Ancient societies
The Greek civilisation built temples that were devoted to the god of healing Asclepeion (Sternberg, 2009, p.63). Although the typology of places of healing changed to reflect society at that time, the concepts stayed the same. These Greek temples were still strongly connected to nature through their inner courtyards (Sternberg, 2009, p.220). Even later infirmaries in monastic communities were places where herbs and prayers were the focus of healing. A cloistered garden still was an essential part of these environments. (Marcus & Barnes, 1999, p.96-97)

1.2 Scientific community
Yet as society flourished we have largely forgotten the effect that nature has on our physical and psychological well-being. Our attitudes changed from healing, to diagnosing and treating (Sternberg, 2009, p.3). Deep down we intuitively know that perceiving nature affects us, yet intuition is not accepted as evidence in the scientific community. The scientific community is evidence based and evidence gathered by environmental psychologist researching the phenomena of restoring through experiencing nature was viewed as soft science (Marcus & Barnes, 1999, p.1-3; Sternberg, 2009, p.3-5).
Introduction

Though the typology of places of healing changed to reflect society at that time, the concepts stayed the same. These Greek temples were still strongly connected to nature through their inner courtyards (Sternberg, 2009, p.220). Even later infirmaries in monastic communities were places where herbs and prayers were the focus of healing. A cloistered garden still was an essential part of these environments. (Marcus & Barnes, 1999, p.96-97)

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Figure 2.1:
Left top - A hindu statue in a Devara Kaadu, small sacred groves meant for worship and are left untouched. (Source, 2015)

Figure 2.2:
Left middle - Uluru in the centre of Australia, a spiritual place for the local aboriginal people. (Source, 2015)

Figure 2.3:
Left bottom - Pamukkale or Cotton Castle, a series of healing hot springs in the shape of natural terraces. (Source, 2015)

Figure 2.4:
Right top - Asklepi- on near Pergamum in Greece. (Source, 2015)

Figure 2.5:
Right middle - Cloister garden in New York, a place where people can rest and contemplate. (Source, 2015)

Figure 2.6:
Right bottom - Tokyo, a mega city with very little places for healing
2 Nature affects people

Frederick Law Olmsted, a renowned American landscape architect is often considered the first to describe the benefits of nature for people (Kaplan, 1995, p.170; Ulrich, 1979, p.17). He believed that urban dwellers find nature relaxing, and wrote that nature in urban environments brings “tranquillity and rest to the mind” (as cited in Ulrich, 1979, p.17).

From the intuitive musings of Olmsted originate two bodies of literature within environmental psychology. Roger S. Ulrich (1979; 1981; 1983; 1984) specifically looks at the effects of viewing nature on stressed individuals, while Rachel Kaplan & Stephen Kaplan (1989; Berman, Jonides & Kaplan, 2008; Kaplan, 1995; Kaplan, Kaplan & Ryan, 1998) focus on the effects of fully experiencing nature through immersion on attention.

2.1 Stress Restoration Theory
Ulrich found that there is a relentless notion in all cultures that exposure to nature positively influences human psychology. He refers to this phenomenon as the “health benefit assumption” (Ulrich, 1979). Many people, both in the scientific community and among the general public, often believe this, yet the majority of research dealing with this subject was based on subjective psychological data rather than physiological measurable data. This scientific gap motivated him to perform studies in which the influence of visual exposure to outdoor environments on well-being is evaluated. (Ulrich, 1979; 1981; 1983; 1984)

2.1.1 Experiments and studies
In order to evaluate specific cases of visual contact with outdoor environments, Ulrich conducted a series of studies. First and foremost he found that natural landscapes in the form of photographs resulted in decreased stress levels when the subjects viewed photos of vegetation or water as compared to urban landscapes (Ulrich, 1979, p.21-22). Compared to the influence of the landscape photographs especially water had more beneficial influences on psychological states (Ulrich, 1981, p. 548). The beneficial effects of landscapes that predominantly contained vegetation were stronger for females than for males.
Arousal
However while evidence favouring natural scenes is ample, it is clear that exposure to natural environments did not have a global beneficial effect on the psychological and physiological states (Ulrich, 1981, p.549). Ulrich proposes that people benefit from visual contact with nature when they are in states of high arousal and tension. For people experiencing these states of arousal nature appears to reduce arousal more effectively than urban environments. For cases in which people are under-stimulated and experience low arousal it might be that visual contact with urban environments has more beneficial influences than exposure to natural landscapes. (Ulrich, 1981, p.548-552)

Preference
In the previous experiments the photographs were carefully selected from hundreds of similar photographs by a jury (Ulrich, 1979; 1981). This however created a bias in the final selection of natural landscape photographs. They were chosen to elicit a positive reaction from the viewers thereby overstating the beneficial effects of visually experiencing nature.

Although Ulrich mostly focusses on documenting the effects of visually experiencing nature scenes, he also analysed the photographs of natural landscape in order to determine why some are more preferable than others. Through these analyses several properties were found that if present increase the preferable-ness of the scene. (Ulrich, 1979; 1981)

Ulrich postulates that feelings of like-dislike emerge early in visual encounters with natural scenes as part of the initial generalised reaction. Subsequently this generalised reaction can be refined through cognitive assessment. He further argues that the initial general reactions to natural scenes are elicited by the general atmosphere, the presence or absence of preferred elements. For the most part the features that elicited a positive initial reaction are the presence of “gross structural or configurational aspects, the gross depth properties and the classes of environmental content”. (Ulrich, 1983)

2.1.2 Radical study
These studies, as well as his personal experience led him to design a study investigating the association between window view and recovery from surgery. Published in Science (Ulrich, 1984), this paper raised consciousness about the potential positive effects of green space on health, and is considered a seminal paper in the field of neuroscience and environmental psychology. (Sternberg, 2009, p.2-3)

Using hospital records from 1972 to 1981 Ulrich identified and condensed data on 46 patients who received a common type of gall bladder surgery at a hospital in Pennsylvania. Accounting for the time of the year, since deciduous trees only have foliage between May and October he selected 46 patients. These patients
were divided into 23 pairs matched on sex, age, weight, medical history, hospital floor and nurses that took care of them. In each pair there was one member who had a window view on a small grove of trees, while the other member had a window view on a brick wall. Due to their hospitalisation all vital signs and other indicators of health could easily be monitored and recorded. (Ulrich, 1984)

Analysing the results unveiled that patients with a window view on the small grove of trees spent significantly less time recovering in the hospital compared to those with window views on the brick wall. Individuals with the tree view had significantly fewer negative annotations in their medical records, as well as, a significant difference in the number of pain doses they required two to five days after surgery. Those with a tree view needed fewer moderate and strong pain doses while requiring more weak pain doses than those with a brick wall. Though the difference was not statistically significant, the tree-view group had fewer post-operative complications. (Ulrich, 1984)

**Limitations**

There are however potential limitations that should be considered. Ulrich was unable to match the pairs of patients based on the surgeons that performed the surgeries due to the large number of doctors performing these surgeries. This could have created a bias if the surgical outcomes varied by doctor. (Jackson, 2013)

The researchers also measured the length of recovery in the hospital in day and not hours which potentially created a bias if the timing of surgery and discharge from the hospital varied per group. The nurse’s notes were the basis for monitoring the psychological state the patients, however they were non-standardised and could therefore be subjective. (Jackson, 2013)

Similar to the patients the mood of the nurses could potentially also have been influenced by the view from the window.

These potential limitations could have affected the conclusions Ulrich drew from his experiment. However it is unclear to what extent, if at all, these limitations affected the study results. (Jackson, 2013)

Besides these limitations the research itself is inconclusive. Although a difference between the view of nature and the

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**Figure 2.7:**
Left - Original floorplan of the rooms in which the patients recovered from their surgery. Half of the rooms are directed towards a stand of trees, while the other half is directed towards a brick wall. (Ulrich, 1984)
brick wall group has been established. It remains unclear whether the view of nature had a positive effect on the patients or the brick wall a negative effect.

While Ulrich (1984) accounted for the difference between winter and summer for trees, he did not consider how sunlight might influence the patients as well. The floor-plan of the hospital clearly shows that the rooms facing the brick wall are less likely to receive sunlight. The absence or presence of sunlight is another factor that could have influenced the patients (Sternberg, 2009, p.45).

**Provoking evidence**
Regardless, this study provided ample provoking evidence that window views influence recovery from surgery and that in general green space influences well-being. The “health benefit assumption” was no longer an assumption. These results caused additional studies to examine the effects of nature and landscape on healing and well-being (Moore, 1981; Verderber, 1986).

### 2.2 Attention Restoration Theory

While Roger Ulrich focusses on the effects of nature on stress, Stephen and Rachel Kaplan explore the effects of nature on the attentional capabilities of people. Just as Ulrich they noted the relentless notion across cultures that experiencing nature is beneficial and explored this notion further (Kaplan & Kaplan, 1989, p.2). They found that there was ample evidence that nature was beneficial but that there was a lack of a comprehensive volume that was scientifically based. Their book, an accumulation of 20 years of research, *The Experience of Nature* is such a comprehensive volume. (Kaplan & Kaplan, 1989)

#### 2.2.1 Perception of preference

By exploring how people perceive natural environments and the preferences people have, they find that there is a general preference for certain aspects, such as water, complexity and order within these environments. Although, preference is often viewed as frivolous, preference of natural environments is actually a deep and underlying aspect of human functioning (Kaplan, 1995; Kaplan & Kaplan, 1989, p.40-41; Kaplan, Kaplan & Ryan, 1998).

Unbeknownst to most people their preferences are often also based on factors such as whether they can learn more in a given environment, whether they are able to easily move about, and if they can easily navigate the area without getting lost (Kaplan, 1989, p.41-58).

These findings concur with the elements Ulrich defined by analysing the photographs he used in his experiments (Ulrich, 1983, p.95-106). Especially the aspects of order and complexity show quite a bit of overlap. These aspects are thus present in the two-dimensional plane as well as in the three dimensional plane.
Kaplan & Kaplan combined ten years of wilderness experience concerning the benefits people reap from their experience of nature. They found that people most often mentioned a sense of satisfaction and feeling rested (Kaplan & Kaplan, 1989, p.140-141).

Beyond stress
However in order to synthesise their findings of preference and the benefits of nature, they had to move beyond the concept of stress, with which Ulrich deals, and expand on the concept of attention. In 1892 William James speculated that people use two types of attention to perceive their surroundings. His concept of "voluntary attention" (as cited in Kaplan, 1995, p.169) detailed a kind of attention that went 'against the grain'. Voluntary attention was employed when a stimulus did not attract enough attention of itself, but when it was important to concentrate on it nonetheless. (Kaplan, 1995, p.169-170; 1989, p.178-180)

2.2.2 Directed attention
Crucial to the synthesis of the theories of Kaplan & Kaplan was this concept of a kind of attention that could be directed by exerting effort. Although William James emphasised the role of effort in the concept of voluntary attention, he did not consider the possibility that, in contradiction to involuntary attention, voluntary attention could be susceptible to fatigue. (Kaplan, 1995, p.169-170; Kaplan & Kaplan, 1989 p.179-180)

Frederick Law Olmsted, the source of inspiration for Roger Ulrich, did not have an as well developed concept of attention, he did however consider the possibility that the human capacity to focus could be fatigued. He recognised the need for citizens to restore this capacity by experiencing nature. (Kaplan, 1995, p.170)

Neurology
While most of the concepts Kaplan & Kaplan drew upon were deductions rather than scientific fact, they are supported by clinical neurologists. Neurological research on brain damage identified a mechanism that is similar to what both William James and Frederick Law Olmsted described almost a century before (Mesulam, 1985, p.187-188)

This mechanism in the field of neurology is called directed attention. The name refers to the fact that this type of attention can be directed to focus on a specific stimulus by inhibiting all others through exertion of will and thus effort. It is the concept of directed attention that Kaplan & Kaplan explore further in their research (Kaplan, 1995; Kaplan & Kaplan, 1989).

Fatiguing
Combining the findings of Olmsted, James and Mesulam, they describe the mechanism of directed attention as requiring an effort, being central in attaining focus, under voluntary control, fatiguing, and controlling distractions through an inhibitory process (Kaplan, 1995, p.170). It is however the possibility of fatiguing
directed attention that is central in their research into restorative environments.

Most people will not find the mechanism of directed attention familiar. However the state of mind that goes hand in hand with its fatigue is something everyone has experienced. After working intensely on a project for a prolonged time one is often left mentally exhausted. This exhaustion is the effect of fatiguing directed attention. (Kaplan, 1995, p.169-172)

Although the fatiguing of directed attention seems strange in the light of it being so crucial to human effectiveness, evolutionary this limitation is quite logical. The ability to focus on one particular thing by choice for a longer period of time would leave one susceptible to surprise since all other stimuli are inhibited. Being vigilant and alert to one’s surroundings has been more important in our evolutionary history than the ability for long and intense concentration. (Kaplan, 1995, p.169-172; Kaplan & Kaplan, 1989, p.6-7; Sapolsky, 2004, p.1-18)

Only in the modern world, in which it is more important to concentrate intensely for long periods of time, has fatiguing of directed attention become a pressing problem for our society. Even momentary lapses in directed attention at critical times can have drastic consequences. Pilots, drivers, cyclists, and surgeons present vivid examples where a lapse of directed attention can and has had dire consequences (Moore-Ede, 1993).

2.2.3 Criteria for restorative environments

Since the mechanism of directed attention is used more often in our society, exhaustion of this mechanism has become more common as well. The normal process of resting directed attention through sleep has become insufficient. Therefore different means of resting this mechanism are needed, a place where directed attention does not have to be used. (Kaplan, 1995, p.172)

The notion for these additional places or states of mind where directed attention

Figure 2.8:
Left - Necker cube, this excersise for the mind can cause directed attention fatigue without causing stress.

By focussing one can either see the blue square as the front or the red square. Keeping the mind from switching between the two views causes directed attention fatigue.
can be rested are also be found in the works of James and Olmsted.

James identified two kinds of attention, voluntary and involuntary attention (James, 1892, 217-221). Where directed attention or voluntary attention takes effort involuntary attention is the state in which directed attention is rested. Kaplan & Kaplan however found the concept of involuntary attention confusing and therefore named it fascination. (Kaplan & Kaplan, 1989, p.170-171, 184-185; Kaplan, 1995, p.172)

**Fascination**
There are many types of fascination, some people derive fascination through process, such as reading, playing golf, or knitting. In other words hobbies. However, fascination can also come from content such as plants, animals or in other words nature. The type of fascination that is universally restorative for people is one of soft-fascination. Soft fascination provides special advantages for opportunities of reflection which can enhance the restorative experience. (Kaplan, 1995, p.173; Kaplan & Kaplan, 1989, p.184-185, 192-193)

Natural environments are places that provide soft-fascination through a multitude of natural stimuli. Natural environments are thus places where people can rest their directed attention and restore their effectiveness. However just as Ulrich noted that not all photographs of natural scenes had an effect on ones health, so did Kaplan & Kaplan (1989, p.184-185, 192-193; Kaplan, 1995, p.172) find that not all natural environments are restorative. Through analysis of their wilderness experience experiments they distilled the components that environments need to contain in order to be restorative.

Although soft fascination is a crucial part of a restorative experience it does not guarantee that directed attention can be rested. Three additional components of restorative environments have been identified. These components are: being away, extent and compatibility. (Kaplan, 1995, p.172; Kaplan & Kaplan, 1989, p.185-186)

**Being away**
In principle the sense of being away frees the mind from activity that requires directed attention. Unknowingly people often use the phrase ‘getting away from it all’ for going to a restorative environment. However if one is in such a place and one keeps struggling with thoughts that require directed attention, the environment will not have the desired restorative effect. (Kaplan, 1995, p.173; Kaplan & Kaplan, 1989, p.189-190)

Rather than being a physical relocation the sense of being away is more abstract. Even a change in the gaze or acquiring a new perspective can provide the necessary mental shift. (Kaplan, 1995, p.173; Kaplan & Kaplan, 1989, p.189-190)

**Extent**
In order for the environment to be restorative it must have extent. Extent often
refers to the size of a place. However, in this case the complexity and coherency of an environment is more appropriate since size is only one of the aspects meant with extent. Obviously the environment needs to be rich enough to explore and provide sufficient soft-fascination. (Kaplan, 1995, p.173; Kaplan & Kaplan, 1989, p.190-192)

The coherency of the environment on the other hand also constitutes an important part of the restorative effect. An incoherent environment or an environment too different from the usual would provide an endless stream of stimuli to engage the mind and thus leave the mind unable to rest the directed attention. (Kaplan, 1995, p.173; Kaplan & Kaplan, 1989, p.190-192)

Compatibility
Finally the environment needs to be compatible with the purpose. A compatible environment is one where the purpose fits the environment. Yet an environment can be perfectly compatible with what it is intended for, but not with the expectation of the person seeking restoration. In such a case the purpose of the environment is incompatible with the purpose of the person. (Kaplan, 1995, p.173; Kaplan & Kaplan, 1989, p.193-195)

The environment provides information to the person seeking restoration, thus a compatible environment is one where the purpose of the person seeking restoration can be carried out without struggle. One naturally reacts to the soft fascination and automatically does what is appropriate in the environment. (Kaplan, 1995, p.173; Kaplan & Kaplan, 1989, p.193-195)

2.3 Comparison
Both the Stress Restoration Theory (SRT), by Ulrich, and the Attention Restoration Theory (ART), by Kaplan & Kaplan, propose that nature affects people in a positive manner. Where Ulrich focusses mainly on the effect of nature on one’s stress level, Kaplan & Kaplan focus more on the effect on the attentional capabilities.

Ulrich finds that nature not only improves one’s mood but also reduces one’s arousal. In other words viewing nature reduces stress levels. His findings also identify other effects such as either feeling less pain or having a higher tolerance for pain and increased speed of the healing process. Although Kaplan & Kaplan find similar effects of nature on one’s mood such as, higher rates of satisfaction and improvements in self-image, they also find that nature restores effectiveness.

It is in restoring the effectiveness of people that SRT and ART differ. Ulrich argues that stress is the cause of reducing one’s effectiveness and that reducing the feeling of stress restores one’s effectiveness. Kaplan & Kaplan however argue that, while stress is certainly one cause, prolonged intense concentration without inducing or experiencing stress can fatigue directed attention as well.
Although they may differ in cause of directed attention fatigue they do agree on the solution, restoration through perceiving and experiencing natural environments.

They also find that stress is one of the major causes for the psychological and physiological problems we face in our current society. Therefore the next section will focus on how stress is caused, in what way the body deals with it, and how changes in the environments that we perceive can facilitate this restorative effect.
Ulrich and Kaplan & Kaplan both register stress as one of the causes for lapses in directed attention and psychological and physiological problems. Stress may be one of the causes for Directed Attention Fatigue, yet it is also an essential part of life (Sapolsky, 2004). Without stress neither plants nor animals would be able to react and adapt. There is however a certain tipping point where stress becomes more damaging than beneficial.

While the focus of this thesis is on finding ways through which design of restorative environments can facilitate greater psychological and physiological comfort, understanding the causes of stress is paramount in understanding how the body reacts to the environments that are designed. Therefore being aware of stressors and how the body deals with these stressors through the stress response is crucial.

Unbeknownst to most people, who often describe stress as a feeling or a state of mind, it is actually a process whereby an organism responds to a situation that challenges or threatens its well-being.

The cognitive assessment of the situation, emotions such as fear and sadness and the coping responses are psychological factors. The physiological aspects of this process include changes in bodily function that prepare the organism for dealing with the situation. While behavioural changes are also instigated by this process. This type of stress is useful; it induces a reaction. (Sapolsky, 2004)

### 3.1 Stressors

While stress is thus the process through which the body reacts, the cause initiating this process is called a stressor. Even though there is an infinite amount of different stressors they can be divided into three categories: acute physical stressors, chronic physical stressors and psychological and social stressors. (Sapolsky, 2004, p.6, 13)

Critical is that for the vast majority of organisms stressors and stress is about a short-term crisis. Think about a prey being attacked by a predator, this scenario does not take, years, months, weeks or even days, but rather a few minutes, an hour at most. (Sapolsky, 2004, p.6, 13)
**Long term and short term crises**

For humans however, stress is no longer about short-term crisis but has become a long-term crisis. A large body of evidence suggests that such a long term-crisis, which causes prolonged activation of the stress response, can lead to stress related diseases (Sapolsky, 2004, p.6, 13).

The main difference between the short-term crisis that animals experience and the long term crisis humans experience can be found in the third category of stressors. Viewed from the perspective of evolution of the animal kingdom, sustained psychological and social stress is a type of stressor that is limited to humans and other social animals. (Sapolsky, 2004, p. 4-7)

Although there are many different types stressors, the mechanism driving the stress response is one and the same.

**3.1.1 Homoeostasis and Allostasis**

Through homoeostasis and allostasis the body tries to actively seek the perfect balance for each situation. Homoeostasis is the idea that the body has among others, an ideal level of oxygen, food, water and acidity. However it is not difficult to imagine that each situation calls for different ideal level of oxygen, food, water, acidity and energy. Take for example the amount of oxygen needed for walking and running. Therefore a general homoeostatic balance is impossible. What ideal is under basic conditions is different under stressful conditions. (Sapolsky, 2004, p.9)

Allostasis describes the idea that the body constantly seeks the perfect homoeostatic balance for each situation. The homoeostatic balance for walking and running is different and through allostasis that homoeostatic balance is achieved. Allostasis is thus “stability through change”. (Sapolsky, 2004, p.9)

**Anticipation**

However it is important to note that the homoeostatic balance does not only change under direct influence of the stressors. Considering the human tendency to worry about the future and the vigilant nature of animals, the notion of stressors being acute is not broad enough. In these cases a change in homoeostatic balance is anticipated instead of acute.
Causes of stress

Looking for example at the prey-predator example again, the prey anticipates physical damage and even though nothing harmful has happened yet, a homoeostatic balance for flight is sought and achieved. (Sapolsky, 2004, p.4-7)

It is the degree of anticipation that sets humans and animals apart. Humans can anticipate and activate the stress-response by merely thinking about possible stressors that may or may not affect them in the future. Thus activating the stress-response and seeking a different homoeostatic balance countering the perceived disruption that the possible stressor may bring. (Sapolsky, 2004, p.4-11)

3.2 Stress-response

Considering the differences between the physical and psychological stressors, the stress response is surprisingly general. As has been mentioned before, psychological and social stressors are relatively young and limited to humans and other social animals. Therefore from the perspective of evolution, the development of a physiological mechanism dealing with short-term physical stressors was much more plausible. (Sapolsky, 2004, p.10-11)

3.2.1 Changes

Evolutionary the basis of the stress response focuses on the fact that our muscles are going to have to work hard. In a threatening situation the prey is often forced to choose between either flight or fight. Regardless the choice, a massive amount of energy will soon be needed for the muscles since they are either going to have to sustain a fight or a flight. (Sapolsky, 2004, p.10-11)

**Energy**

Energy will be needed in the most readily available form and not stored in fat cells as a source for growth or healing. One of the principal effects of the stress-response is to rapidly mobilise energy from fat cells and to prevent further storage until the stressor is gone. Glucose, proteins and fat are extracted from the fat cells and deposited in the bloodstream, ready to be delivered to the area that needs the energy. In order to hasten the transport of all this energy, the blood pressure is increased, as well as the rate of breathing and the heart-rate. (Sapolsky, 2004, p.11)

**Inhibition**

However there is also a downside to the stress-response. Growth is inhibited, repairation of damaged tissue is halted and digestion is slowed. During a stress-response digestion is not the right source of energy since it is a slow process.

More importantly, reproduction and the immune system are inhibited as well (Sapolsky, 2004, p.120-122, 129-131). In males the production of sperm is halted and females stop ovulation.

**Immune system**

While most of these processes are inhibited the focus of the immune system
merely changes, in the first minutes of a stress-response the immune system is actually enhanced. It is with prolonged stress that the immune system ceases to find, identify and eliminate infections, bacteria and viruses that can potentially make one ill in the future (Sapolsky, 2004, p.151-155). These long-term processes will be resumed after the stressor has passed and the level of arousal decreases.

### Pain
Besides inhibiting processes within the body, the stress-response also affects perception. With sufficiently sustained stress, as can happen during a life threatening fight or a chase, the perception of pain is blunted. Pain is a warning that the body has been damaged and that rest is needed to heal this damage, however as one can imagine this signal is quite useless in a life threatening situation.

One can either fight or flee the stressor but stopping to let the wound heal would certainly end one’s life. Once the danger has passed, perception of pain is elevated since the wound has now become the mortal stressor. (Sapolsky, 2004, 194-198)

This reaction to pain is similar to what Ulrich documented in his window view experiment in 1984. However there is one major difference, Ulrich finds that reduction of stress reduced the pain one feels while high levels of stress, as described above apparently have similar effects. The reason for this similar reaction to these different situations will be clarified later.

### 3.2.2 Summary
Research has shown that the stress-response has three stages. The alarm stage is when the stressor is noticed or anticipated. The adaptation stage is when the body establishes a new allostatic balance through successful mobilisation of the stress-response mechanism. The exhaustion stage is entered when the organism endures prolonged periods of stress. It is not that the stress-response becomes exhausted but rather with sufficient activation of this mechanism it becomes harmful and stress-related diseases emerge. (Sapolsky, 2004, p.12)

### 3.3 Modulating effect of psychological stress
For humans whose lives generally do not evolve around survival through fighting and running for our lives, the third category of stressors, psychological and social, is the most common type of stressor. Although psychological and social stressors do not necessarily revolve around the flight or flight dichotomy the stress-response is still the same.

It is the anticipation of such psychological and social stressors, thus inappropriately activating the stress-response that is most damaging to us. Strangely enough our brain seems able to conjure up an infinite amount of likely and unlikely scenarios that cause us psycho-
logical stress (Sapolsky, 2004, p.7, 255). Everyone knows the feeling of thinking about the presentation you have to give next week. Just thinking of it will disrupt your allostatic balance and activate the stress-response, making your heart beat faster, increase your rate of breathing and making you sweat.

Not everyone, who experiences similar stressors develops stress-related diseases such as ulcers. The reason for this difference is that the effect of a stressor can be modulated and thus the severity of the stress-response is reduced. Through experimentation on rats the mechanisms that have this modulating effect have been identified as having outlets for frustration, social support, predictability of the stressors, being in control and a perception of things improving. These aspects are better known as coping responses. (Sapolsky, 2004, p.252-263)

3.3.1 Modulation
One of the coping responses is an outlet for frustration. This simply means that the energy released during a stress-response needs to be dissipated. Another outlet for frustration is social support. A shared burden is often a lighter burden.

There are two different manners through which the dissipating of the released energy can be accomplished: exercise and distraction.

Exercise
Through exercise such as walking or sporting, the energy mobilised by the stress-response can be utilised and at the same time provide a distraction if the exercise is vigorous enough.

Distraction
Creating an outlet through distraction is similar to the concept of fascination. As mentioned before, fascination can be both soft and hard, mostly when people want to relieve feelings stress and frustration they turn towards hard-fascinations such as hobbies like reading, playing golf, knitting or any other activity that one is fascinated by. However for hard-fascinations it is important that the activity is enjoyable. (Sapolsky, 2004, p.255-256)

Soft-fascination, in the form of nature on the other hand is a universal fascination for people. It automatically distracts, often due to the change of scenery and the sense of being away it creates, oth-

Figure 2.10:
Left - Maggie’s Centre in Gartnavel, a support centre for cancer patients and their family and friends, has a private walking trail where people can go an walk undisturbed as a way to relieve the stress and contemplate.
er aspects crucial to restorative spaces. (Kaplan & Kaplan, 1989, p.184-186)

**Social support**
Social support is another manner through which the severity of the stressor can be mediated. Reaching to the example of the presentation again, if one has to present before strangers the severity of the stressor is increased while generally the opposite is true if the onlookers are friends or acquaintances.

The same is true for spouses and children; they provide social support that often reduces the severity of psychological and social stressors. Although worrying about them can induce these types of stressors as well. (Sapolsky, 2004, p.256-258)

**Personality**
Yet there is a third type of modulation; personality. On the one hand the effectiveness of the coping responses described above is in part determined by one's personality and on the other hand one's personality also modulates the magnitude of the perceived stressor and the consequent stress-response. People who are above average at using the coping responses generally seem relaxed in even the most stressful situation. However, individuals who are below average at using the coping responses generally do not even try to mount a coping response. (Sapolsky, 2004, p.309-316)

The interpretation of the stressor strongly influences the magnitude of the consequent stress response. Individuals who perceive even the most neutral of interactions with their peers as threatening have an elevated stress-response in a resting state as compared to the individual who is able to distinguish between threatening and neutral situations. This elevated stress-response in resting state also means that in a threatening situation the consequent stress-response is elevated as well. (Sapolsky, 2004, p.312-315, Marcus & Barnes, 1994, p.39-41)

### 3.3.2 Recommendations for design

Both outlets for frustration and social support can easily be translated into guidelines for designs. Restorative spaces in the form of natural environments, soft-fascination, can be used to provide general distractions (G) and a way to exercise (O, 11), while social meeting places (10) within these spaces can facilitate the social support that people use to decrease the severity of stressors.

These recommendations are coping mechanisms, meaning that one's person-
ality will influence the effectiveness of a restorative environment. However, only a small percentage of people actually have such an extreme personality that it leaves them unable to enjoy the restorative effect of these spaces. Most of the population will be able to experience the effects to one degree or another.
Ulrich and Kaplan & Kaplan showed that nature affects people through reducing their stress-response by providing distractions in the form of soft-fascination. This type of distraction not only reduces stress but also allows them to rest their directed attention if the environment adheres to the other three components of restorative environments Kaplan & Kaplan identified (Kaplan, 1995, p.172; Kaplan & Kaplan, 1989, p.185-186). In turn neuroscience describes the cause of stress as a stressor, something that disrupts the allostatic balance.

The manner in which the world around us is perceived, including stressors and the components of restorative environments, is crucial in understanding why nature has this effect on us. But more importantly in understanding how architecture can facilitate the restorative effect described by Ulrich and Kaplan & Kaplan.

4.1 Senses
Everyone learns in biology that animals, including humans, perceive the world through five basic senses: sight, sound, smell, taste, and touch. Ulrich first touched upon the senses to explain why photographs were employed in his study instead of actual natural environments (Ulrich, 1979, p.17). He stated that although we have five senses, sight is by far the most influential in the perception of the world and thus seeing a photograph of a natural environment instead of experiencing it would not alter the outcome of the experiment. Simply thinking of a beautiful environment that smells like a cesspool already presents a problem with his statement.

Kaplan & Kaplan had a better understanding of this and instead of viewing nature they mostly concerned themselves with wilderness experience experiments (Kaplan & Kaplan, 1989, p.121-150). People not only visually perceive natural environments but also hear, smell, feel and taste these environments. Surpri-
ingly however is that both Ulrich (1979) and Kaplan & Kaplan (1989) in analysing the natural environments found a preference for a smooth ground level texture. Walking along a smooth and flat forest path is more restorative than a cluttered uneven rocky forest path since the mind does not actively have to search for a foothold and is thus able to wander.

This preference for a smooth ground texture means that the perception of an environment demands a more profound system of senses than simply the five senses.

4.2 Sensory systems
Malnar & Vodvarka (2004, p.41-43) as well as Pallasmaa (2005, p.41-42) argue that the traditional set of senses, sight, sound, smell, taste and touch is too limited to describe how people experience the environment around them and thus restorative environments as well as architecture. Malnar & Vodvarka do not think in terms of senses but rather how these senses are combined in sensory systems. They identify five sensory systems: the visual system, the auditory system, the taste-smell system, the haptic system, and the basic orientation system.

4.2.1 Traditional systems
Although these sensory systems still resemble the original senses there are profound differences in a few of them. The visual system and the auditory system are fairly straightforward. They use the eyes and the ears to perceive, similar to the workings of the traditional senses of seeing and hearing. The taste-smell system, as the name already implies, is a combination of two traditional senses. It is proposed that taste and smell often go together and therefore work together in a sensory system. (Malnar & Vodvarka, 2004, p.42)

4.2.2 Untraditional systems
The last two sensory systems are profoundly different from the traditional senses we are taught in biology.

Basic orientations system
The basic orientation system concerns itself with equilibrium and uses general information provided by specialised organs in the ears. Structure, vision, movement, time and balance are for example combined to navigate a worn stone path in a forest. Through the basic orientation system one is able to maintain balance, determine orientation, sense whether

Figure 2.12:
Left - The five different sensory systems as proposed by Malmar and Vodvarka
one is moving up or down and stabilise
the eyes while moving. (Malnar & Vodvar-

**Haptic system**
The haptic system is by far the most com-
lected of sensory systems. To make this
system more understandable it has been
subdivided into the three different types
of information it provides. Through touch
we gather information about texture, ma-
terial, hardness and vibrations or move-
ment of the object we are touching. Ki-
naesthesia is the sense of self, it allows
us for example to touch our nose even
though we are unable to see it. It regis-
ters muscle tension, weight, movement
through our joints and gives us a sense
of our bodily position. The last type of
information is that of temperature and
humidity, through our skin we can feel
the temperature around us, feel a cold or
warm flow of air and the humidity of the
air. (Malnar & Vodvarka, 2004, p.42-45)

The haptic system is one of the most
important sensory systems in judging
comfort of an environment, or in the case
of architecture, a space. Simply put, a
beautiful location, visually appealing and
preferable can become unbearable if the
temperature and humidity are too high.

**Perception**
Strictly speaking Ulrich was not wrong
in stating that the sense of sight is an
important way in which we perceive the
world around us. However, he under-
stated the effect other sensory systems
could have on people and thus overstat-
ed his conclusions. Building on the pre-
vious example, if the patient’s rooms had
a high enough temperature and humid-
ity level to be uncomfortable, his results
concerning visually perceiving the stand
of trees outside the window could have
been significantly lower. The same would
go for an unbearable smell in the hospi-
tal room.

It is undeniable that each of the senso-
ry systems is important in perceiving the
world, also evident is that some sensory
systems are more important than other
regarding the perception of architec-
ture (Malnar & Vodvarka, 2004, p.42-45,
Pallasmaa, 2005, p.41-46). However, this
hierarchy is not standardised but rather
influenced by past experiences, learn-
ing and cultural factors (Malnar & Vod-
varka, 2004, p.49-58). In the western
world the visual sensory system is often
considered the most important manner
through which we judge aesthetic ex-
perience (Pallasmaa, 2005, p.15), “other
cultures like the Shipibo-Conibo have
a much more pluri-sensorial aesthetic
experience”. (Malnar & Vodvarka, 2004,
p.53)

**Implications for design**
Since each of the sensory systems has an
implication for the design tools that will
be proposed later they will be discussed
separately on how they work, and how
perceiving nature through these systems
can induce the benefits that Ulrich and
Kaplan & Kaplan found.
4.2.3 Image vs Space
Since the patients Ulrich observed were lying in bed in a hospital room, separated from the outside world by glass and brick, they could not use the basic orientation system, the auditory system, the haptic system nor the taste-smell system to experience that scene. They could only use the visual system to observe the scene visible through the window. Yet the wilderness experiments used by Kaplan & Kaplan to study the restorative effects on people shows that the perception of space is not mono-sensorial but rather a multi-sensorial experience.

The difference between the view through a window and the wilderness experience is the same as the difference between an image and a space respectively a two-dimensional and three-dimensional experience.

In order to fully understand the difference between the experiments of Ulrich and Kaplan & Kaplan and thus the difference between an image and a space one has to understand how each of the sensory systems work and what type of information they respond to.

The sensory systems will be discussed in the following order: visual system, the auditory system, the taste and smell system, the haptic system and the basic orientation system.

4.3 The visual system
Looking at the experiment that Roger Ulrich performed in 1984 it becomes clear that there is a significant difference between looking at an urban view with brick walls and a simple grove. What is it about viewing those trees that soothes the viewer, or looking at the brick wall that stresses the viewer?

The eyes
The visual system is based on the information photoreceptors gather. These receptors-cells are only located in the retina. Under influence of photoreceptors the eyes have the ability to focus and detect visible light. This is accomplished through two different types of photoreceptors; rods and cones. The rods responds only to light and dark while the cones respond to the different wavelengths of the light, however the cones become less sensitive in dim light. (Bluyssen, 2009, p.25-26; Sternberg, 2009, p.27)

The rods and cones are located in the retina, the back of the eye. Visible light enters through the pupil and is projected onto the retina (Bluyssen, 2009, p.25-26). When the light reaches the pigments in the photoreceptors a chemical reaction is triggered. This in turn generates an electrical signal that eventually travels through the optic nerve to the visual cortex in the brain. (Bluyssen, 2009, p.25-26; Sternberg, 2009, p.27)

4.3.1 Recognising objects
The eyes only register parts of contrasting lines, the visual cortex connects these
lines by filling in the blanks, creating a shape. Simultaneously a different part of the brain compares this shape to the visual memory. Once it finds a close enough match, the object is recognised. Consequently different regions in the brain use this information to determine what to do with the object. (Sternberg, 2009, p.28-29)

Depending on the type of object that is identified, different regions within the brain are activated. If the object the eyes register is identified as, a tool, the motor cortex will be activated. This region is specialised in controlling the muscles. (Sternberg, 2009, p.29-30)

Each category of objects has a region in the brain that is specifically adapted to recognise such objects. Faces, animals, tools, each object category has their own region in the brain that becomes active. (Sternberg, 2009, p.29-30)

Recognising buildings
Interesting to note is, that there is a specific region in the brain that recognises buildings. This is surprising when one takes into account that the stress-response has adapted through millions of years of evolution to deal with acute physical and chronic physical stressors but not to the much more recently developed psychological and social stressors. How is it that there is a region in the brain that specifically adapted to recognise buildings, objects that are even younger than psychological and social stressors? (Sternberg, 2009, p.30-31)

One of the theories trying to explain the development of this region in the brain speculates that the region does not specifically recognise buildings but rather large objects, landmarks that are used for navigation. These objects can only be viewed from a distance and from a limited amount of angles. During evolutionary history these objects would have been mountains, hills, and other large objects that were landmarks in the ancient landscapes. (Sternberg, 2009, p.30-31)

4.3.2 Recognising of coherency
Another important region in the brain is dedicated to recognising scenes; large amount of objects grouped together. This region becomes active when one views a scene but is only weakly activate when viewing a single object.

It has also been shown that when a subject views a familiar scene a different area of the brain is active than when they view
an unfamiliar scene. Epstein explained this by linking the familiar to memory and that memory is evidently important in locating familiar scenes. (Sternberg, 2009, p.31)

**Individual elements**

When first viewing an unfamiliar scene it can be recognised for what it is, a beach, a street, meadow of wild-flowers, or farmland. This is because the brain, recognises the individual elements such as flowers, the general image of a building, a lamp-post, or a car. (Sternberg, 2009, p.31-32)

**Narrative**

When identifying a scene the brain not only looks for individual identifying objects but also for a narrative that ties the objects together. This narrative allows us to recognise the function of a scene such as, urban, farmland, meadow, or street. However when there is an inconsistency within the narrative it induces a feeling of unease, a feeling of wrongness. (Sternberg, 2009, p.32)

From the wilderness experiments Kaplan & Kaplan (1989) distilled four aspects that determine the preference for a scene. They argue, similar to Ulrich (1983, p.95-106) that the brain first judges a two-dimensional image to assess the coherence or complexity, in other words the narrative (Kaplan, Kaplan & Ryan, 1998, p.13). Almost immediately followed by legibility and mystery, which are judged in the third dimension.

**Depth**

For the visual system the third-dimension often entails a sense of depth. The brain deals with two different types of depth: distance and immersion. The depth perceived by visual system is distance. (Gibson, 1950, p.2-9)

The scene perceived by our eyes consist of light projected through lens onto the retina. It is often thought that this projection is similar to a photograph. As such the three-dimensional elements present in the scene are flattened. (Gibson, 1950, p.2-9; Lim, 2011)

Yet even while looking at a photograph or when we are standing still while viewing a scene we are able to perceive this distance.

There are multiple theories that propose how our brain is able to recreate or perceive the distance between the objects in the flattened scene (Gibson, 1950). These theories will be discussed at a later stage since they are concerned with mul-

**Figure 2.14:**

Right - In this scene the narratives clash. On the one hand the lantern implies an urbanised area where people often walk at night. On the other hand the forest and the dirt path imply an natural landscape. This clash in the narrative creates a feeling of unease.
tisensorial experiences and thus draw on the other sensory systems as well.

Yet for now it is enough to recognise that the brain differentiates between nearby elements and far-away elements when viewing a scene. The nearby elements are recognised as objects while the far-away elements are processed as a scene.

The brain constantly scans the far-away elements for objects that stand out. Once such an object has been found the brain zooms in and back out again, resuming the scanning of the horizon. (Sternberg, 2009, p.32-33)

**Endorphins**

The nerve cells along the neural path leading from the visual cortex to the parahippocampal place area contain many receptors for endorphins, which are akin to morphine (Sternberg, 2009, p.33). When people view scenes that are commonly perceived as preferable the nerve cells along this pathway become active. In other words when one looks at a pleasing landscape the brain releases endorphins which reduce the perception of pain and can trigger an overall positive feeling in the body as well (Bloom, 2011).

Earlier on the discrepancy between the findings of Ulrich and the effects of the stress-response in reducing the perception of pain were noted. The release of endorphins by the brain when viewing pleasing landscapes explains the findings of Ulrich, explaining the discrepancy as well. It seems that not only stress but also pleasure can induce the reduction in pain perception.

Endorphins are not only able to reduce the pain perception, many studies link them to feelings of happiness as well (Bloom, 2011). This explains the reduction of arousal or stress Ulrich found in his patient. Under the influence of endorphins excreted due to the pleasing view of the grove, the severity of the stress-response in the patients Ulrich observed was decreased. Thus explaining why patients viewing a grove would heal faster. The inhibition of the healing mechanism resulting from the decreased stress-response would be less severe as compared to patients viewing the brick wall.

4.3.3 Recognising of order

Besides the overall scene itself and the landscape it represents, the organisation of the objects within a scene can have a positive effect on the perception of a scene (Sternberg, 2009, p.33-34). In other words this concerns the complexity of a scene, which is another aspect judged in the two-dimensional plane (Kaplan, Kaplan & Ryan, 1998, p.14).

A group of Japanese researchers used mathematics to analyse the arrangement of the objects in the dry landscape garden of the Ryoan-ji Temple in Kyoto (Tonders, Lyons & Ejima, 2002). The arrangement of the rocks in this dry landscape was created in the fourteenth century and the analysis found that the rocks were arranged in a series of branches that originated from a central
Furthermore, each individual branch was identical to every other branch in the system. (Sternberg, 2009, p.33-34)

**Fractals**

Such a repeating pattern is known as a fractal pattern. If the pattern is identical at every scale it is called a self-similar pattern (Tonders, Lyons & Ejima, 2002).

The arrangement of the rocks, an example of such a self-similar pattern, is not unique within nature. There are countless phenomena that express fractal features: river networks, fault lines, lightning bolts, trees and the veins on a leaf (Sternberg, 2009, p.34). Fractal patterns can even be found within our bodies; the nervous system, blood vessels and our heart beat (Goldberger, et al., 2002).

Although it has been proven that fractal patterns are calming it is unclear why they are perceived as calming. Goldberg-er (1996) suggested that fractal patterns allow our “mind to move inward or outward, up or down, at will” (as quoted in Sternberg, 2009, p.35). This means that there is nothing unusual for the mind to notice and thus no stressor that can activate the stress-response. As such the consequent scene is viewed as preferable, stimulating the release of endorphins.

**4.3.4 Colour**

As mentioned before the photoreceptors in the eyes register both light and colour. The cones in our retina register the colour we perceive. Each cone is programmed, through our genes, to register one of three colours, accomplished through two different proteins. The first protein is called opsin and reacts to the wavelength of the light that reaches it. The second protein is made from vitamin A, which can be found in a multitude of vegetables (Bluyssen, 2009, p.25-26; Sternberg, 2009, p.36-37)

The information the cones gather is send to the visual cortex as well. Adding this information to the shape it produces. This enhances our ability to recognise
the objects we see. Surprisingly we can only identify three different pigments; green, blue, and red. However with just these three pigments we are able to account for the entire visual spectrum. (Sternberg, 2009, p.37-38)

**Evolution**

Through analysing our genes it became clear that the genes for the different pigments emerged during different periods of our evolutionary history. First to develop was the pigment that responds to the yellow-green range of wavelengths. Second, the pigment responding to the blue range wavelengths and the third pigment responds to the orange-red wavelengths. The period in which the different pigments emerged correspond with the need to see specific colours in the ancient landscapes that were around in those times. (Sternberg, 2009, p.38-39)

The emergence of green corresponds with the need to distinguish plants. The blue wavelength allowed animals to differentiate between the different shades of green, thus being able to see the individual plants. The pigments that registers orange and red wavelengths developed around the time when early primates began to eat fruit and needed to identify the bright colours of fruit from the green background. (Sternberg, 2009, p.39)

Most of our evolutionary history has not been spent in urban environments but in forests and fields; landscapes that teem with shades of green. One of the explanations provided for the restorative effect of nature, is that the colour green is the default setting of our brain. It was the first colour our eyes could recognise and made up most of the scenery in primeval times. Although this evolutionary theory is still unproven it would account for why so much of what the eye sees falls within the colour green. (Sternberg, 2009, p.39-40)

**Emotions**

There are many articles that deal with the influence of colour on our emotions. Most find that the longer wavelengths such as red and yellow are stimulating while blue is calming. However they also find that the colour green is balance. It signifies the medium wavelengths in the middle of the spectrum of visible light. The brain does not need to adjust this colour as with all the other colours in the visible spectrum, therefore the colour green is restful to our eyes and our mind. (Sternberg, 2009, p.40-41)

**Foliage**

Ulrich in his experiment only analysed patients operated between May and October, the months during which the trees had foliage (Ulrich, 1984). Although he did not describe the effect of colour specifically he did take into account that trees were more preferable during the time they had leaves. Thus just as the scene and its objects elicited a sense of pleasure, the colour of the foliage had a restorative effect. It is unknown what the exact effect of colour is on the secretion of endorphins but it is reasonable to assume it only contributed to the general
preferableness of the view and on the excretion of endorphins as well.

**Water**
However the preference for the colour green does not explain why people also express a preference for water, which in most cases is a shade of blue. Yet as mentioned before the blue wavelengths are experienced as calming. This is however not the whole reason that people have a preference for water, it is also the rhythmic movement of water that draws ones attention and allows the mind to wander.

**4.3.5 Light**
Besides colour, texture, and shape our bodies also react to the intensity of sunlight. This is all too clear by looking at the high rate of depression in the northern and central Europe during the winter months. This form of depression, which is often attributed to gloom or lack of sunlight, is known as seasonal affective disorder. In contradiction to what most people think, this kind of depression can also be brought on by long-term exposure to artificial light. (Sternberg, 2009, p.45)

**Seasonal affective disorder**
People who suffer from seasonal affective disorder feel depressed, sluggish and fatigued. The reason for this is that hormones such as epinephrine and norepinephrine are excreted under the influence of light intensity. They are synchronised with the rising and setting of the sun. Just before dawn the brain starts excreting hormones. The peak of hormone production is during the end of the morning after which the production gradually halts. This is the reason we wake up in the morning and need a coffee or similar boost at the end of the day. (Sternberg, 2009, p.45-46)

**Artificial light**
Artificial fluorescent lights, used in offices, have a different intensity and light spectrum than natural sunlight and it is these two aspects that influence this natural rhythm the most. Prolonged exposure to fluorescent lights in offices also means prolonged concealment from natural sunlight. Since if there is enough sunlight, why would artificial lights be needed?

Therefore prolonged exposure to fluorescent light in offices can induce seasonal affective disorder. (Sternberg, 2009, p.48-49)

**4.3.6 Recommendations for Design**
The combined flow of information from the photoreceptors in the eyes has several implications for restorative environments and design in general. Objects, scenes, fractals, colour and light all influence us in one way or another and thus provide valuable information for design in general.

**Habituation**
Objects, and how we have learned to use them, greatly influence our perception. If a specific type of nature is associated with a positive memory this type of na-
nature will enhance positive effect on our physiological and psychological state.

This process, called habituation, will be discussed further on. However this means that perception of design in general is subjective rather than objective and so is the intensity of beneficial effect of nature on people.

**Composition**
The composition of the scene, coherence and complexity (A), greatly influence the preference for certain scenes. This means that objects that are known and associated with nature contribute to the narrative of natural environments.

However elements that give the scene an ambiguous feeling will reduce the preference of that scene. Great care should therefore be taken when designing restorative environments in high-rise buildings. By definition a natural space rich in vegetation on the upper floors will induce an ambiguous feeling and reduce the preference of that environment over a ground bound natural environment.

**Fractal patterns**
Furthermore, compositions through fractal patterns (1, 2) allows the mind to turn inward more easily. However it needs to be said that fractal patterns do not have to be obvious. It was only after in-depth mathematical analysis of the dry landscape of Ryoan-ji Temple that the fractal pattern was discovered. Designs embracing fractal patterns should therefore also look to the essence of fractals instead of merely replicating shapes.

**Colour**
Colour (H, 29) is one of those highly controversial aspects in the psychological world. Most research is ambiguous in its outcome and theories surrounding the preference of colour is unproven. Although unproven, the conclusions are reasonable and thus provide valuable input for design. The green spectrum of light has to be modulated the least by our eyes and brain thus inducing a feeling of balance. If one is overstimulated as in the case of stressed individuals than green will decrease the level of arousal (Sternberg, 2009, p.41-42).

**Natural light**
Light (K) in general affects our moods. While light or dark does not directly affect our stress-response it does affect the effectiveness of registering objects, scenes, patterns and colour.

Thus the effect of light is two-fold. On the one hand sufficient light reduces the chance of depression, while it enhances general visual perception as well.

### 4.4 The auditory system
In the western world it is often assumed that the visual system is the most important sensory system in perceiving architecture (Malnar & Vodvarka, 2004, p.53, Pallasmaa, 2005, p.41-42). Yet it is simply the most consciously experienced sensory system.
The world we perceive is not limited to visual stimuli, it is filled with a multitude of other stimuli, some of which are experienced subconsciously, that affect our perception. Each of the sensory systems contributes to the overall perception of environments through an intricate intersensorial interplay.

One of the other stimuli in this interplay that greatly affects whether we find a space pleasant is sound.

4.4.1 Silence
David Thoreau once said, "I want to hear the silence of the night... The silence rings." (as quoted in Sternberg, 2009, p.53). However silence cannot be heard, there will always be sound to perceive. Even in anechoic chambers, rooms designed to have negative decibels, sound can still be perceived. Not sound from external sources but rather from internal sources: the beating of ones heart, the rattling of breath and the flow of blood (Samuel, n.d.).

When Thoreau referred to the silence of the night, it was not silence he meant but rather the absence of everyday sounds. The night is generally a time when sounds produced by humans quiet down and the sounds of nature can be heard. No more engines, no more talking, no honking, no sirens, just what people call silence. It is the absence of everyday sound that is comforting for people instead of the silence they refer to. (Sternberg, 2009, p.53-54)

4.4.2 Ears
Sound is perceived in a similar manner to light, through the use of a single sense, the ears (Bluyssen, 2009, p.36-38; Malnar & Vodvarka, 2004, p.43; Sternberg, 2009, p.53). Sound travel in waves meaning that the ear actually perceive minuscule movements of air molecules. The sound waves are reflected and attenuated when they reach the pinna, providing additional information used to determine the direction from which the sound came.

From the outer ear, the sound waves move to the middle ear where the wave hit the ear drum. The wave information travels through a series of delicate bones: the hammer, anvil and stirrup to the inner ear. The organ of Corti in the inner ear converts the wave information into electrical activity through hair cells. (Bluyssen, 2009, p.36; Sternberg, 2009, p.54)

This organ of hair cells is the real organ of hearing. It is a flat, ribbon-like structure winding around in a spiral, similar to a shell. Each filament of a hair cell is a different thickness and thus vibrates at different sound frequencies. In the final step in transporting the wave information, the vibrating hairs trigger electrical impulses. The frequency with which these electrical impulses are fired correspond with the frequency of vibration of the hairs. (Bluyssen, 2009, p.36; Sternberg, 2009, p.55)
Where and what
The electrical signals are finally divided into two streams of information, the where- and the what-stream. As the name already suggests the where-stream is used to determine the direction from which the sound came and the what stream identified what the sound is. In the animal kingdom species are adapted to better deal with one of the streams of information. Bats for example are specialised in the where, while primates are adapted to deal with what. (Sternberg, 2009, p.55)

Due to humans having two ears to perceive sound with, we can gauge the general direction of the sound. The brain perceives the slight discrepancies between the information the ears gather. We can also determine whether a sound is stationary or where it is moving too; coming closer or moving away. (Bluyssen, 2009, p.38; Sternberg, 2009, p.55)

The what-stream is directed to several different areas in the brain, the speech area, areas for musical detection and various emotion centres. This feature extraction is a crucial part in which we perceive sounds. The speech area extracts the spoken language, while the music area extracts pitch, timbre, contour and rhythm. The emotion areas are the reason why sound can elicit emotional responses. (Bluyssen, 2009, p.38; Sternberg, 2009, p.56)

As will be discussed further on, just as with the visual sensory system, contrast is an important aspect to interpreting sound. Sound, more than with visual stimuli, can be habituated to recall a certain memory, relive the emotions and acquire the state of mind during that memory.

4.4.3 Contrast
Thoreau says “The silence rings” (as quoted in Sternberg, 2009, p.53). However it is not the silence that rings, it is the contrast between everyday sounds and silence he refers to that rings. Just as with vision it is contrast that draws our attention. The jolt we experience when someone screams in a quite space.

When someone screams in the bustle of a busy city, the scream is hardly noticed. There is too little contrast between background noise and the scream to be perceived. Many large cities have to deal with this problem. Sirens that used to signal emergencies are now drowned in the sound pollution produced by everyday life. (Sternberg, 2009, p.59-60)

Jolt
The reason that contrast gives us a jolt can be found in the nerve cells. They respond better to a sudden change than to repeated stimuli of similar intensity. This is not only true for the auditory system but for all other sensory systems as well. One could argue that loud noise would always induce a jolt, however the contrast is measured against the nerve’s background firing rate. A soft noise in a quiet room can therefore induce a similar jolt to a scream in normal room. (Sapol-
In animals the jolt we experience is called a startle-response. The startle-response is inherent to the fight or flight response and triggers an immediate shift in allostatic balance. If the situation that causes the startle-response is similar to a previous situation, the body automatically shifts the allostatic balance to that same balance, thus increasing the speed with which we can react and enhancing the stress-response. (Sapolsky, 1994, p.412-413; Sternberg, 2009, p.60)

4.4.4 Habituation

However repeated exposure to the same startling experience can cause our body and mind to become too accustomed to the contrast (Sapolsky, 1994, p.413; Sternberg, 2009, p.60). In that case each repeated exposure will cause less and less of a reaction. In essence numbing us to the contrast our sensory systems perceive. This process is called habituation (Sternberg, 2009, p.61). Habituation is crucial in understanding why we become so accustomed to certain stressors that we can block them out. In the case of noise, this can happen to any noise that becomes too monotonous, either in loudness, rhythm or pitch.

Habituation can turn a monotonous sound into a relaxing sound that actually soothes us. For babies and children this can mean that they can only sleep with everyday sounds in the background, such as vacuum cleaning, a running motor, the whir of the refrigerator, or simply a lullaby. For adults who can’t sleep, a contrasting sound that becomes monotonous such as thunder or rain can help to refocus their mind due to the contrast, while the monotonous continuation of the sound will ‘lull’ them to sleep (Zhou, et al., 2012, p.71-72). The type of sound that has this effect is called pink noise. (Sternberg, 2009, p.62-63; Zhou, et al., 2012)

However, habituation can also work in a different manner. When the brain deciphers a tune it has to retain the notes it hears, along with all other features of the sound while it recognises a pattern. This process of retaining information is called working memory. These memories are only transient and stored in the pre-frontal cortex. However the working memories can draw forth childhood memories that are long forgotten and elicit the exact same emotion one felt at that moment. (Sternberg, 2009, p.65-68)

Inducing or reducing

The relaxing effect of pink noise can shift people from stress mode into relax mode. However music and sound can have the opposite effect as well. Through rhythm, loudness, and pitch music can also induce a feeling of stress. In ancient times the drums of war often had this effect instilling fear in the enemy while bolstering the moral of their own troops.

By inducing or reducing stress, music can change ones physiological state:
increase heart-rate, blood pressure and rate of breathing. (Sternberg, 2009, p.63, 69-72)

4.4.5 Fractals
Another reason for finding some sounds relaxing and others agitating revolves around the same patterns we find visually appealing. Fractals, as mentioned before, are present everywhere and as such in sound as well. These infinitely repeating self-similar patterns are akin to monotonous sounds and thus lull us as well. (Sternberg, 2009, p.70-72)

Ary Goldberger who proposed that visually perceiving fractals is pleasing to the mind, proposed the same for music. Similar to the Ryoan-ji temple dry landscape garden, he analysed heart-rate variability and reduced them to mathematical equations finding that the more complex and variable the system, the healthier. (Goldberger, et al., 2002; Sternberg, 2009, p.70-72)

Variability
An experiment he often executes during one of his lectures shows that people often think that simpler is better. He shows several graphic representations of heart rate variability. People often choose the simple straight line as healthiest; however that line is actually a heart that does not beat. The healthiest pattern is the pattern with most variability. (Sternberg, 2009, p.70-72)

Goldberger assigned musical notes to each heart-rate interval wondering whether the resulting music would be calming or jarring. He found that the more complex and variable the heart-rate interval the more calming the resulting music. The unhealthiest pattern, the straight line, was the exact opposite; it produced a sound that had an agitating effect on people. (Sternberg, 2009, p.70-72)

4.4.6 Relaxation and health
Swedish studies, similar to the study of Ulrich, have shown that hernia patients listening to pink noise while under anaesthesia during surgery or directly after surgery need significantly less pain medication as compared to patients who did not listen to music (Nilsson, Rawal, Enqvist & Unosson, 2003). Other stud-

![Figure 2.18](image)

**Figure 2.18:**
Right - The images Goldbershows during his experiments, four different heart rate, one health three unhealthy. People often chose A or C but only B is a healthy heart rate.
ies have shown that music can induce the production of certain antibodies in the saliva as well, strengthening the first line of defence of the body. (Sternberg, 2009, p.73-74)

**4.4.7 Recommendations for Design**

Sound has several implications for design. Simply put there are objects that produce sound and there are objects that reflect sound.

Sound producing objects can either produce pink noise (M) such as a waterwall (H), or produce noise pollution such as a car. In turn objects that reflect sound can either fully reflect the sound or absorb it (L, 14).

Sound that is too loud, too jarring, or too contrasting can cause the stress-response to activate. Architects should therefore create designs that can negate the effects of unwanted sound, this can be accomplished by taking the reflective properties of spaces and materials (L) into account. Hard materials are more reflective while soft materials are more reflective.

Designing a highly reflective space in which one cannot identify where the sound originated from, can induce ambiguous feelings leaving one uncertain at best or frightened and stressed at worst. This too means that sounds should not echo endlessly around the room.

**Figure 2.19:**
Left - Paley Park in New York. An oasis of rest in the busy city. The trees reduce resonance of sound, while the waterfall at the back creates pink noise effectively shutting out the sounds of the city.
Pink noise
Pink noise (44) is an example of an object that produces noise. Eliminating loud noises in a restorative environment by creating pink noise strengthens the restorative effect of these environments.

Besides music created by people, natural elements also create pink noise. Simply adding a water feature (H) to an environment can create the pink noise that both lulls the listener and negates the noises of everyday life. Parley park designed by Zion and Breen landscape architects in New York is such a restorative environment in which everyday noise is negated through the use of a waterwall.

Fractals
Fractals (2) are again an important aspect of why sounds can contribute to the restorative effects. Here too it is shown that perceiving fractals is not only visually but also auditory preferable. Although fractals in sound do not provide any design guidelines it does reinforce the idea that perceiving fractals is preferable and therefore an important design tool.

4.5 The taste and smell system
The sensory system of taste and smell is often ignored in architecture. Yet its contribution to the intersensorial experience of environments is anything but small.

An important difference between the previous sensory systems and the taste smell system is that it deals with two separate stimuli. The contraction of the two traditional senses taste and smell is the result of their close link. Smells can often be tasted and tastes can often be smelled. This is a form of habituation similar to recalling childhood memories through music. (Malnar & Vodvarka, 2004, p.42-43; Sternberg, 2009, p.89-90).

The effect of smell on the perception of architecture can be very primal. Activities of people produce smells, such as a kitchen that smells of food or detergent, a bathroom that smells like soap, or scents associated with toilets.

Yet the effect of scents can be more profound as well, such as the scent of water, soil, trees and wood. It is these scents of nature that can strengthen the restorative effect of environments.

4.5.1 Olfactory organ
The olfactory organ, the nose, registers smell in a similar way to how the eyes register images and the ears register sound. When the odour molecules hit the mucous membrane in the nose they dissolve in mucous fluid around the nerve cells. The molecules are then transported to the olfactory organ where they come in contact with the olfactory nerve cells. These cells have tiny hair like structures which contain proteins of different shapes. (Bluyssen, 2009, p.30-35; Sternberg, 2009, p.75-77)
Each protein has a unique shape that corresponds to the shape of a scent molecule, like a key and lock. If the molecule has the wrong shape it will not bind, and if the shape is only slightly off it bind less strongly. Once a molecule has been bound a series of chemical reactions take place that send electrical signals along the nerves to the brain. This way not only the chemical is identified but also the concentration, the more molecules are bound the more concentrated the smell and the more rapid the olfactory nerve cells fire. (Bluyssen, 2009, p.30-35; Sternberg, 2009, p.75-77)

### 4.5.2 Categorisation

Interesting is that the brain not only sorts the chemicals individually but also as a category. This way a person can identify for example a sunflower by smell if he or she is familiar with that smell. However, a person who is unfamiliar with the exact smell of a sunflower can still identify the smell as floral. (Sternberg, 2009, p.80)

Due to this categorisation people are able to gather information about their location at a whiff. Moving through the spaces of a building each space has a distinct different smell that people can use to determine their general location. Spaces bordering the exterior of building have a more natural smell while interior spaces have a more man-made smell. (Malnar & Vodvarka, 2004, 281)

### Atmosphere

Atmosphere is another thing people can smell. A sunny summer day has a completely different scent than a rainy day in late autumn. During the summer the air contains many floral scents and the air is dry. While in autumn the floral smells are mostly gone, replaced by the sweet smells of leaves in early stages of decomposition and the air contains more moisture. All these elements can tell us something about the time of the year, the weather and even the time of day. (Sternberg, 2009, p.75-77)

### Mood and disease

Besides gathering information about a space, people can also smell the mood and physiological state of another person. Before modern machines and medicine doctors would often smell the breath, urine and other excrements of people to determine if their patient was sick and what the problem was (Sternberg, 2009, p.81-82). Nowadays everyone still uses smell as an indicator for being drunk, the expression ‘I can smell the beer on you’ is very apt. Instead of literally smelling the beer on the body, people smell the beer on the exhaled breath, similar to how breathalysers work.

The composition of sweat excreted through the sweat glands can tell a lot about the mood of the person. People are often able to identify whether the person felt fear, happiness or love simply based on the chemical composition of the sweat that was excreted during that specific mood. (Sternberg, 2009, p.83-84)
4.5.3 Aromatherapy

Smell does not only provide information but affects us as well. In ancient times herbs were burned to cleanse a patient or room. One of the most prominent examples of the use of scents to cleanse people of disease is that of Frankincense as used in Christian churches. The use of frankincense was not merely ritual but also common sense. The herbs that were burned have been proven to relax and heal. In the world of science the physician Joseph Lister was the first to promote the use of antisepsis and used an oil of thyme to cleanse wound (Sternberg, 2009, p.84-86). This use of fragrant oils is called aromatherapy and is based largely on ancient practises of both Western and Eastern cultures (Sternberg, 2009, p.87-88).

Pavlovian conditioning

Although the use of fragrant oils is preceded and some aspects have been proven, it is difficult to compare the effects of fragrances on ones mood since they are potent at triggering memories. This is a form of conditioning and recalls the emotional state linked to that memory. The smell of lavender, which generally relaxes a patient, can cause the exact opposite effect if that fragrance is linked to a negative and stressful memory. (Sternberg, 2009, p.88-90)

Repeated association of a scent with an emotion can strongly link them together. This process is better known as Pavlovian conditioning and is not unique to scent and emotion but can happen with colours as well. Even though such a link is often formed after repeated association, a powerful emotion can be conditioned in a split second. Once such a link has been established it is notoriously difficult to break. (Sternberg, 2009, p.88-90)

4.5.4 Recommendations for Design

There are several implication that provide guidelines with which can be designed. With smell we can determine our general location: near the exterior of a building (34), in the kitchen, a bathroom or a hallway. This implicates that each function has a distinct scent that we associate with the room.

Through smell we can also determine the time of the year, the weather outside and the time of the day. After precipitation the forest smells distinctly loamy (14), moving water (H) is often accompanied with a crisp and clear smell, and in spring time the air is permeated with the smell of flowers and grass (G).
Ambiguity
Thus in designing restorative environments great care has to be taken that the information gathered by smell fits with the information gathered by the other sensory systems. Again stressing the intersensual aspect of each of the sensory system.

A restorative environment that smells like a kitchen but looks like a Japanese dry landscape sends an ambiguous signal that negates the restorative effect of the environment.

As such smell and by extend taste is an important tool in creating or strengthening an atmosphere through the use of materials.

4.6 The haptic system
The haptic system is different from the previous sensory systems that were discussed. Those systems received information from one organ; the haptic system however receives information from several different organs. Another difference between the haptic system and the other sensory systems is that the haptic system gathers information through active exploration (Pallasmaa, 2005). As mentioned before this sensory system is the most intricate and has therefore been split in three different aspects: touch, kinesthesia, and temperature and humidity.

4.6.1 Touch
As the name already implies touch needs a physical connection between the person and the material. The skin works through two different receptors: mechano-receptors and thermo-receptors (Malnar & Vodvarka, 2004, p.43). Each receptor registers different types of information which the brain combines with all other information streams in order to form a complete impression of the space one is in.

Walter (1988) argues that the haptic system in itself can provide an array of information that allows one to understand the space without seeing, hearing or smelling. However haptic perception is enhanced when it is combined with the visual data gathered by the photoreceptors in the eyes (Zucker, 1959). In essence they complement each other.

This becomes clear when one views the bark of a tree. The concept of texture is only partially grasped by only viewing or touching but both seeing and touching the bark provides a complete experience. It is good to note that although the haptic sensory system and the visual sensory system perceive the same information. The space one is in cannot be fully grasped without the use of both sensory systems.

Texture
As mentioned in the example the texture of objects can be felt and explored through touching that object. However on a larger scale the shape of that object
Effects of nature on the sensory systems

can be perceived as well. Since the haptic system gathers information through active movement, the ground surface texture is an important aspect to perceive. (Malnar & Vodvarka, 2004, p.281)

The ground surface texture is an aspect of restorative environments that both Ulrich and Kaplan & Kaplan touch upon (Kaplan, 1995, p.173; Ulrich, 1983, p.101-102). They find that the restorative experience diminishes with increasing roughness of the ground surface texture. This is easily explained since in an environment with an uneven and cluttered ground surface one has to concentrate on where one places their feet and thus one is unable to relax and acquire that state of being away. Although Ulrich, Kaplan & Kaplan only consider the ground surface texture the same is true for the rest of the space as well. The more clutter there is the more oppressed the space will feel (Malnar & Vodvarka, 2004, p.281).

**Tactility**

There is also a tactile aspect to touch. By simply standing in a space one can also feel whether there is a draft in the space and judge the direction of that draft (Malnar & Vodvarka, 2004, p.41-58). In a natural environment touch registers the direction of wind and the wind speed (Malnar & Vodvarka, 2004, p.281).

**4.6.2 Temperature and humidity**

Temperature and humidity are mostly registered by thermo-receptors specialised in registering fluctuations in temperature (Malnar & Vodvarka, 2004, p.43).
The wind or draft one perceives through the difference in pressure is also registered by the thermo-receptors. However instead of registering direction and wind speed it allows us to judge the temperature of the wind, whether it is cold or warm. (Bluyssen, 2009, p.23)

They are also our primary sense in judging the thermal comfort of a space. A space that is warm and humid often feels clam, another feeling that is registered by both mechanoreceptors and thermo-receptors.

The thermo-receptors register the temperature of the space while the mechanoreceptors register the condensation on the skin and a slight change in air pressure. In general a humid and warm environment feels heavier than a warm and dry environment creating a slight difference in the air pressure that is registered by the mechanoreceptors. (Bluyssen, 2009, p.23-24; Malnar & Vodvarka, 2004, p.281)

**Intersensory aspect**

Temperature and humidity also enhance the sensory system of smell and taste. Higher temperatures increase molecular volatility, the ease with which a substance turns into a gas. Higher levels of humidity intensifies the odour of chemicals that easily dissolve in water.

The effect of higher temperatures and humidity is the same. The concentration of odourant molecules in the air increases, leading to an intenser experience of odours.

### 4.6.3 Kinaesthesia

The kinaesthetic aspect of the haptic system is mostly turned inwards. Instead of dealing with external stimuli it gets its information from the body itself. Kinaesthesia is the system that allows us to touch our nose without seeing it. Through continually analysing the position of each of the joints, muscles and tendons in the body the brain can ground itself in the space. (Malnar & Vodvarka, 2004, p.42-43)

This sense is not only used to touch ones nose, we also use it to walk up a stairs without seeing the treads we are stepping on. Most people have experienced a sudden trip on the stairs; accidentally misjudging the height of the next riser and just scraping the top of the tread. The cause of this is that the monotonous action of walking up a stairs is remembered through the kinaesthetic sense. The movement of each step is similar allowing the mind to wander and leaving the motions to reflex. A slight difference in the riser-tread ratio will therefore not be noticed by the brain and the motion that was sufficient for all other steps is now lacking, resulting in a trip. (Malnar & Vodvarka, 2004, p.42-43, 281)

### 4.6.4 Recommendations for Design

The haptic system has many implication for the design of both architecture and
restorative environments. Not only is it
used to judged the temperature and hu-
midity levels but also the texture of the
ground surface and the space in general.

A restorative environment that becomes
unnavigable loses its restorative poten-
tial due to the increased concentration
needed to judge the route one is taking
and the oppressed feeling one get due
to the cluttered space.

**Thermal comfort**

Although the thermal comfort in each
room needs to be sufficient, the thermal
comfort of the adjacent spaces need to
be similar as well, but most importantly it
needs to be compatible with the intent
of the user.

While being at work in an office, moving
from room to room and encountering
different temperatures along the way will
leave the body continually adjusting the
allostatic balance through the stress-re-
response. This leaves the person more
stressed than relaxed in the end.

While in a relaxing spa the intent of the
user is different, thus the acceptable
temperatures are different as well. The
temperature of a sauna, which is unac-
ceptable while working can suddenly
become pleasant.

Having similar thermal comforts in the
individual spaces also demands restora-
tive environments that have similar ther-
mal comforts.

**Wind**

Being able to sense wind considers as-
pects of nature that are inanimate (I).
Many of the pink noises perceived by
the auditory system, such as the rustling
of leaves, are not caused by plants and
trees but by wind or weather. This sug-
gests that simply designing restorative
environments with flora is insufficient.
Other natural aspects have to be includ-
ed as well. This substantiates the find-
ings by Ulrich and Kaplan & Kaplan who
found that moving water (H) enhances
the restorative effect of restorative envi-
ronments.

**Kinaesthesia**

Kinaesthesia is closely related to the
ground surface texture and how one
moves through a space. This provides
guidelines stipulating that spaces in
general should have smooth and even
ground surfaces (14) in which height dif-
ferences are bigger rather than smaller
when they are irregular. This increased
contrast in the height differences jolts
the brain and the other sensory systems
to re-evaluate the space, preventing one
from tripping.

4.7 **Basic orientation system**

The difference between kinaesthesia
and the basic orientation system is of-
ten unclear. A succinct way to define this
difference is scale. Kinaesthesia places
the body in context with other objects,
whether they are stones on a forest path,
the treads of a stairs, or a dining table
with chairs. The basic orientation system
on the other hand deals with information on a much larger scale. Instead of objects it is concerned with the relation between the body and the world.

The basic orientation system is based on but not limited to the relation between the horizontal ground plane and our vertical position (Malnar & Vodvarka, 2004, p.42).

One of the main organs driving this sensory system is the vestibular organ located in the inner ear. The vestibular organ contains three semi-circular canals and by working in pairs through a push-pull mechanism they can register the position of the body in all three dimensions. Through this mechanism the brain stabilises the eyes when the head moves. (Bluyssen, 2009, p.38-39;)

The otolithic organs, located in the inner ear, are specialised in sensing linear accelerations, both gravity and motion. The otolithic membrane supported by hair cells bears directly down when the head is erect causing minimal stimulation. Any other orientation of the head causes the weight of the otolithic membrane to shift. The brain compares this shift to information from other mechano-receptors thereby determining whether the head is tilted or the entire body. (Bluyssen, 2009, p.38-39; Gray, 2000)

Through the combination of both organs the body can quickly determine whether in what direction the body is facing, whether one is high or low. The slight differences in pressure between high ground and low ground are registered by the otolithic organs thus providing a sense of vertical elevation. When moving from room to room the otolithic organs also tell us if we have been moving horizontally or slowly climbing or descending. Even the smallest slopes are noticed this way. (Malnar & Vodvarka, 2004, p.281)

The vestibular organ registers movement and thus allows us to track the rotations one has made when moving from room to room. This tells us if the room we came from has a different orientation than the room we are moving to. It also tells us whether we are lost or not. (Malnar & Vodvarka, 2004, p.281)

4.7.1 Recommendations for Design

The basic orientation system has little to do with how nature influences us but it does provide guidelines for the design of restorative spaces. The otolithic organs that register the vertical position of the body tells us whether we are moving up or down, or simply standing on a slope. Just as with all other senses contrast is an important issue. The otolithic organs register the smallest deviation from the vertical axis. If the contrast between such a deviation is too small, the body can hardly compensate which will induce an uncomfortable feeling. Architects therefore have to design either horizontal surfaces or slanted surfaces that have enough contrast between them.
The vestibular organs that track the rotation of the head also allow people to remember the turns they made while walking. However, the more complex the route, the more information from the other senses is needed to backtrack. Simply thinking of a maze illustrates this idea. A maze is so visually and auditory uniform that the only way to backtrack is through remembering the turns one has made (Sternberg, 2009, p.99). At a certain point, people will not be able to remember the way back anymore since they cannot recall the rotations the body made at each point.

For design, this means that simple layouts with few turns are the easiest to navigate. However, in design, this is often an impossibility. Introducing information for other senses is therefore necessary in order to navigate the more complex spatial layouts.
5 Image vs Space

As has been mentioned before there is a difference between the experiments that were performed by Ulrich and by Kaplan & Kaplan.

5.1 Intersensory experience
In Ulrich first experiment patients viewed a scene through a window (Ulrich, 1984). This means that the distance between the patients and the view was large enough that the brain only viewed it as a scene and not as individual objects. Due to the ineffectiveness of the other sensory systems due to the window that separated the patients from the scene, Ulrich concluded that the visual system was the most important sensory system. Yet his findings concerning a preference for a smooth ground texture for walking contradict this (Ulrich, 1979).

Kaplan & Kaplan (1989) with their wilderness experiments involved the full array of sensory systems described above. Their findings were thus not based on one system being more important than others.

5.1.1 Image vs Space
This marks an important difference between the perception of an image and the perception of a space. An image can only be viewed whereas a space can be felt, smelled, heard and seen.

Since the other senses were rendered ineffective due to the window separating the patients from the view. In turn Ulrich concluded that the view through a window is perceived like an image.

5.2 Depth
Another difference between an image and a space, as mentioned before, is the sense of depth. Depth can either be interpreted as distance or immersion, in other words two-dimensional vs three-dimensional (Kaplan, Kaplan & Ryan, 1998).

Although it is often thought that the eyes flatten an image, removing three-dimensional information from the scene, we can still see the distance between the objects and judge where they are located whether in an image or a real life experience (Lim, 2011; Gibson, 1950, p.2-9).
There are several theories on how the brain accomplish this. No one theory is correct since each is still under scrutiny (Gibson, 1950).

### 5.2.1 Theories

#### Binocular vision

The first theory proposes the concept of binocular vision. Our eyes are identical in the way they process information, each of the eyes thus registers the same scene. Binocular vision suggests that the position of our eyes is key into translating the two-dimensional information into depth perception. (Gibson, 1950, p.19-22; Haralambidou, 2012, p.313)

Due to the different positions of the eyes, the image they register is slightly different (Gibson, 1950, p.19-22). Drawing on the concepts of kinaesthesia it is proposed that the muscles in the eyes register their direction telling the brain the difference between the two images. In turn the brain modulates the images to recreate the depth in the scene. (Gibson, 1950, p.19-22; Haralambidou, 2012, p.313)

While to an extend this is true; walking with one eye closed often leaves people stumbling since they are unable to judge the depth. This would, however mean that animals who’s eyes do not overlap cannot perceive depth (Rossel, 1996). This would also mean that we would be unable to see the depth in a photograph, yet this binocular depth is visible in them (Blundell Jones , p.57).

#### Experience

A second theory suggest that the ability to interpret the flattened image perceived by our eyes is a learned experience. Helmholtz (in Perception, 1968) elaborated that certain properties of the retinal image contain signs or indicators of depth that a child learns to interpret, a process that becomes unconscious in adults. As such adults therefore believe that they perceive the depth of the world immediately (Gibson, 1950).

Gibson (1950, p.71-72) proposes a list of possible indicators that could be used to infer the depth within a scene. Indicators such as, linear perspective, known size of familiar objects, and the covering of one object by another can all be reproduced by a painter and are supposed to occur in the retina (Gibson, 1950). Except for the “motion parallax” indicator which in contradiction to the others concerns itself with immersion.

The indicators that can be reproduced by a painter are the indicators that can be used to recreate the three-dimensional information of a scene viewed in a photograph.

#### Gestalt theory

The third general theory suggests that depth perception depends on a spontaneous process called “sensory organisation” (Gibson, 1950, p. 23). The foundation of this theory proposes that light may carry a much richer load of information about the environment. It was suggested that there exist field forces that yield
some electro-physiological information concerning the objects that divulges the three-dimensional aspects of the scene. (Gibson, 1950)

This however does not explain how the three-dimensional information from a photo is recreated since the light information of the real scene is different to that of the image.

**Combination**

It is proposed that depth perception, distance and immersion, is a result of both the visual system and the haptic system. (Pallasmaa, 2005)

Pallasmaa (2005, p.101-102) notes this duality between vision and touch. He argues that the eyes carry the hands to great distances, while the hands inform the eyes at the nearby scale.

Reading is often thought of as a purely visual stimuli, however the reading of braille as done by blind people, uses touch to identify the letters. As such it can be concluded that touch informs the eyes at the nearby scale.

Through previous handling of objects we can already get an inkling on how the object will feel. The memory of touch is thus linked with vision. Seeing a wooden chair with a coarse texture, tells us that the type of material, the way the material will feel due to the texture we see.

Another aspect of the second theory of experience is reflected in how the haptic system and the visual system work together; ‘motion parallax’ (Gibson, 1950, p.71-72).

“Motion parallax” (Gibson, 1950, p.71-72) describes the need for movement to fully understand the three-dimensional layout. Where touch is part of the tactile aspect of the haptic system, motion parallax describes kinaesthesia.

While one moves their head from side to side, the location of each object in relation to the body is registered. The change of the location of the objects in regard to the change of the body is analysed by the brain (Gibson, 1950, p.117-118). Similar to what the binocular vision theory describe only on a grander scale.

Combined with the flows of information from touch, sight, and memory the brain is able to recreate the three-dimensional aspects of a space.

**5.3 Immersion**

While depth is an important difference between an image and a space there are many more and immersion is at the inception of all of them.

Immersion describes the act of engaging with ones environment and in doing so every sensory systems registers information, not just the visual system and the haptic system.

When one enters a space, the visual and haptic system concerns itself with the
objects, the narrative and the order of a scene. In other words with coherence and complexity which are judged in the two dimensional place.

The three-dimensional aspects of a space such as legibility and mystery are judged in the third dimension (Kaplan, Kaplan & Ryan, 1998). Both Ulrich and Kaplan & Kaplan propose that these aspects are judged through a process of immersion.

Through immersion the other sensory systems also contribute to the flow of information used to judge a space.

The haptic system assesses the temperature and humidity levels in a space.

The auditory system registers any sound present determining for example the function of the space. Yet sound and the way it echoes in a space also provides information about the size of a room and the type of materials that are present. Soft materials absorb the echo while hard material resound the echo.

The taste and smell system do a similar job in assessing the space. Certain smells can be used to determine the function of a space such as whether it is a kitchen, a garbage dump, a forest or a field.

The basic orientation system works on a much larger scale. One can determine the slope of the floor plane, ones orientation in the world, and even how high one is above the ground floor.

5.3.1 Intersensorial experience
As such the difference between an image and a space is not simply two dimensional vs three dimensional. In reality the difference is in the experience of each. A photograph is assessed only with the visual system, a painting is assessed by the visual system and the tactile aspect of the haptic system, whereas a space is assessed by the full array of sensory systems.

Although one can argue that sound, orientation, smell and taste only add to the completeness of the third dimension.

It is apparent that unlike Malnar & Vodvarka (2004, p.42-45) argue, that in the western world the visual system is the most important system in experiencing architecture, architecture is experienced with the full array of the sensory systems. Each sensory system contributes to the full experience of a space.
As has been established, preference is crucial in experiencing the restorative effect of natural environments. As Ulrich and Kaplan & Kaplan found not all natural environments elicit the same positive reaction, nor are all urban environments viewed as undesirable.

6.1 Prospect vs Refuge

The prospect refuge theory is crucial in understanding why certain environments are more preferential than others. The habitat theory proposes that humans interact with the environment in a similar manner to how animals interact with their habitat (Singh & Ellard, 2012, p.22). Therefore studies focusing on animals provide valuable insights for design. The use of the term prospect is not coincidental; it refers to two aspects both animals and humans look for in environments. On the first hand prospect refers to open view, or the ability to observe, on the other hand however it refers to the predictability of the environment.

Through natural selection during our evolutionary history the mental ability to quickly and accurately distinguish safe environments from dangerous environments has developed. The chances of survival are therefore enhanced the more an individual can observe without being observed, and the more familiar or predictable an environment is. (Singh & Ellard, 2012, p.22)

This duality between observing and not being observed is called the prospect-refuge theory. This theory proposes that the ability to see without being seen allows for the satisfaction of many of the aspects that make an environment more preferable. The ability of an environment to ensure the achievement of prospect and refuge automatically becomes a direct source of aesthetic enjoyment. (Singh & Ellard, 2012, p.22)

The prospect-refuge theory proposes that we not only prefer environments that protect us from threats but also provide open views. Another aspect of the theory offers that if the view is limited, but the environment is known and thus predictable, prospect is still provided. (Singh & Ellard, 2012, p.22)
6.2 The Maze and Labyrinth Dichotomy

Although the example of a maze was adequate in explaining the limits of the basic orientation system there are of course many more reasons that make mazes stress inducing places. It was mentioned before that mazes are such visually uniform places that the visual stimuli do not offer any information by which choices can be made while navigating the maze. Nor do the auditory system, the smell-taste system, or the haptic system provide additional stimuli that can be used for navigation. It is the ineffectiveness of the visual and auditory system that disorients people the most in the mazes. (Sternberg, 2009, p.99)

To increase the pressure, mazes are designed to induce feelings of stress. High walls make it impossible to see out, so there is little to no prospect, and they muffle sounds. The only way to escape a maze is to try different routes and remembering the choices one makes along the way.

The maze continuously presents you with choices, forcing you to choose a route while not having adequate information for making those choices. Not knowing the route, nor the length of the route or how many twists one has to make, further increases the pressure one feels while navigating the maze. (Sternberg, 2009, p.99-103)

The neutralisation of the senses, the novelty of the environment and the uncertainty are all potent triggers for the stress-response (Sapolsky, 2004, p.263; Sternberg, 2009, p.99-103). Through this neutralisation of the senses, prospect in the form of open views and the sense of refuge are eliminated. While the novelty of the environment and the uncertainty of all the choices eliminates the predictability.

Combining them in one environment is almost certainly a way to induce stress levels high enough to cause crippling feelings of anxiety.

On the other hand, a place where no navigation is necessary and thus no choices have to be made since the route has already been determined and deviation from that path is unnecessary provides a restorative effect (Sternberg, 2009, p.103, 107-108). Such a place is called a labyrinth.

The terms maze and labyrinth are often used interchangeable; a misconception that dates back to before the Greek civilisation (Sternberg, 2009, p.103). Descriptions of the Minoan labyrinth refer to a fearful place where people lost their way among the many twists and turns and were devoured by the beast at its centre (Sternberg, 2009, p.103-105). The Minoan Labyrinth is at the heart of the misconceptions between mazes and labyrinths. This place, with twists and turns inspiring fear and causing death, should instead be called the Minoan Maze.
A true labyrinth has only one way in and one way out. There are no decisions to be made, no dead ends, and no blind alleys but most important the route ahead is visible or predictable. The need for vigilance, present in mazes, is absent in labyrinths. Therefore, uncertainty and, after the first visit, novelty are eliminated from the equation.

Since no choices have to be made, the sensory systems no longer need to gather information for survival. Leaving the mind free to wander, move inwards and outward in a way similar to what both Kaplan & Kaplan and Goldberger described as a way of restoration. (Sternberg, 2009, p.103)

### 6.3 Alone or with a friend

Just as Kaplan & Kaplan (1995, p.173) propose, the amount of prospect and refuge preferred differs with the intention of the person (Staats & Hartig, 2004, p.200). Certain situations demand for a greater degree of refuge, for example an individual who feels psychologically threatened will require a greater degree of refuge than prospect. However the opposite is true for a comfortable individual. (Singh & Ellard, 2012, p.23; Staats & Hartig, 2004, p. 199-211)

It was found that the same is true for animals by providing a gerbil with three different types of shelters. Each shelter with a different degree of prospect and refuge. The first shelter provides minimal prospect while providing a high degree of refuge, the second shelter is balanced while the third shelter provides more prospect and almost no refuge. (Singh & Ellard, 2012, p.23)

Without a threatening stimulus the gerbils visited each shelter equally, thus no preference for the shelters was exhibited. However after the introduction of a predator there was a significant preference for the enclosed refuge. This proves that different situations demand different degrees of prospect and refuge. (Singh & Ellard, 2012, p.23-24)
Another study, this time with humans, found that feelings of safety greatly influence the restorative effect of natural environments. Company increased the preference for urban environments but not for natural environments which lost its restorative quality as well. However when controlled for safety, in other words a greater degree of refuge, natural environments that were deemed unsafe regained their restorative quality. It was also found that travelling in company increased feelings of safety. (Staats & Hartig, 2004, p. 199-211)

6.3.1 Recommendations for design

For the design of restorative environments this means that spaces meant to be visited in solitude (9, 10) should have vantage points which allow individuals to enjoy the open view without being observed by others. While restorative spaces in which individuals can be observed should be larger (10) in order to accommodate the enjoyment of these spaces in company.
7 Summary and conclusions

The initial findings of Olmsted and James concerning the restorative effect of experiencing nature have been proven by the continued research of both Ulrich and Kaplan & Kaplan. The experience of natural environments, whether through visual perception or through the perception of all sensory systems has a restorative effect on people. The restorative effect works through reducing the severity of the stress-response as well as through allowing directed attention to rest. As Kaplan & Kaplan proposed for natural environments to have a restorative effect they need to meet four criteria: fascination, a sense of being away, extent, and compatibility.

The examination of the sensory systems reveals why natural environments in particular have this effect on people. While the visual system holds many crucial elements in explaining how nature reduces the stress-response and how nature allows us to rest the mind, it is a combination of all the sensory systems that cause these effects. Among the different sensory systems there are several common themes in ensuring the restorative effect of natural environments.

7.1 Contrast
The mind responds to contrast, whether it is loud noises, sudden changes in scenery, an out of place object or sudden change in elevation. Evolutionary such a contrast often meant danger and resulted in a change in allostatic balance and consequently readying the body through the stress response. However restoration is not about danger and so eliciting an stress-response is unwanted. The absence of contrast signals a coherency to the environment fundamental to the criteria of extent.

Contrast however can also be used to refocus the mind, to draw it away from everyday problems, the criteria of getting away. Contrast in a design can be used to incite this effect. However one should guard against designs that create continuous contrast and thus force the body to keep changing the allostatic balance through the stress response.

7.2 Fractals
Fractals are another aspect to which the mind reacts. The nature of fractals, self-similar patterns, means that the mind
Summary and conclusions

7.3 Ambiguity
Ambiguity in restorative environments needs to be avoided to safeguard the restorative effect of these spaces. Often a restorative environment is synonymous with an environment rich in vegetation. Yet there is a much greater diversity of natural environments beside simply green environments.

Vegetation rich natural environments in high-rise building can result ambiguous spaces. The mind does not expect to find these natural environments raised high in the air. Therefore the design of restorative spaces in high-rise building needs to be carefully considered in order to ensure that the criteria of extent is met and the restorative effect of natural environments is preserved.

While a vegetation rich environment such as a forest is unexpected at such high and steep elevations, there are other environment that are expected at those heights. The focus in those environments shifts from the animate aspects of nature and changes to the inanimate aspects of nature. Some of these inanimate aspects of nature have been touched upon before such as, water, stone, sunlight, and weather.

For the design of high-rise buildings the elevation of a restorative environment determines the type nature that can be integrated to meet with the criteria of extent. Simply put, a ground-bound restorative environment can focus on vegetation in order to satisfy the need for fascination, being away, extent and compatibility. While a restorative environment located at the 60th floor will need to focus more on the sky: the movement of clouds, the weather, sunlight and water.

7.4 Prospect vs Refuge
The prospect refuge theory provides many insights into the spatial qualities of restorative environments. Restorative spaces need to be easily navigable. Meaning the more complex the route, the more understandable the route needs to be. This can be achieved by not using any branching paths, clearly marking the path that needs to be followed, or by creating more open views that reveal the direction of the path.

Pink noise is an example of sound that does not distract nor elicits a stress-response. Rather the monotonousness of pink noise distracts the mind allowing it to reach a contemplative state; the sense of being away.

While a vegetation rich environment such as a forest is unexpected at such high and steep elevations, there are other environment that are expected at those heights. The focus in those environments shifts from the animate aspects of nature and changes to the inanimate aspects of nature. Some of these inanimate aspects of nature have been touched upon before such as, water, stone, sunlight, and weather.

For the design of high-rise buildings the elevation of a restorative environment determines the type nature that can be integrated to meet with the criteria of extent. Simply put, a ground-bound restorative environment can focus on vegetation in order to satisfy the need for fascination, being away, extent and compatibility. While a restorative environment located at the 60th floor will need to focus more on the sky: the movement of clouds, the weather, sunlight and water.

7.4 Prospect vs Refuge
The prospect refuge theory provides many insights into the spatial qualities of restorative environments. Restorative spaces need to be easily navigable.

Meaning the more complex the route, the more understandable the route needs to be. This can be achieved by not using any branching paths, clearly marking the path that needs to be followed, or by creating more open views that reveal the direction of the path.
The prospect refuge theory also argues that depending on the mood of the individual, different spaces are needed to fully experience the restorative effect. Closely linked to the mood of the individual is the feeling of safety. Natural environments that are deemed unsafe are only restorative in company, while the restorative effect of safe natural environments can be fully be experienced in solitude.

This difference in being alone or in a group is also reflected in the size of a restorative environment. The larger a space, the less restorative it becomes to an individual. Unless the large space is designed to feel secure to an individual. This can be accomplished through the creation of smaller areas that feel sheltered.

7.5 Modulation
It may be clear that the restorative effects we experience while viewing and residing in natural environments are real and scientifically proven. Our evolutionary history is at the base of why and how nature can positively influence both our physical and psychological state. However, conditioning, habituation and personality modulate both the restorative effect of natural environments and the severity of the stress-response. Individuals will therefore experience the restorative spaces in a unique way that will determine the extent of the restorative effect.

7.6 Continuation
In the third part of this thesis the design recommendations as well as the difference between two-dimensional and three-dimensional will be described more in depth. The focus will shift from literature to design through the analyses of four precedents in order to identify themes, strategies and tools to be used in the design of restorative environments.
Summary and conclusions
Part 3: Natural Elements, Materials and Design Elements
1 Introduction

The previous chapter dealt with the psychological and neurological effects of nature and why certain environments have a restorative effect on us. Several key aspects were introduced, such as fascination, the sense of being away, extent and compatibility, to explain the restorative qualities of environments. Each of these aspects deals in one way or another with the preferability of an environment.

The sensory systems were used to explain why certain elements in natural environments elicit a more positive reaction than others. An example that was drawn upon was the colour green and the balancing effect it has on us. As such vegetation is an important part as to why people prefer natural environments over the build environment.

In order to create these strategies and tools two different sources will be examined, firstly a volume in which Kaplan, Kaplan & Ryan (1998) try to translate their findings into a pattern language, secondly a series of four precedents.

The precedents will function as a mediating factor between the theory and the toolbox. Used to better understand how existing buildings deal with the integration of nature in order to create restorative environments. Combining the findings will lead to the formulation themes, strategies, and tools that will form the basis for the toolbox.
Kaplan, Kaplan & Ryan (1998) developed a pattern language in order to make their psychological findings better understandable for designers and managers of the build environment. This pattern language, however, focuses mostly on landscape architecture. Some of the patterns deal with structures but still on the level of landscape design. Still there are lessons that can be learned from their explorations.

In essence the four aspects of restorative environments, fascination, being away, extent, and compatibility, determine the restorative effect of an environment (Kaplan, 1995, p.173; Kaplan & Kaplan, 1989, p.193-195). If for some reason one of the aspects is lacking, the restorative effect of an environment for that person is decreased. Yet as Ulrich (1981, p.548-552) noted, a restorative environment is only restorative for people in a state of high arousal and tension. He speculates that under-stimulated people might prefer urban environments.

Besides the restorative aspects, people also express a preference for certain environments depending on their needs. This is reflected in the aspect of compatibility as formulated by Kaplan & Kaplan (1989, p.193-195; Kaplan, 1995, p.173). Yet almost all studies conducted by Kaplan & Kaplan (1989; Kaplan, 1992; 1995; Kaplan, Kaplan & Ryan, 1998), as well as Ulrich (1979; 1981; 1983; 1984), and Staats & Hartig (2004) find that people also profess preference for certain elements or characteristics in the environments they are viewing.

These additional characteristics determining preference have been touched upon before in the discussions about the sensory systems and how the perception of an image is different from the perception of a space. These aspects were identified as coherence, complexity, legibility, and mystery.

### 2.0.1 Preference

In 1968 Wohlwill conducted a study with a mere 14 scene’s in which he reported that environmental patterns have the highest preference at medium levels of complexity. Although Kaplan & Kaplan found his study an exciting venture, their disagreement with his conclusions led them to replicated his venture on a grander scale. (Kaplan, 1992, p.586).
Through an extensive array of studies, they replicated and extended his findings. They found partial support for Wohlwill’s conclusions in the sense that scenes lacking complexion were not preferred. Yet scenes with a high level of complexity did not increase preference by itself. It was clear that preference was influenced by more than complexity. (Kaplan, 1992, p.595).

Complexity goes hand in hand with coherency, within their studies they had complex scenes that looked coherent as well as complex, incoherent, or chaotic scenes. Thus they found that in addition to complexity, coherency also influenced preference for certain scenes. (Kaplan, 1992, p.586-587; Kaplan, Kaplan & Ryan, 1998, p.7-14).

In judging landscapes people often appear to judge the potential for how they can function in the environment they are viewing. Indications of the possibility to enter, gain information and to easily navigate were found to be vital attributes. Two characteristics influencing preference were distilled from this: “legibility” and “mystery” (Kaplan, 1989, p.38, 52-56; Kaplan, Kaplan & Ryan, 1998, p.7-14, 49-66).

### 2.0.2 Preference matrix

One of the crucial differences between these four characteristics is in what order they are judged. Coherence and complexity are immediately judged when one views a scene, later followed by legibility and mystery (Kaplan, 1992, p.587-588). Although they are judged at different times, the time frame is still only a few milliseconds. Perhaps a clearer way to put to explain the difference is by looking in which plane they are identified. Coherence and Complexity are judged in the two-dimensional plane while legibility and mystery are judged through immersion and thus in the three-dimensional plane. (Kaplan, Kaplan & Ryan, 1998, p.13).

Another difference between the characteristics is that they deal with different human needs. It is inherent to human nature to want to understand their environment and what goes on around them (Kaplan & Kaplan, 1989, 50-51; Kaplan, Kaplan & Ryan, 1998, p.7-14). Through understanding we achieve a sense of security, an element that has been touched upon before in the narrative of scenes, in the prospect refuge theory and by Staats & Hartig (2004, p. 199-211).

However we do not stop at merely wanting to understand our environment. We want to explore and broaden our horizon as well (Kaplan, 1989, p.52-53; Kaplan, Kaplan & Ryan, 1998, p.9-13). Exploring is thus the second human need. It focuses our mind on the environment, breaking it away from our daily struggles, as well as giving us a feeling of enjoyment at finding out what was hidden, or finding a place we have not seen before.

The understanding of how preference is determined, how information is acquired and what human need is satisfied al-
allowed for the creation of the preference
matrix (Kaplan, Kaplan & Ryan, 1998).

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<tr>
<th>Understanding</th>
<th>Exploration</th>
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<tr>
<td>Coherence</td>
<td>Complexity</td>
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<tr>
<td>Legibility</td>
<td>Mystery</td>
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**Coherency**
The term coherency has been discussed
before in relation to viewing scenes. The
mind first identifies individual elements
when viewing an unfamiliar scene (Stern-
berg, 2009, p.32-33). The mind then uses
the individual elements to create a narra-
tive for that scene. In the preference ma-
trix coherence is used in a similar manner.

A coherent scene is ordered; organ-
ised into clear areas and has repeating
themes for the different areas. This al-
 lows viewers to more quickly discern the
narrative of the environment they are
viewing (Kaplan, Kaplan & Ryan, 1998,
p.14; Sternberg 2009, p.31-32). Coherence
thus allows the need for understanding
to be satisfied.

Especially the grouping of elements is
important in achieving a coherent scene. If
one looks at the dry landscape of the
Ryoan-ji Temple, a quick glance yields
a couple of distinct rock formations
against a background of pebbles with a
rather smooth and uniform texture. Clo-
er inspection however reveals that the
distinct rocks we perceived actually are
groupings of multiple rocks. Groupings,
such as in this dry landscape, facilitate
visual organisation allowing us to quickly
understand the scene.

**Complexity**
Complexity can thus easily be under-
stood to be the opposite of coherent,
since it often means more difficult. Yet
this is not always true (Kaplan, Kaplan &
Ryan, 1998, p.14). Complexity is defined in
the number of different visual elements a
scene contains, the distribution of these
elements, and the abundance of for ex-
ample textures or colours (Kaplan &
Kaplan, 1989, p.53-54).

It reflects how much is going on in the
environment and how much can be ex-
plored. Complexity thus allows for great-
er exploration, satisfying the second hu-
man need.

If the clear groupings of rocks in the dry
landscape of the Ryoan-ji temple were
to be removed only the background of
pebbles with a relatively smooth texture
would be left. This scene would however
not offer much more to look at after the
first glance.

While adding similar groupings of rocks
into the dry landscape within the same
pattern would increase its intricacy and
offer more richness. It would not alter the
number of different visual elements. The
scene would become more complex but
stay highly coherent.

**Legibility**
Legibility is closely related with way-find-
ing and as such memorable and distinc-
tive features in an environment like landmarks are important elements. Yet natural features, such as a tree, a rock or a hill, that appear to be landmarks can quickly turn out to be repetitive elements that can decease the navigability and thus disorient users. Open environments with views can make way-finding easier since people are able to see where they came from and where they are going.

Legibility is increased the more familiar one is with the environment, meaning that they know what elements are suitable landmarks and which elements will turn out to be repetitive elements. Legibility thus allows the need for understanding to be satisfied. (Kaplan, Kaplan & Ryan, 1998, p.15)

**Mystery**

The desire for exploration is greatly enhanced when mystery is introduced into the environment. People often want to see what is around the corner. A curved path induces the urge to continue exploring more than a straight path. (Kaplan, Kaplan & Ryan, 1998, p.16)

When vegetation partially obscures what is come it induces curiosity since it promises something more to see. However dense vegetation fully obscuring what is to come reduces the preference of the environment. In this case the view does not give a promise that anything is behind it. Mystery thus initiates exploration, satisfying the second human need.

The dry landscape of the Ryoan-ji Temple has been composed with fifteen rocks clustered into five groups (Lafrenier, 2014). The landscape has been composed in such a way that only fourteen rocks can be seen at any time from any angle.

The local people intuitively know the amount of rocks that should be there since the number fifteen signifies completeness in Buddhism. Knowing how many rocks should be there and only being able to view fourteen at the same time ensures that people explore the garden. They will be trying to find a vantage point that will allow them to see all fifteen rocks at the same time.

**2.1 Preference vs Restorative**

Many different ways in which preference for natural environments can be elicited have been introduced. Often the preference for an environment can be reduced to simple concepts: the need for legibility, complexity, exploration, and mystery.

These concepts go hand in hand with the concepts of restorative environments. Where preference for an environment does not necessarily mean restorative. Yet it does increase the likeliness of entering and enjoying restorative environments.

While much of the literature has been explored and many of the theoretical themes, strategies and tools for the de-
sign of restorative environments have been introduced, they remain theoretical.

Through the use of precedents possible design solution integrating the theoretical themes, strategies and tools in the toolbox will be explored.

Identifying how each of the precedents deals with specific challenges will provide additional practical input for the formulation of the themes, strategies and tools.
In order to create a better understanding on how the theoretical constructs, like soft fascination, being away, extent, compatibility, mystery, exploration, legibility, and complexity can be translated, four different precedents were selected.

They all constitute a restorative environment but have to deal with different challenges in creating these restorative environments.

3.1 Precedents
Maggie’s Centre Gartnavel has been chosen due to the small scale of the project, the location, and its function. Since it deals with cancer patients, their family and friends, it qualifies as a high stress environment. The location of the centre is the most secluded of the four, and as such is able to use the landscape.

The Bosco Verticale is a high-rise apartment building thus dealing with a specific aspect of the design brief; restorative spaces in high-rise buildings. Due to the height of the building the design can do very little with existing nature on the ground floor.

The ING Headquarters is known as an healthy office environment. People working there report it as an pleasant environment and they have the lowest rate of sickness in the Netherlands. It also deals with yet another aspect of the design brief; offices.

The last precedent is Paley Park in New York city. While technically not a building it is a famous restorative environment in the middle of one of the busiest cities in the world.

Each of the precedents has been analysed with major themes such as: space, routing, transitions, soft fascination, water, light, sound, involvement, activities, and suitability in mind.

Below the most important findings for each of the precedents can be found. The last paragraph discusses the themes, strategies (identified with a letter), and tools (identified with a number) that specific precedent influenced.

The complete analysis for each precedent can be found in the appendix.
4 Maggie’s Centre Gartnavel

Maggie’s Centers are small scale centres that provide free practical, emotional, and social support to people with cancer, their family and friends. The centres belong to the The Maggie Keswick Jencks Cancer Caring Centres Trust which was founded by cancer patient Maggie Keswick Jencks. The centres are always constructed on the grounds of cancer hospitals to illustrate that they are not meant to replace conventional cancer therapy, but as a caring environment.

4.1 Design
Maggie’s Centre in Gartnavel Glasgow has been designed by OMA, and as with all Maggie’s Centres the aim was to design a warm and welcoming environment. According to Rem Koolhaas (in Kim, 2010) the strength of the location in Gartnavel was the nearness of the hospital while retaining the possibility of creating a private space which is both shelter and exposed due to the landscape and its central position.

Maggie’s Centre Gartnavel is a single story building with courtyard and a small basement. It has been designed to radiate a welcoming and pleasant atmosphere through the use of open views, natural light and an intimate connection with nature. The final design resulted in a series of restorative environments with various degrees of privacy.

4.2 Findings
4.2.1 Prospect refuge
The strength of the design can be found in how the prospect refuge theory was applied to the design. Each of the spaces needed to be open, light, and welcoming, yet the different functions demanded that some of the spaces felt more secure than others.

This was accomplished by altering the exterior landscape to the north of the building. This ensured that people were able to look outside unseen, while maintaining the light and open atmosphere of each of the rooms achieved through ceiling high windows. At the South end of the building, where the public spaces are located, the opposite has been done. The ceiling high windows reveal
far-sights where people can stare and let their eyes wander.

### 4.2.2 Outlets for frustration

The walking trail behind Maggie’s was designed as a loop and can only be accessed through the centre itself. It serves as an outlet for the frustration the visitors of the centre might experience. It allows people to walk and thus spend the excess energy they might have. The simple layout and private nature of the trail ensures that people walking along it can wander in any direction without getting lost or bothered by outsiders.

This ensures that their mind can wander, allowing one to experience the restorative effects of the environment.

### 4.2.3 Connection with nature

There are several ways in which the visitors of Maggie’s Centre Gartnavel experience nature. They can walk outside amongst the trees and shrubs, smell the loam and vegetation while enjoying the far-sights. They can sit in one of the many social areas in the building while looking out through the ceiling height windows viewing the vegetation outside. They can enjoy seclusion in the contemplation space with a skylight that focusses ones attention on the sky. Or they can sit in the courtyard enjoying the small scale vegetation in a sheltered area.

The intimate connection with nature also exposes the visitors to the less tangible aspects of nature such as the passing of time and weather. The many windows, the skylights and the courtyard ensure that people experience every aspect of the weather. The design of the landscape allows the formation of a seasonal pond filled by rainwater during the wet periods of the year. The vegetation surrounding Maggie’s centre changes with the seasons thus reflecting the passing of time.

### 4.3 Themes, Strategies, and Tools

Maggie’s Centre Gartnavel reflects on many of the themes that were identified in the theory. As such it substantiates the choice for these themes. The analysis also resulted in strategies and tools for the toolbox:

- The way in which elevations (3 and 12) are used to create and obstruct far-sights,
- The organisation of the routing system in which the hallway (23) is part of the spaces instead of a separate space,
- The height difference (20) marks the transition between spaces,
- The way in which the vegetation was chosen to reflect the passing of time (30),
- The inclusion of a seasonal pond in the interior courtyard (H),
- and the use of windows (38) and variable floor height to allow natural light (40) in.
The Bosco Verticale is a part of the rehabilitation of the historic district of Milan. As a densely populated city, Milan struggles with the little green space it has and the amount of pollutants in the air as well as high temperatures in the summer and low temperatures in winter. As a part of this rehabilitation, the architects Boeri, Barreca and La Varra wanted to restore the connection between people and nature while at the same time countering the problems of the city.

5.1 Design
The Bosco Verticale is a pair of residential towers in the Porta Nuova district near the centre of Milan. The towers have a height of 110 meters and 76 meters respectively containing 26 and 18 floors and total of 111 apartments. The apartments vary in size ranging from two to five bedrooms.

What makes this project special is that the façades contain nine-hundred trees and over two-thousand smaller perennials. The plants have been specifically chosen by landscape architect Laura Gatti to serve as active shading and being wind resistant. She also took the different orientations of the façades into account while selecting the trees.

5.2 Findings
5.2.1 Connection with Nature
The analysis revealed that the realised building is substantially different from the proposed concept that won the design competition. The concept and the actual building were both analysed and compared to see what the difference meant to the restorative qualities. The concept detailed patio like balcony spaces with different ways to integrate vegetation. The realised building only used one method for integrating the vegetation.

While the reason for this change is unclear it is most likely that the containers for the soil turned out to be too small to house the different types of trees and other perennials. Therefore the containers in the final design are much larger than the ones initially proposed limiting the potential of the balconies.
The final containers not only housed the vegetation but also serve as the baluster for the balcony. This means that, with a height of 1200 mm, they are too high to offer far-sights while seated and most of the trees and perennials are above eye height.

5.2.2 Seasonal change
The vegetation was not only chosen on their ability to withstand wind, provide shade, and the amount of sun hours they needed but also on how they changed over time. Each type was specifically selected based on how they changed throughout the year as well. While some retain leaves, others turn bright yellow before they shed their leaves, and groups of flowers bloom after each other ensuring the facade is ever changing. This added complexity invites for constant exploration.

5.2.3 Prospect refuge
One of the most successful aspects of the Bosco Verticale is the well defined balcony space. The vegetation in combination with the containers form spaces that are not fully exposed like regular balconies. The sparsity of the vegetation ensures that far-sights are still possible from this sheltered space. The vegetation and the concrete containers also ensure that vertical neighbours do not constantly look down on the other balconies.

5.2.4 Temperature and sound
The screen of vegetation also shelters the inhabitants from the sun by providing shade, as well as from the sounds pollution of the city through the creation of pink noise and absorption. This is however not as effective as proposed in the initial concepts.

5.3 Themes, Strategies, and Tools
Many of the themes identified in the theory are reflected in either the concept or the design of the Bosco Verticale. As such it substantiates the choice for these themes. The analysis also resulted in strategies and tools for the toolbox:

- The way in which the duality between closed and open (6 and 9) are used to create and obstruct far-sights,
- The use of different types and sizes of flora (28),
- The change of the vegetation with the seasons (29 and 30),
- How the vegetation is used to shelter from the sun (41, 45, 46, 48, and 49) and sound pollution (42, 43, and 44) of the city.
6 ING Headquarters

The ING Headquarters, formerly known as the NMB Headquarters, is a large office building in the Amsterdamse Poort, a small shopping area in the Bijlmer which is a suburb of Amsterdam. NMB Headquarters is located on the south edge of the shopping area and is flanked by a residential district, commercial district and business district.

6.1 Design
The building was designed by Alberts and van Huut in 1987. They strove to create the most sustainable building of their time, not just in energy but in functionality as well. Alberts en van Huut are known for the anthroposophical and organic architecture which is reflected in the s-shaped building.

The building consists of a central interior street which connects the ten towers and contains communal functions such as the entrance, the restaurant and the rooftop gardens. Each tower has a central atrium with a large skylight providing natural light for all the floors and the interior street. In turn each floor contains five office units of 88m2. Despite the scale of the building the user was central to the design and each employee had 17m2 of workspace.

6.2 Findings

6.2.1 Functions
With the creation of ten smaller towers instead of one large tower they took the risk of creating separately functioning buildings that would not interact with each other. It is the interior street in combination with the atria that promotes interaction between the floors, and the clusters. The interior street also contains pieces of art, water features, and flora to provide additional place where one can be distracted or socially interact.

The atria contain stairs interconnecting the different floors, allowing for easy access. This also promotes the use of the stairs over the use of elevators.

6.2.2 Connection to nature
The meander in the shape of the building naturally created three spaces for the rooftop gardens. As such each cluster looks out over at least one of the roof-
top gardens. The gardens have a different theme ensuring that the employees have enough to explore. When one of the gardens becomes under-stimulating one can visit the other two gardens.

The atria also serve as a connection with the outside, ensuring that people are able to experience the changes in the weather, the movement of the sun and the changes of time such as the passing of seasons. The inclusion of perennial plants in the atria serve as another form of soft fascination strengthening the restorative effect of the atria and interior street.

Another connection with nature is in the form of water, each of the gardens has a water feature. The effect of water is not limited to the garden but present in the interior as well. The handrails of the main stairs in the interior street have a flow-form water feature as well. People can touch the water as well as hear and smell it.

6.3 Themes, Strategies, and Tools

The design of the ING Headquarters deals with many of the themes used in the toolbox, further strengthening their connection with restorative spaces. Some of the strategies and tools in the toolbox resulting from this analysis are:

- The way in which the distribution of functions is used to promote interaction and movement (1, 50, and 51)
- The way in which the interior street (23) connects each of the clusters (13) by providing a clearly defined path (11, 17, and 22)
- The function of the atria (39) in connecting people with both the animate (G) and inanimate (17, 30, 32, and 34) aspects of nature.
- and the use of art (34), flora (G and 28), and water (32 and 33) to create a restorative effect.
Paley Park

Paley Park is a vest pocket park. The concept for these parks has been created by Zion & Breen Associates as a counter proposal for the New York minimum park size. Zion & Breen argued that occasional spots of open space had to be set aside where residents and visitors would be able to sit and enjoy themselves as they paused their daily activities.

7.1 Design

The plot on which Paley Park has been build measures 15.2m by 30.4m. The park intrudes into the street scape and marks its location without giving away the park itself. The park consists of three sections, the entrance, the sitting area and waterwall at the back of the park.

The twelve honey locust trees, the water and the ivy covered walls create an abstract image of a natural environment. It is an oasis in which the noise from the waterfall masks the sounds of the city. Both the setback of the entrance and the canopy of the trees provide a visual barrier against the city.

7.2 Findings

7.2.1 Transitional spaces

Several design elements were cleverly used to create transitional spaces to create an illusion of distance between the park and the city. The honey locust trees mark the location of the park and create a barrier between the sky and the visitor. The setback of the park, the small stairs, the gate and the narrowing of the path through the use of two kiosks form a series of transitions that create distance between the city and the park.

After this series of transitional spaces a change in materials marks the change from entrance to the park proper, while a second stairs at the back forms the transition between the park proper and the waterwall.

7.2.2 Sound

The trees also function as objects that produce pink noise to mask the sounds of the city as well as objects that absorb the noise pollution. The waterwall at the back of the park serves the same function and produces a large amount of
pink noise that can be heard throughout the park.

Through the production and absorption of noise the narrative of the restorative environment is strengthened and as such the restorative effect as well.

7.2.3 Prospect refuge
The trees in the park are multifunctional, they serve as soft fascination, filter the sunlight, and shelter the people underneath them. The canopy of the trees effectively obstruct the view from the surrounding buildings ensuring that the people feel secure in the park.

7.3 Themes, Strategies, and Tools
Even though Paley park is such a small place it employs many of the themes described in the literature to create a restorative environment. As such the analysis provided leads for the strategies and tools in the toolbox:

- The use of transitional spaces (E) in Paley Park to create an illusion of distance with the city.
- The effective dealing with sound through absorption (L) and creation (M).
- Use of the trees to filter sunlight (K and 41) and create refuge (9, 25, and 26).
- and using a waterwall (32, 33, and 44) as a focal point strengthened by the use of artificial lights.
8 Conclusion

Through examination of the theories on stress, the sensory systems, the prospect refugee theory, the patterns (appendix B) (Kaplan, Kaplan & Ryan, 1998), the biophilic design theory (appendix A) (Kellert, 2008) and the four case studies, greater understanding on the design of restorative environments is attained.

8.1 Identifying tools
The case studies served as the mediating factor in identifying themes, strategies, and tools from the previously discussed literature. Each of the case studies had its own focus and the analyses provided the means to see how each dealt with different themes, strategies, and tools that are to be included in the toolbox for restorative design.

8.2 Preliminary toolbox
The toolbox has a hierarchical structure with three levels. The themes are the first level, the strategies the second and the tools the third level.

8.2.1 Themes
There are several important themes in the design of restorative environments. Each of the themes deals with a different aspect of architecture and restorative environments. Space, routing and transitions are large scale themes dealing with architecture. Soft fascination, light and sound deal with creating and safeguarding restorative qualities. While involvement and activities deals with the human aspect in restorative environments. The last theme suitability deals with anchoring and contrast between the built environment and a restorative environment.

8.2.2 Strategies
Each of these themes contains one or more strategies. Among these strategies are for example legibility and complexity (A), prospect and refuge (B), experience (C) and way-finding (D).

The strategies are derived from both the literature and the findings from the case studies.

8.2.3 Tools
Each of the strategies contains one or more tools that can be used to imple-
ment that strategy. For example in the creation of spaces, the strategy legibility and complexity (A) can be employed by using the design tool groupings (1) or patterns (2).

8.2.4 Toolbox
The table below shows each of the themes with its strategies and tools. Although the themes are unique, the strategies and tools are not. Within the toolbox there are identically named strategies and tools belonging to different themes.

While they have a similar name they deal with slightly different aspects in the design of restorative environments.

It is important to note that the proposed toolbox is not exhaustive. Further research and different precedents will yield additional themes, strategies and tools.
<table>
<thead>
<tr>
<th>Theme</th>
<th>Strategy</th>
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<tbody>
<tr>
<td>Space</td>
<td>A. Legibility and complexity</td>
<td>1. Groupings</td>
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<td></td>
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<td>2. Patterns</td>
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<td></td>
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<td>3. Elevations</td>
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<td>4. Windows</td>
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<td>B. Prospect refuge</td>
<td>5. Orientation</td>
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<td>9. Closed and open</td>
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<td></td>
<td>10. Uncrowded and crowded</td>
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<td>Routing</td>
<td>C. Experience</td>
<td>11. Paths</td>
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<td>12. Height difference</td>
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<tr>
<td></td>
<td></td>
<td>13. Place of interest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14. Materials and textures</td>
</tr>
<tr>
<td></td>
<td>D. Way-finding</td>
<td>15. Landmark</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16. View</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17. Natural light</td>
</tr>
<tr>
<td>Transitions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E. Thresholds</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Gates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Narrowing of path</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Height difference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Materials and textures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Light and dark</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **F. Transitional spaces**     |
| 23. Hallway                    |
| 24. Pergola                    |
| 25. Green tunnel               |
| 26. Overhang                   |
| 27. Arcade                     |

| **Soft fascination**           |
| **G. Flora**                   |
| 28. Size variation             |
| 29. Colour                     |
| 30. Seasonal change            |
| 31. Interaction                |

| **H. Water**                   |
| 32. Running water              |
| 33. Interaction                |

| **I. Weather**                 |
| 34. Outside connection         |

<p>| <strong>J. Culture</strong>                 |
| 35. Photos                     |
| 36. Art                        |
| 37. Music                      |</p>
<table>
<thead>
<tr>
<th>Toolbox</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
</tr>
<tr>
<td>K. Natural light</td>
</tr>
<tr>
<td>38. Windows</td>
</tr>
<tr>
<td>39. Atria</td>
</tr>
<tr>
<td>40. Floor height</td>
</tr>
<tr>
<td>41. Diffuse</td>
</tr>
<tr>
<td>Sound</td>
</tr>
<tr>
<td>L. Elimination</td>
</tr>
<tr>
<td>42. Absorption</td>
</tr>
<tr>
<td>43. Reflection</td>
</tr>
<tr>
<td>M. Creation</td>
</tr>
<tr>
<td>44. Pink Noise</td>
</tr>
<tr>
<td>Involvement</td>
</tr>
<tr>
<td>N. Regulation</td>
</tr>
<tr>
<td>45. Temperature</td>
</tr>
<tr>
<td>46. Windows</td>
</tr>
<tr>
<td>47. Ventilation</td>
</tr>
<tr>
<td>48. Light</td>
</tr>
<tr>
<td>49. Humidity</td>
</tr>
<tr>
<td>Activities</td>
</tr>
<tr>
<td>O. Action</td>
</tr>
<tr>
<td>50. Walking</td>
</tr>
<tr>
<td>51. Separation of functions</td>
</tr>
<tr>
<td>52. Gardening</td>
</tr>
<tr>
<td>P. Inaction</td>
</tr>
<tr>
<td>53. Sitting</td>
</tr>
<tr>
<td>54. Viewing</td>
</tr>
<tr>
<td>Suitability</td>
</tr>
<tr>
<td>Q. Awe-inspiring</td>
</tr>
<tr>
<td>55. Flora</td>
</tr>
<tr>
<td>56. Otherness</td>
</tr>
</tbody>
</table>
Part 4: Toolbox
1 Introduction

In the previous chapter the aspects of preference were discussed as well as four precedents in order to identify and validate themes, strategies, and tools for the design of restorative environments.

The final themes, strategies, and tools proposed in the conclusion of the third part include themes, strategies, and tools from a multitude of sources.

- the biophilic theory (appendix A)
- the stress restoration theory
- attention restoration theory
- stress
- the sensory systems
- the prospect refuge theory
- the pattern language (appendix B)
- and the precedents

This toolbox is not exhaustive, different precedents will undoubtedly reveal other themes, strategies, and tools for the toolbox. As such the toolbox is an ongoing project that will have to be supplements at a later stage.

The proposed framework for the toolbox consists of themes that contain strategies. Each of the strategies is comprised of one or more tools based on the four aspects of restorative environments and the four aspects of preference: soft fascination, sense of being away, extend, compatibility, coherence, complexity, legibility, and mystery.

Below each of the tools will be explained. Often a tool is useful in implementing different strategies. As such there are multiple mentions of the same tool. Each tool however still deals with a slightly different aspect of the implementation.

As with all volumes discussing architectural tools there are multiple ways to accomplish the design of restorative spaces. As such each tool is accompanied with related strategies and tools.

These refer to different strategies and tools that can be used together. As such they can be combined in many different ways ensuring a versatile toolbox usable for many different design challenges.
A. Legibility and complexity

1. Groupings
Increasing the complexity of a space often entails incorporating additional objects. In doing so the legibility of the space should be maintained by grouping individual objects. Each group will be viewed as an individual objects ensuring that the space will be legible, while the objects in each group add complexity.

Related strategies and tools
G. Flora

2. Patterns
Organisation of functions and objects in patterns increases both the legibility and complexity of a space. Such underlying patterns can be simple; large to small, or it can be more complex; fractals.

Related strategies and tools
G. Flora

44. Pink noise

3. Elevations
Height differences increase the legibility of a space by acting as a landmark for navigating and by providing an overview of the space. Elevations also obscure part of the space introducing a sense of mystery, which increases the likeliness for exploration.

Related strategies and tools
B Prospect Refuge  C Experience

4. Windows
A window serves multiple functions. It often marks the boundary of a space, making the dimensions of the space legible. While the view window provides from one space to another adds to the complexity.

Related strategies and tools
K. Light  5. Orientation
N. Regulation  8. Windows

B. Prospect and refuge

5. Orientation
The aspect of prospect is closely related to orientation. It is not merely view that people want, but a view that allows them to orientate. To see the sun, to view a landmark, or the scout the path ahead.

Related strategies and tools
C. Experience K. Light
D. Way-finding 54. Viewing

6. Platform
Viewing from a platform changes one’s perspective and provides an overview of an area, thus fulfilling the demand for prospect.

Related strategies and tools
C. Experience P. Inaction
D. Way-finding

7. Bridge
A bridge often spans a gap, leaving a wide open view, while also leaving the person exposed to its peers. A bridge thus offers prospect but little refuge. Through design, a bridge can be changed to provide prospect while offering refuge as well.

Related strategies and tools
C. Experience 9. Closed and open
H. Water 50. Walking
P. Inaction

9. Closed and open
This duality forms the crux of prospect and refuge. Often a closed space offers little prospect while providing adequate refuge. The reverse is true an open space. Restorative spaces should offer both prospect and refuge at the same time.

Related strategies and tools
C. Experience 1. Groupings
G. Flora

10. Uncrowded and crowded
Often the scale determines whether people feel comfortable in a space. Smaller spaces are enjoyed more when uncrowded, while larger spaces are either enjoyed more when used by others, or when in a group.

Related strategies and tools
G. Flora 20. Height difference

8. Windows
The view through a window provides both prospect and refuge. One can see into another space, prospect, while the framing of the view ensures refuge.
Routing

C. Experience

11. Paths
The paths that guide people through a space or building should be simple, clearly defined, offer complexity and mystery, and an aim. Curved and winding paths can be used to strengthen the narrative of a space while at the same time creating the illusion of a larger space.

The curved paths can be used to partly hide what is to come, adding to the sense of mystery that provides an incentive for exploration. The paths can also be used to guide the eye towards an object or function, adding to the incentive for exploration.

Related strategies and tools
D. Way-finding
E. Threshold
3. Elevation

12. Height difference
A route that traverses height differences allows people to attain different perspectives of the environment. The height differences should however provide an incentive in the form of view.

Related strategies and tools
B. Prospect refuge
D. Way-finding
P. Inaction

13. Place of interest
The objects that create the incentive for the exploration can be an array of different things: a single tree, a rock, a bench, a folly, a view, a function, or simply an expectation.

Related strategies and tools
D. Way-finding
P. Inaction
K. Light
50. Walking

14. Materials and textures
Distinguishing between the route and the space through a different material ensures that the route is easily identifiable. This serves as an invitation for people to follow the path and see where it leads, with the confidence that they will not get lost.

The texture determines the ease with which the route can be followed. This strengthens the invitation to follow the path. A smooth ground texture is more inviting than a jagged path of rocky outcappings.

Related strategies and tools
C. Experience
L. Elimination
D. Way-finding
21. Materials and textures
D. Way-finding

15. Landmark
Depending on the size of a landmark it can function on a small scale: along a path, or it can function on a larger scale: a reference point for a whole space.

Related strategies and tools
A. Legibility    P. Inaction
G. Flora         5. Orientation
H. Water         13. Place of interest

16. View
View from a platform, elevation or a bridge is a manner through which people can determine where they are, where they are going to, and how to get there.

Related strategies and tools
P. Inaction     12. Height difference
B. Prospect refuge    13. Place of interest
3. Elevation

17. Natural light
Using light for way-finding is especially useful when it concerns sunlight. People always orientate towards the light. Whether walking in nature or working at a desk. In a building: doors, windows, or skylights signify an opening to the outside and thus a view to the outside. In a park or forest an opening in the foliage signals a place to orientate.

Related strategies and tools
G. Flora     15 Landmark
K. Light     22 Light and Dark
N. Regulation 13 Place of interest
Transitions

E. Thresholds

18. Gates
Simply put, a gate is an opening in an object one uses to enter a different space or area. The opening is a threshold marking the boundary between spaces. This threshold can be strengthened by including a fence. A Gate can also partially obscure the place beyond and thus inducing a feeling of mystery.

Related strategies and tools
- B. Prospect refuge
- H. Water
- C. Experience
- 3. Elevation

19. Narrowing of path
Within the same space the narrowing of a path can signify the entering of a different area. At the same time however it can also create a sense of mystery by partially obscuring the place beyond.

Related strategies and tools
- C. Experience
- H. Water
- G. Flora
- 5. Orientation

20. Height difference
The height difference is two fold. It can be a physical barrier like a stairs or ramp, or a metaphorical barrier like a variation in the height of a ceiling. Both have similar effects in signifying the entering and leaving of a space. The varying of the ceiling height can however also decrease or increase the sense of security.

Related strategies and tools
- D. Way-finding
- G. Flora
- K. Light
- N. Regulation
- 4.-8. Windows
- 13. Place of interest

21. Materials and Textures
A change in materials and texture is a very subtle way to signify the entering of a different place with a different atmosphere. Concrete is often perceived as hard and cold, yet wood is often thought of as warm and soft. By changing the dominant material of a space, it gets an entirely different atmosphere.

Materials are also a subtle way to change the atmosphere of a space.

Related strategies and tools
- C. Experience
- L. Elimination
- G. Flora
- 2. Patterns
- H. Water

22. Light and Dark
The intensity of light has a major influence on the atmosphere of a space. The transition between light and dark creates a metaphorical distance between two places.

Related strategies and tools
- D. Way-finding
- G. Flora
- K. Light
- N. Regulation
- 4.-8. Windows
- 13. Place of interest
F. Transitional spaces

23. Hallway
Hallways are often undetermined spaces with the sole function of allowing people to move from one room to another. Although hallways are an inevitable part of circulation, they should include other qualities to ensure they fit the narrative of the sequence of spaces.

Related strategies and tools
C. Experience  D. Way-finding  G. Flora  5. Orientation
39. Atria  50. Walking

24. Pergola
A pergola is an exterior space in the circulation system allowing people to move from one area to another. The pergola can either connect exterior spaces or the interior with the exterior. The quality of a pergola is that it frames a space without closing it off using a lattice work which is often used to train vines on.

Related strategies and tools
39. Atria  47. Ventilation

25. Green tunnel
A path connecting exterior spaces where trees on either side form a more or less continuous overhead canopy. The canopy shelters from rain and filters the sunlight. In winter the trees will be bare letting in more sunlight, but rain as well.

Related strategies and tools
47. Ventilation  53. Sitting

26. Overhang
The change in height from sky to overhang, and from overhang to interior eases the change in ceiling height. It also protects people from weather yet is still part of the exterior domain.

Related strategies and tools
D. Way-finding  N. Regulation  P. Inaction
K. Light

27. Arcade
The arcade forms a transitional space between the exterior and interior. It protects against perspiration and sun and has a connection to the exterior but is not part of either the interior or exterior domain.

Related strategies and tools
C. Experience  D. Way-finding  K. Light  45. Temperature  50. Walking
47. Ventilation  53. Sitting
Soft Fascination

G. Flora

28. Size variation
Mixing large elements such as trees with small elements like plants ensure complexity. Through the creation of such groupings legibility is maintained.

Related strategies and tools
1. Groupings
2. Patterns

29. Colour
The green colour of most vegetation is perceived as neutral by our brain, it calms when overstimulated and arouses when under stimulated. Blue on the other hand is calming, whereas red arouses.

Related strategies and tools
H. Water

30. Seasonal change
The endless changing of vegetation ensures constant complexity in the scenes we perceive. With each passing season the vegetation appears different; flowers in spring, lively green in summer, vivid colours and fruits in autumn, and bare branches in winter.

Designing with the different qualities of each type of plant allows for the creation of restorative environments that look different each season. Some of the aspects are flowering times, colours, fruits, and leaf retention.

Besides the seasonal changes, the passing of time is also reflected in the growth of plants. This too ensures a constant change in the restorative environment and thus sustained complexity.

Related strategies and tools
K. Light
N. Regulation
P. Inaction

31. Interaction
While flora universally fascinates the restorative effect can be strengthened by allowing for interaction with the vegetation. This interaction can be physical, like smelling flowers, gardening, and feeling the textures, or it can be purely visual, such as a view through a window.

Related strategies and tools
M. Creation
N. Action
H. Water

32. Running water
Moving water has the quality that it reflects the light and the surrounding area in varying patterns ensuring endless complexity. As such moving water is uniquely able to capture attention in such a way that people get lost in thought.

Related strategies and tools
P. Inaction 15. Landmark
3. Elevations 16. View
12-20. Height differences 29. Colour
13. Place of interest 50. Walking

33. Interaction
The relation between people and water can be more profound than simply visual. Through design the touching of water can be facilitated, stimulating the haptic system. The movement of water creates calming pink noise which also masks unwanted sounds as well.

Related strategies and tools
B. Prospect refuge
P. Inaction
I. Weather

34. Outside connection
The inanimate aspects of nature such as the weather are also sources of soft fascination. Connections with the exterior allow people to experience the changes in weather ensuring that they can be used as a source of soft fascination.

Related strategies and tools
K. Natural light  H. Water
M. Creation  30. Seasonal change
J. Culture

35. Photos
Photographs of natural scenes have a similar effect to viewing a natural scene through a window. The experience of this photograph is however limited to the visual system.

Related strategies and tools
G. Flora
4. Window

36. Art
Most art has a similar ability to capture attention. This can simply be due to the natural scene it displays, the use of colour, the texture of the strokes, or the narrative. Including art in spaces where flora or water is absent can thus facilitate the restorative effect.

Related strategies and tools
P. Inaction
16. View
13. Place of interest

37. Music
Similar to the effect of pink noise, music based on complex fractals and patterns has calming quality. Important is that the music fits the narrative of the space and intent of the person.

Related strategies and tools
M. Creation
Light

K. Natural light

38. Windows
Openings in the facade are a direct connection with the exterior allowing one to have a view outside but also ensuring that sunlight can penetrate into a space.

The position of the window determines the depth to which the light penetrates a space. While the size of the opening in the facade regulates the amount of sunlight that enters a space. As such windows have a major impact on the atmosphere of a space. Sunlight can however only enter through windows in the facade, limiting the effect natural light can have in a sprawling building.

Related strategies and tools
B. Prospect          G. Flora
C. Experience        I. Weather
D. Way-finding

40. Floor height
The ceiling height determines how far direct and diffuse sunlight can penetrate a space. The lower the ceiling, the smaller the area affected by direct sunlight. This affects the atmosphere of a room while also limiting the types of vegetation that can grow in a space.

Related strategies and tools
G. Flora
10. Uncrowded or crowded

41. Diffuse
The canopy of trees can filter the sunlight, only allowing diffuse light to pass through. As such the atmosphere of the area underneath a tree is different from an area lit by direct sunlight or artificial light.

The same effect can be accomplished by using a filter between the interior and exterior such as milk glass or a shutter system. A shutter system adds to the complexity as well through the play of shadow on the floors and walls throughout the day.

Related strategies and tools
G. Flora
22. Light of dark
Sound

L. Elimination

42. Absorption
Soft natural materials like foliage and wood dampen the sound waves of noise.

*Related strategies and tools*

G. Flora

43. Reflection
Instead of absorbing sound waves, moving water disperses the sounds in many directions. Still water on the other hand directly reflects the sound only allowing it to travel further.

Concrete and other hard materials have a similar effect. They reflect the sound waves resulting in an echo.

*Related strategies and tools*

H. Water
M. Creation

44. Pink noise
Pink noise is a category of sounds created by or associated with nature that have a particular calming effect on people. They merge with the narrative of natural restorative environments and add complexity. Pink noise can also mask unwanted sounds that clash with the narrative of the environment, such as everyday sounds in the city.

Related strategies and tools
G. Flora
H. Water
I. Weather
Involvement

N. Regulation

45. Temperature
In naturally ventilated buildings thermal comfort is closely related with outdoor temperatures. This means that the mean comfort temperature for interior spaces varies depending on the outdoor temperature.

*Related strategies and tools*
- G. Flora
- K. Light
- H. Water

46. Windows
Ensuring that people can influence the indoor environment through the opening and closing of windows increases the mean comfort temperature. A simple measure of opening a window can change the comfort temperature from 24.22 to 25.10 degrees Celsius.

*Related strategies and tools*
- G. Flora
- K. Light
- 4.-8. Windows

47. Ventilation
The addition of fans in an offices allows people to increase the flow rate of the ventilation increasing the mean comfort temperature from 24.55 to 26.49 degrees Celsius.

*Related strategies and tools*
- G. Flora
- 4.-8. Windows

48. Light
Allowing people to regulate the amount of sunlight penetrating a space positively affects the mean comfort temperature. Blinds or louvres are an architectural measure that can facilitate this interaction, while vegetation is natural solution. Through this type of interaction the mean comfort temperature changes from 24.45 to 25.50 degrees Celsius.

*Related strategies and tools*
- G. Flora
- K. Light
- 4.-8. Windows

49. Humidity
Temperature and relative humidity are closely linked, meaning that there is not one single level of humidity at which people are comfortable. The comfort zone chart shows the relation between temperature and relative humidity.

It is important to consider the transpiration of plants during photosynthesis. This transpiration increases the relative humidity in a space. Water elements have a similar effect on the relative humidity in a space due to evaporation.

*Related strategies and tools*
- G. Flora
- H. Water
Indoor temperature (°C)
Outdoor temperature (°C)
Relative humidity (%)

Too warm
Too cool
Too humid
Too dry
Activities

O. Action

50. Walking
The action of walking is an outlet for energy released during a stress response. Walking through a natural environment is an outlet that for energy while also allowing for restoration of the mind.

Related strategies and tools
C. Experience
D. Way-finding
E. Thresholds

51. Separation of functions
Through functional separation the act of walking can be facilitated. Care has to be taken that the functioning of the building is not compromised.

Related strategies and tools
50. Walking

52. Gardening
The physical effort of gardening serves as an outlet for energy while experiencing and interacting with nature allow the mind to restore. This involvement in taking care of an environment strengthens the connection between the environment and the person as well.

Related strategies and tools
G. Flora
K. Light
P. Inaction

53. Sitting
A restorative environment should never be too taxing. This would negate the restorative effect. Creating spaces where one can rest and sit in the form of benches, a log, or a tree stump is an excellent way to facilitate the inaction of sitting.

*Related strategies and tools*
C. Experience  K. Light
G. Flora  16. View
H. Water

54. Viewing
A natural way through which to facilitate inaction is to create lookouts. They invite to stand still or sit and look around. Allowing for physical resting while also allowing for mental restoration.

*Related strategies and tools*
C. Experience  K. Light
D. Way-finding  5. Orientation
G. Flora  16. View
H. Water
Suitability

Q. Awe-inspiring

55. Flora
A restorative environment should never be awe-inspiring since the over stimulation would negate the restorative effect. As such, local and well known natural qualities should be used as inspiration for the restorative environments.

56. Otherness
While over stimulation negates the restorative effect, restorative environments should also contrast with daily life. This eases the attaining of the sense of being away. It is a fine line between creating a narrative and breaking a narrative.
Part 5: Sources


Part 6: Appendices
The table below shows the dimension and elements that were defined by Kellert (2008). These elements strengthen the connection between people and nature.

<table>
<thead>
<tr>
<th>Environmental features</th>
<th>Natural shapes and forms</th>
<th>Natural patterns and processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Botanical motifs</td>
<td>Sensory variability</td>
</tr>
<tr>
<td>Water</td>
<td>Tree and columnar supports</td>
<td>Information richness</td>
</tr>
<tr>
<td>Air</td>
<td>Animal motifs</td>
<td>Age, changes and the patina of time</td>
</tr>
<tr>
<td>Sunlight</td>
<td>Shells and Spirals</td>
<td>Growth and efflorescence</td>
</tr>
<tr>
<td>Plants</td>
<td>Egg, oval and tubular forms</td>
<td>Central focal point</td>
</tr>
<tr>
<td>Animals</td>
<td>Arches, vaults and domes</td>
<td>Patterned wholes</td>
</tr>
<tr>
<td>Natural materials</td>
<td>Shapes resisting straight lines and right angles</td>
<td>Bounded spaces</td>
</tr>
<tr>
<td>Views and Vistas</td>
<td>Simulation of natural features</td>
<td>Transitional spaces</td>
</tr>
<tr>
<td>Geology and Landscape</td>
<td>Biomorphy</td>
<td>Linked series and chains</td>
</tr>
<tr>
<td>Habitats and Ecosystems</td>
<td>Geomorphy</td>
<td>Integration of parts to wholes</td>
</tr>
<tr>
<td>Fire</td>
<td>Biomimicry</td>
<td>Complementary contrasts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dynamic balance and tension</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fractals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hierarchically organised ratios and scales</td>
</tr>
<tr>
<td>Light and space</td>
<td>Place-based relationships</td>
<td>Evolved human-nature relationship</td>
</tr>
<tr>
<td>-------------------------------</td>
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<td>--------------------------------------------</td>
</tr>
<tr>
<td>Natural light</td>
<td>Geographic connection to place</td>
<td>Prospect and refuge</td>
</tr>
<tr>
<td>Filtered and diffused light</td>
<td>Historic connection to place</td>
<td>Order and complexity</td>
</tr>
<tr>
<td>Light and shadow</td>
<td>Ecological connection to place</td>
<td>Curiosity and enticement</td>
</tr>
<tr>
<td>Reflected light</td>
<td>Cultural connection to place</td>
<td>Change and metamorphosis</td>
</tr>
<tr>
<td>Light pools</td>
<td>Indigenous materials</td>
<td>Security and protection</td>
</tr>
<tr>
<td>Warm light</td>
<td>Landscape orientation</td>
<td>Mastery and Control</td>
</tr>
<tr>
<td>Light as shape and form</td>
<td>Landscape features that define building form</td>
<td>Affection and attachment</td>
</tr>
<tr>
<td>Spaciousness</td>
<td>Landscape ecology</td>
<td>Attraction and beauty</td>
</tr>
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<td>Spatial variability</td>
<td>Integration of culture and ecology</td>
<td>Exploration and discovery</td>
</tr>
<tr>
<td>Space as shape and form</td>
<td>Spirit of place</td>
<td>Information and cognition</td>
</tr>
<tr>
<td>Spatial harmony</td>
<td>Avoiding placelessness</td>
<td>Fear and awe</td>
</tr>
<tr>
<td>Inside-Outside spaces</td>
<td></td>
<td>Reverence and spirituality</td>
</tr>
</tbody>
</table>
Appendix B

The table below contains the themes and patterns of the pattern language that Kaplan, Kaplan & Ryan (1998) formulated. These patterns work towards increasing preference for an environment.

<table>
<thead>
<tr>
<th>Fear and Preference</th>
<th>Way-finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fear</td>
<td>Design</td>
</tr>
<tr>
<td>Visual access</td>
<td>Regions</td>
</tr>
<tr>
<td>Enhancing familiarity</td>
<td>Landmarks</td>
</tr>
<tr>
<td>Human sign</td>
<td>Paths and signs</td>
</tr>
<tr>
<td></td>
<td>Maps</td>
</tr>
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<td>Mapping for the mind’s eye</td>
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<th>Gateways and Partitions</th>
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<td>Gateways and orientation</td>
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<td>Separation from distraction</td>
<td>The view through the gateway</td>
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<td>Wood, stone, and old</td>
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<td>The view from the window</td>
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### Trails and locomotions
- Trails
- Trials, narrow and curving
- Views, large and small
- The trail surface
- The trial’s path
- Points of interest

### Views and Vistas
- Views and Vistas
- Enough to look at
- Guiding the eye
- More than meets the eye
- Think view

### Places and their elements
- Places and their elements
- Trees
- The water’s edge
- Big spaces
- Small spaces
- A sense of enclosure
Maggie’s Centre Gartnavel
Maggie’s Centres

“As soon as I entered it was a different world, a calm world. From that day on I felt an affinity with the place.” (Gordon, n.d.)

Maggie’s Centres are small scale centres that provide free practical, emotional and social support to people with cancer, their family, and friends. The foundation for the ideas about cancer care and support were originally laid out by Maggie Keswick Jencks. (Maggie’s Centres, n.d.; Kellaway, 2011)

Maggie’s Centres are always built on the grounds of cancer hospitals. They are places with professional staff who offer support to people in need. They are not intended as a replacement for conventional cancer therapy, but as a caring environment. (Maggie’s Centres, n.d.; Kellaway, 2011)

Maggie’s Centres

Maggie Keswick Jencks
Maggie Keswick Jencks the founder of the Maggie’s Centres was herself diagnosed with terminal cancer in 1993. In order to live more positive with cancer, she believed that you need information that would allow you to be an informed participant in your medical treatment, stress-reducing strategies, and needed the opportunity to meet other people in similar circumstances. (Maggie’s Centres, n.d.; Kellaway, 2011)

The close relation many of the Maggie’s Centre have with nature is not a surprise. She and her husband, Charles Jencks the famous architect, were firm believers in the ability of buildings and gardens to uplift people.

Maggie passed away in 1995, a full year before the opening of the first Maggie’s in Edinburgh in 1996. Since than another sixteen Maggie’s Centres have been opened. Bringing the total to seventeen Maggie’s Centres at major cancer hospitals in Great Britain. (Maggie’s Centres, n.d.; Kellaway, 2011)
Figure 5.24: Left - Site plan of Maggie’s Centre Gartnavel, original scale 1:250 (HarrisonStevens, 2010)

Figure 5.25: Right - Ground floor plan of Maggie’s Centre Gartnavel, original scale unknown (HarrisonStevens, 2010)

Figure 5.26: Left - East west section of Maggie’s Centre Gartnavel, original scale unknown

Figure 5.27: Right - North south section of Maggie’s Centre Gartnavel, original scale unknown

Figure 5.28: Left - Axonometric view of Maggie’s Centre Gartnavel

Figure 5.29: Right - Detailing of the glass windows, original scale 1:5
The Maggie’s Centre in Gartnavel, Glasgow, was designed by the international architecture firm OMA. As with all Maggie’s, the aim was to create an environment that is warm and welcoming. OMA interpreted the foundation of Maggie’s as exceptional and innovative spaces that can make people feel better.

The strength of the location according to Rem Koolhaas was the nearness of the hospital yet far enough to create a private space which is both sheltered and exposed due to the landscape and its central position. (Kim, 2010)

OMA designed a single level building in the form of a ring with an inner courtyard. The function of the spaces demanded a careful composition of the floor plan where spaces can be open, semi-private or private. Another innovation of the arrangement is that it minimises the need for hallways instead drawing the circulation area together with functional spaces. The final design has interlocking rooms that flow into one another while remaining separate, like a series of domestic scenes. This makes the Centres feel homely in direct contrast with the institutional character of a hospital.

During the design process OMA worked closely with Lily Jencks, the daughter of the Maggie and Charles Jencks (Etherington, 2011). Lily Jencks is responsible for the design of the inner courtyard plantings and the wooded glades areas surrounding the centre.
Figure 5.30:
Plan view of the courtyard garden, original scale unknown (HarrisonStevens, 2010)

Figure 5.31:
North - South section of the courtyard, original scale unknown (HarrisonStevens, 2010)
**Figure 5.32:**
Photograph taking from the waiting room near the entrance. The connection between the courtyard and building is very strong.


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**Figure 5.33:**
Exterior of Maggie’s Centre Gartnavel showing young trees in front of the overhanging glass facade.

Figure 5.34: View of the courtyard from one of the terraces


Figure 5.35: Photograph of the courtyard showing the topography, the flora, natural elements and seating that were used for the design

Maggie’s Centre Gartnavel is located in a highly urbanised area surrounded by several large building, amongst which the general hospital. The nearness of the general hospital can be expected since the Maggie’s Centre are safe havens for cancer patients. Interesting is the placement of the building on the slope. The slope seems to continue suggesting multiple floor levels.
The layout of the building is very simple. The main layout is open plan with three spaces that can be closed off to increase privacy.

The building also has a private pathway, which can only be accessed through the building itself. Both the inner courtyard and the surround area are abundantly planted.
The topography of the inner courtyard as designed by Lily Jencks does not follow the natural topography. She designed a courtyard with two embankments with small hollow in the middle that serves as water retention area.

The plantings are therefore wetland shrubs and other perennials tolerant to shade and wet conditions.
The building seems to follow the topographical contours of the land. Parts of the building are buried in the land while other parts hang above the landscape.

Especially North - South section has many fluctuation in the height of the landscape. Whether this topography is natural is unclear. The different heights suggest that the landscape was altered.
The building is surrounded by six other buildings and located next to a large car park. Yet Maggie’s centre has an introvert as well as extrovert character. The proximity of the surrounding buildings and infrastructure should therefore impede of the sensitive function of the building.

However OMA used the surrounding landscape to separate Maggie’s centre
from the surrounding infrastructure and buildings.

Maggie’s centre is located on a gentle slope that naturally steepens just behind the building ensuring a height difference between Maggie’s Centre and the general hospital.

The planted trees provide shelter from the street, the car park, and the dilapidated university building.

Where both the topography and trees were insufficient, additional groundwork was used to separate Maggie’s Centre from the public realm.
The original topography has been altered to accommodate the building as well as North of the building to provide more shelter. This additional work, as mentioned before separates the street and Maggie’s Centre. Passers-by will look over the building while the visitors will not be able to observe the pedestrians.
Entrance

The entrance of Maggie’s Centre is located on the Eastern facade, and can be reached by a walkway. The walkway leads to a curb between the two car parks. The walkway is also set apart by the height difference ensuring that people can only reach the building through this one path and not through the landscape.
As can be expected the public areas are located near the entrance while the work related areas are located at the back of the building. This layout strengthens the low key atmosphere of the building. However the private areas are located closest to the surrounding infrastructure and the dilapidated university building.

Terraces in the building provide different views of the courtyard and the surrounding landscape.
Although the private meeting rooms are located closest to the public realm, the additional embankments that were created in conjunction with the height differences ensures the privacy of those rooms.
As mentioned before there is only one path leading towards the entrance. The interior routing is circular, allowing the visitors to wander in the building.

Interesting is that OMA took great care in creating a route that does not feel like a hallway. They accomplished this by creating open plan spaces that include area for circulation.
The height differences within the building are spanned with ramps and one stair. Due to the nature of the visitors, stairs would have decreased the accessibility of Maggie’s Centre.

Although the ramps span the height differences, the roof is horizontal, meaning that each area has a different height.

**Ramps**
The height differences of the rooms seem natural with the topography, yet the height of the rooms is contraditive to the topography.

The highest rooms are located on the North side while the lowest rooms are on the South side. The reason for this is the view from each room. The rooms with far-sight have a low ceiling while the rooms with near sights have a high ceiling.
Maggie's Centre Gartnavel

Maggie’s Centre has glass walls on almost every side. This ensures a transparent building that is connected with the exterior and the courtyard.

It also ensures that the visitor as well as the employees can see all rooms from two spots.

Interior views
Beside the entrance there are several doors leading to the terraces both in the courtyard and the exterior. Each room, except for the largest counselling room, has a door leading to an exterior space in the form of a terrace.

The doors of the South-Eastern part of the building lead to a private trail instead of terraces.

Entrance and exits
Maggie’s Centre has a private walkway that can only be reached through the building itself. This pathway has the same circular nature as the interior route thus allowing the visitors to wander.

The private trail leads to an art installation where people can read positive slogans, wander among the trees or simply sit and enjoy the view.
The routing and the private walkway provide near sights and far sights. Logically the far sights are orientated to the South of Maggie’s centre since that is where the down slope is located.

The near sights are orientated to the interior courtyard and to the North. The man made topography on the North side limits the view to grass, rocks, trees and plants.
Figure 5.36: Looking out from point D


Figure 5.37: Looking at the chair that is point A

Maggie’s Centre Gartnavel has been designed to radiate a welcoming and pleasant atmosphere. The intimate connection with the landscape and the natural elements provide a restful environment with different degrees of privacy.

Prospect vs refuge
All of the spaces in the centre needed to be open, light and welcoming. Yet the different functions demanded that some of these spaces made people feel more secure than others. In other words these spaces needed more refuge than prospect.

This is especially true for the counselling rooms. People using these rooms often feel emotionally vulnerable and thus the space needs to make them feel secure.

OMA could have designed the space to be less open but that would have severed the intimate connection with the landscape and prevented light from entering those spaces.

By altering the landscape and preventing far-sights, the counselling room on the North side of the building feel safer while they still have the ceiling high windows that allow the light to enter and the landscape to be seen.

The opposite has been done on the South side of the building, where the public spaces are located. By permitting and designing far-sights people can let their eyes wander while still feeling protected by the building.

Outlets for frustration
The walking trail behind Maggie’s positively influences people in two ways. The ability to walk is an outlet for frustration, something a cancer patient, their friends and family experience quite often during the period of sickness.

The trail is circular without any major intersections meaning people do not have to think about the direction they are going. Any direction will bring them back to the building. Neither can they be bothered by outsiders since the trail can only be reached through the building itself.

People can thus let their mind wander and achieve a contemplative state which is needed for stress restoration.
**Water**
The landscape designed by OMA and Jencks has been designed in such a way that it has become seasonal water storage. This spreads the seepage into the ground of rain water over a longer period of time. It also means that during short periods the landscape contains small ponds.

From the terraces where people can sit sheltered, they can stare into the water. Another aspect that is important in obtaining the right set of mind for restoration.
Bosco Verticale
Bosco Verticale is a pair of residential towers in the Porta Nuova district near the central station in central Milan, Italy. The towers have a height of 110 meter and 76 meters.

The towers were designed by Stefano Boeri, Gianandrea Barreca and Giovanni La Varra. During the design process they worked closely with horticulturists and botanists in order to understand the vegetation they wanted to integrate with the facade. (Arch daily)

**Concept**
The project is part of the rehabilitation of the historic district of Milan and as part of this undertaking Boeri, Barreca and La Varra wanted to restore the connection between people and nature while at the same time countering the problems of the city.

As with all densely populated cities Milan struggles with air pollution. The trees on the building are meant to clean the air for the dwellers. At the same time the trees also provide a barrier against the sound pollution of the city, creating space where people can sit without hearing cars and other noise.

Another problem Milan has to deal with is the high temperature during the summer and the cold temperatures during the winter. Here too the trees help with providing shade in summer while letting the sun and its warmth through in winter.

As such it could be said that the concept of the Bosco Verticale is not merely regenerating the lost forests on the ground within the habitable space of buildings but also utilising natural elements to counter problems of everyday modern life.

“The Vertical Forest is an expression of the human need for contact with nature, it is a radical and daring idea for the cities of tomorrow.” (Rosenfield, 2015)
Figure 5.1:
Map showing the Bosco Verticale and its immediate surroundings


Figure 5.2:
Google satellite map of the Bosco Verticale and its immediate surroundings.

The construction of the Bosco Verticale started late 2009, early 2010, during this period close to 6000 on-site construction workers were involved. The main building material is concrete, not only for the load bearing structure but also for the containers containing the soil for the trees. In June 2012 the building was ready to be planted, yet the official opening was not until October 2014.

The two towers are 110 meters and 76 in height. They house 26 and 18 floors respectively, and 111 apartments combined. The apartments differ in size ranging from two bedrooms to five bedrooms. The initial plans mention that the towers will house 900 trees and over 2000 smaller perennial shrubs and floral plants. Boeri argues that these statistics are similar to 7000m² of normal forest.

The trees and plants were all specifically chosen by landscape architect Laura Gatti. She selected mainly deciduous trees to act as active shading while closely paying attention to the ability of the tree to resist wind. She also accounted for the different sun hours each facade offered and thus the type of tree to be planted. The trees and plants were all grown in nursery containers to allow them to grow further during the design process and building process. At the time of planting the trees ranged in size from 3,6 or 9 meters.


Figure 5.6:
Right top - Conceptual section of the Bosco Verticale showing the functions of the green besides being decorative.


Figure 5.7:
Right bottom - Three conceptual details of the integration of nature with the exterior spaces.

Figure 5.8:
Photograph of 1 of the 900 trees being lifted to the its balcony.

Figure 5.9: View from the North towards the Bosco Verticale

Figure 5.10:
View from a balcony to the other Bosco Verticale tower and the horizon

Figure 5.11:
View from one of the balconies to a balcony on a lower level

(Wester, J. (Photographer). (2015) View from one of the balconies [Photograph]. Milan.)
The site plan of the Bosco Verticale shows a very dense urban fabric around the towers. There is, however, a paved public urban space around the towers. Very little additional green space is present in the surrounding area. This could be one of the reasons for creating vertical green.
Master plan

The Bosco Verticale is part of a larger master plan meant to create more green spaces within Milan. However, in August 2014 only the Bosco Verticale itself was finished.

In 2015 most of the master plan is still under construction. The only green areas completed by that time are marked with [A].
The competition drawings of the Bosco Verticale could not be more different to the building that has been realised. The competition drawings show a building in which the floors shift to create sheltered spaces, almost patios like, that have green walls, roofs, grass floors and any combination of those.
Yet the Bosco Verticale as it was built does not contain any of these patio-like spaces. The final design is a straight tower, with a series of balconies attached to its exterior.

The final design does not have the green roof or green facades that were initially proposed. The reason for these major changes is unknown. It could be possible that the initial design was too technologically advanced. It is, however, more probable that it was too expensive.
The competition design proposed several ways in which the trees on the building could be beneficial. The regulated the temperature, keeping out the sun in summer while letting it through in winter. The trees will divert the wind and filter fine dust from the air. Shield the apartments from the noise of the city and at the same time produce $O_2$. 

**Benefits of the trees**
Proposed benefits competition

The green zone was supposed to cover the whole facade acting as a barrier. However with the change of the facade, the green zone also changed.

Instead of having the a full green facade the pattern of balconies created a fragmented green zone. Each balcony still contains at least one tree, yet the balconies are not directly above each other.
Two of the façades have a balcony every other floor, while the remaining two façades have a balcony every third floor, leaving gaps in the green zone.
The fragmented green facade means that the concept for the green zone does not function as promised. Sound is not fully negated, nor is all fine dust captured. The effect of the fragmented green facade on the wind is unpredictable since each balcony create a lee.
The gaps left by the placement of the balconies are also obvious in the floor-plan.
Apartments

Each floor of the Bosco Verticale houses four apartments. Two small ones, two larger apartments. In total there are six different floor-plans for the apartments.

Taking into account that the Bosco Verticale has two different towers, there being only six different floor plans interesting.
Above, the functions of an apartment are identified. The placement of the balconies compared to the function does not reveal a specific order. The only rule seems to be that either the dinner room or the living room needs to be connected to a balcony. Interesting as well is that the balconies are not fully planted but also contain glass railings.
The decisions to create balconies instead of pavilion like spaces did create different lines of sight. Some of the views are distant focused on the horizon and the city, while other views are directed to the tree tops and still others to the balconies themselves.
The conceptual detail sections for the competition show three different ways in which the plants were to be integrated in the exterior spaces. Each of these allow the space to be used differently. Especially the green space flush with floor level seems an innovative way of integration.
Sight lines competition

The different ways in which the spaces are used also mean that they are viewed differently. The levels which house the trees are mostly focused nearby, on the exterior spaces themselves. The other levels, have far sights to the horizons as well as a view of the tree located on a lower level.
In the final design there is however only one way in which the trees and plants are integrated with the exterior spaces. Large containers form the barriers of the balconies in which the substrate for the vegetation is housed. This however means that the top of the soil is almost 1000 mm above the balcony floor level.
Although the view people have from the new balconies seem similar, some close some far, they are actually very different.

In the competition drawings the nearby views focus on the trees, the stems of the trees and the plants. While in the new system people mostly see the barrier itself instead of the trees and plants.
The balcony containers are planted with a variety of plants and trees. They created a selection of trees specially suited to the different façades.

Each facade is of course orientated differently meaning that the living conditions for vegetation are quite different.

### Trees on the West, North and East facade

<table>
<thead>
<tr>
<th>Tree</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
<th>Winter</th>
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</thead>
<tbody>
<tr>
<td><em>Quercus ilex</em></td>
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<tr>
<td><em>Koelreuteria paniculata</em></td>
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<tr>
<td><em>Pyrus pyraster</em></td>
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<tr>
<td><em>Arbutus unedo</em></td>
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<tr>
<td><em>Amelanchier lamarckii</em></td>
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<tr>
<td><em>Crataegus monogyna</em></td>
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<tr>
<td><em>Hypericum calycinum</em></td>
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**Legend**

- Colour of the foliage
- Colour of the foliage and blossom or fruit
- No foliage
### Trees on the West and South facade

<table>
<thead>
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<th>SUMMER</th>
<th>AUTUMN</th>
<th>WINTER</th>
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<tr>
<td>Quercus ilex</td>
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<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Quercus pubescens</td>
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<td>Fraxinus ornus</td>
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<tr>
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As such each tree was carefully selected to suit those living conditions in order to ensure their survival. Some of the conditions include strong permanent winds, high temperatures and fluctuating water levels.

Yet the trees were also selected for their decorative values such as their change with the seasons such as; leaf retention, change of colour and fragrance.
The trees that were placed on balconies had three different heights: 3m, 6m, and 9m. This ensured a diverse facade image as well as different ways in which they affect the sight lines from the balconies and windows.

However with the size of the container the trees will not grow the same as they would in a forest. At a certain point they will reach the limit of the space the containers provide and will stop growing.
The Bosco Verticale is an interesting building in many ways. Most of the documented drawing were for the competition and not for the actual construction. While this is not necessarily a bad thing, it did make the differences between competition and reality very clear. The initial ideas for the integration of the vegetation and the use of those spaces were very idyllic compared to the reality.

It is unclear why the patio like space were replaced with balconies or why the proposed integration of the trees and grass floors changed so drastically to simple baluster high concrete containers. One of the reasons could be that the trees and plants needed more substrate than originally anticipated by the architect.

The final containers still have limited space for the root systems but far more than initially proposed for the competition. However this space is still not enough for the trees to mature as they would in a normal forest. The use of containers as balusters for the balconies is on the one hand an amazing level of integration but on the other hand a missed opportunity.

Having such high concrete balusters means that people sitting on their balcony or in their homes are unable to look over them, and are unable to see large parts of the trees as well. The system they proposed for the competition was less integrated with the construction and functions but allowed for greater enjoyment of the vegetation.

The change from the patio like spaces to the final pattern of balconies also leaves certain windows exposed to the sun. This means that the shading system they proposed by using plants does not work for all windows demanding a hybrid system, plants for the spaces bordering a balcony and mechanical for all other spaces.

**Prospect vs refuge**

One of the most successful aspects of the Bosco Verticale is the creation of well defined balcony spaces. The vegetation creates spaces that are not fully open as most balconies are but rather shelters the users from the infinite space thus providing refuge. However the vegetation is sparse enough to provide far sights if wanted, thus also allowing prospect. The high closed balusters also ensure that
vertical neighbours do not constantly look down on other balconies, thus also providing a degree of refuge.

Another function of the vegetation is its ability to act as a sound barrier. This means that not only are people sheltered from prying eyes but also from the distraction noise from the city below. This leaves users free to let their mind wander without and reach a contemplative state needed for stress restoration.

**Change**

Another interesting aspect of the Bosco Verticale is how its facade changes with time. The trees and plants have all been chosen for their blooming period, how their leaves change colour in autumn and whether they lose their leaves in winter.

This means that the facade of the Bosco Verticale is never exactly the same. Each year the plants and trees will grow and change. Keeping the facade dynamic both for the dwellers and the inhabitants of the city.
ING Headquarters
The ING Headquarters formerly known as the NMB Headquarters is a large office building in the Amsterdamse Poort, a small shopping area in the Bijlmer which is a suburb of Amsterdam. NMB Headquarters is located on the south edge of the shopping area and is flanked by a residential district, commercial district and business district.

Albers en van Huut
In 1987 the Nederlandsche Middenstands Bank needed a new headquarters. After a pre selection of project they surprisingly hand the commission to Albers en Van Huut architects.

Albers en van Huut architects are most well known for their organic buildings and anthroposophical ideas. The commission for the NMB Headquarters is their first large building, they mostly dealt with smaller-scale social and cultural projects buildings and dwellings.

Concept
The concept for the building was to create the most sustainable building of its time, not only sustainable in energy efficiency but also in functionality in the form of flexibility. Traces of their previous experience can be found in the building. Instead of creating one large building they designed ten different clusters with variable height interconnected by a central street serving as ground level.

Despite the scale of the building they focussed on the individual and the smaller units of employees with similar tasks. As such they created floor plans that contained five office units of 88m² surrounding an atrium and a meeting room. An important demand was that every desk was to be no more than seven meters from a window or an atrium to ensure that people would always experience sunlight.

The interior street connects the clusters and provide the additional service that could not be housed in each cluster such as the restaurant, the main entrance, the kitchen and the rooftop gardens. Following their anthroposophical way of thinking, the next step into strengthening the stimulating working environment was to draw nature into the interior street and the atria from the rooftop gardens.

“The starting point was a functional and flexible building with low operational costs. An optimal working climate for the employees was central.”
Figure 5.12:
Top - Satellite image showing NMB/ING Headquarters and the surrounding area including de Amsterdamse Poort


Figure 5.13:
Bottom - Roof plan and Ground floor plan

**Energy sustainability**
Beside the functional sustainability the building also has an array of features to ensure energy sustainability. The massive interior walls are an important element in warmth retention while the small windows prevent energy loss.

The goal to built the most sustainable office building of its time was not accomplished due to the long preparation time and construction time. Technology had advanced beyond the measures that were included in the building.

**Design process**
During the design process Albers en van Huut worked closely together with Jørn Copijn and Hyco Verhagen for the creation of the rooftop garden. They were not merely an afterthought but integral part of the design.

As such the structure of the parking garages was adapted and strengthened to accommodate the soil, water and vegetation.

For over twenty years Copijn was responsible for the maintenance of the rooftop gardens.
Figure 5.14:
Top - Coloured site plan


Figure 5.15:
Middle - Facade impression


Figure 5.16:
Bottom left - Long section


Figure 5.17:
Bottom right - short section

Figure 5.18:
The roof of the ING Headquarters showing the skylights for the atria


Figure 5.19:
One of the ten atria from the main hall

Figure 5.20:
Planters in the atria, one of the uses of vegetation in the building


Figure 5.21:
A planter in the large interior street of the ING Headquarters

The ING Headquarters is located in a highly urbanised area and part of the shopping area named the Amsterdamse Poort. The urban area a residential as well as business district.

The main road to the South of the building is elevated relative to the square. Nestled within the embrace of the building are three large gardens.
The floor plan of the ING Headquarters shows a meandering form with repetitive shapes and although the layout appears to be complex, the repetition might introduce simplicity into the scheme.

Here too the three gardens are apparent. The orientation of the gardens is different in each case.
The floor plans of the towers show a uniformity. Each tower has a central core with a shared circulation and utility core between each tower. The central core has a stairs and an open atrium. It appears that the utility core also contains the emergency stairs. The floors are open plan and thus can be maximised to the fullest.
Section

The section also shows the atrium with the skylight in roof and the stairs connecting each of the floors. The ground floor is triple high with mezzanines that can be reached with stairs.
Another skylight is visible in the roofscape, only this one seems to only serve one room and the void that runs through all rooms alongside the atrium.

The ground floor in this image is the car park, meaning that the actual ground floor of the building proper is the first floor.
The building has been layout in a giant S-shape with different areas of vegetation in its meanders. The shape is separated by a pedestrian and cycling area. In reality it is thus not a single building but rather two buildings connected by a single bridge.
The small green areas are decorative, some contain a single tree while others contain a few trees. They are located along the borders, near the entrances, and the restaurant.

Each of the gardens, on top of the parking garages, has a different soil type that strengthens their characters. The left most garden has eutrophic sandy clay, perfect for the English landscape garden. The central garden has oligotrophic sandy loam for the Japanese garden.
while the right most garden contains acidic heathland for the Finnish garden.

Each of the gardens also contains at least one water feature but often more. Among these water features are waterfalls, ponds with wooden bridges and the flow-forms that were designed by John Wilkes.

Figure 5.24:
Water ornament near the restaurant in the English garden


Figure 5.25:
Birds-eye view of the English garden

The ING Headquarters appears to be one large building. Yet on closer inspection the building contains ten near identical towers. The only difference between the towers is the orientation and the height. They range between seven and ten floors.

Repetitions of volumes

It is only the ground floor and the car parks that create the impression of one large building.
Each of the towers is identical in the atrium as well. The atria run from top to bottom in each tower and ensure that daylight reaches each floor.

Since each of the towers has an atria, each tower has its own stairwell as well.

Atria

Figure 5.26:
View from the internal street into one of the atria

(ACRAM (Publisher). (nd.) View into an atrium [Photograph]. Amsterdam. Retrieved from http://www.arcam.nl. 5 September 2015.)
Although the towers seem individual structures they are all connected by a single interior street.

The orange street is a single space without any separations. Each of the atria is connected to this street and serves as light well as well as an access point for vertical circulation.
**Natural light for way-finding**

The atria ensure that natural light penetrates into the interior street. This not only ensure that the space has a connection with the outside but also acts as a guide for people.

While traversing the interior street people are drawn from light-well to light-well. The light-wells thus act as a landmark for people while navigating the building.
Legend

- **Yellow**: Atrium
- **Red**: Vertical circulation stairs
- **Orange**: Vertical circulation elevator
- **Red**: Unknown shaft
- **Blue**: Toilet block
- **Green**: Multipurpose room
- **Brown**: Emergency stairs
- **Light Green**: Sightline A
- **Pink**: Sightline B
As mentioned before the towers are similar in almost all aspects. The central atrium in each tower had three functions.

First of all it is a light well, secondly it is a connection with the other floors and the central hall, thirdly it contains an undetermined shaft that runs along the atrium.

The towers are separated by another vertical circulation area containing the elevators, and the emergency stairs.

This area also contains the toilet blocks and the other utility rooms. These utility rooms do not have a set purpose but are multi-purpose. On one floor they can serve as a printer room while on another it is a meeting room.

Grouping these functions and areas together ensures that the main floor can stay open plan and eliminates the need for hallways. Similar to the interior street on the ground floor.
The atrium is dominantly present on all floors not only due to the void and the wall openings that are orientated towards the atrium but also because of its function as a light well.

Sun light and sight lines

The top of the atrium has a glass roof as well as glass walls. This maximises the amount of light in the atrium.

The atrium also allows people to view the other side of the floor and the lower floors.
Sun light and growth rates

The long-section of the tower shows the glass roofs and the sun that shines into the atrium. The representation above is just a representation since each of the towers has a different orientation. The upper floors get more sunlight than the lower floors. This not only affects the space but also the speed of growth of the plants in the planters. The higher they are the faster they grow.
Summary & Conclusion

The NMB/ING Headquarters was designed as a stimulation working environment for the employees, to create a pleasant atmosphere, to be flexible in its use and to be sustainable.

**Human scale**
The design with the ten clusters created a building that feels small-scale instead of the large-scale development it is. Each floor was designed with the users in mind, providing them with views, sunlight, and easy ways to navigate the building.

In creating these ten clusters they took the risk of creating individual buildings that did not interact or promoted interaction between the different clusters. It is the ingenious interior street that contains the large-scale services and the atria connecting each of the floors of a cluster with the interior street that ensures and promotes interaction.

**Rooftop gardens**
The rooftop gardens could easily have been added as an afterthought, a sedum roof instead of actual gardens. It was the involvement of the landscape architects and the anthroposophical ideas that not only allowed for well functioning but also for well designed gardens.

The different themes for the gardens not only reflect the international character of the NMB but also allows the users of the building to experience different environments when one of the environments becomes to boring. In such a case the stimulating and restorative effect can decrease (Kaplan, 1995). Changing the scenery or the environment safeguards the restorative effect.

**Connection with nature**
The meander in the building creates three natural areas for the rooftop gardens. The meander also means the clusters are draped around the rooftop gardens, as such each of the clusters overlooks at least one of the rooftop gardens. This creates the first connection with vegetation.

The atria do not only ensure the interaction and connections with the other floors and the interior street but they also ensure that people experience the sunlight with their orientation on the sun.
This sounds minor but we are very sensitive to the intensity of sunlight, it tells us something about outside, the weather, the time of the day, and even the time of the year. This is an important aspect contributing to the pleasant atmosphere in the building.

The small windows prevent energy loss but also prevent people from looking outside too much. Instead the focus is on the atria space. By drawing the vegetation into the interior street and into the atria people not only experience the inanimate aspects of nature but also the animate aspects in the form of vegetation.

The last connection with nature is in the form of water, each of the gardens has a water feature, yet some of the handrail of the stairs in the interior street have a flow-form water feature as well.
Paley Park
Paley Park is what is called a vest pocket park. The concept for these parks has been created by Zion & Breen Associates as a counter proposal for the New York minimum park size. Zion & Breen argued that occasional spots of open space had to be set aside where residents and visitors would be able to sit and enjoy themselves as they paused their daily activities.

In 1967 William S. Paley visited an exhibition of the work of Zion and Breen where this proposal of vested pocket parks was showcased. After his visit he decided to build such a pocket park to commemorate his father.

Instead of rebuilding the Stork Club, he had just bought in downtown Manhattan, Paley decided to use the plot for the pocket park.

The design for Paley Park came from the hands of Zion & Breen landscape architects and was paid for by the foundation William S. Paley created for it. Nowadays it is still owned and maintained by this foundation.

**Location**

Paley Park is located on 53rd street, near 5th avenue, a main shopping street and business district in Manhattan New York. Its central location makes it unique since it is the only privately owned plot that does not contain a building.

**Design**

The plot on which Paley Park has been build measures 15.2m by 30.4m. The building lot is starting point for design of the park. The park intrudes into the streetscape and marks its location without giving away the park itself.

The twelve honey locust trees, the water and the ivy covered walls create an abstract image of a natural environment. It is an oasis in which the noise from the waterfall masks the sounds of the city. Both the setback of the entrance and the canopy of the trees provide a visual barrier against the city.

*"The midtown park may be designed as a small park- yet big enough in essence to reaffirm the dignity of the human being" (R. Zion)*
Figure 5.33:
Sattelite image showing Paley Park in the urban fabric of Manhattan

Figure 5.34:
Section of Paley Park

Figure 5.35:
Floor-plan of Paley Park
Figure 5.36:
Black and white aerial photograph of Paley Park


Figure 5.37:
Photo of Paley park taken from just outside the entrance.

Figure 5.38: Composite image of Paley Park showing the trees, the seating, green wall and waterfall


Figure 5.39: Close up of the waterfall at the back of Paley Park

Paley park is situated in downtown Manhattan. It is surrounding by a multitude of buildings, amongst which many high-rise buildings. It is one of the few parks in the area, the only other green features are the odd tree along the street.

Unique is that the park covers a whole privately owned plot in the urban grid.
Floor plan

The plan of Paley Park shows a narrow plot in between two buildings. There are two stands of trees, the first located on the pavement and marking the entrance to the park. The second stand of trees covers almost the whole park. Another prominent feature is the waterfall in back. Underneath the canopy people can sit and relax at the tables.
The section shows the same two stands of trees with the gate in between. Meaning that the park can be closed off, this probably happens during the evening hours.

The waterfall at the back of the park fall down from the top of the wall, flowing into a large reservoir.

The trees are complemented by ivy clad walls on either side of the plot.
The entrance to the park is located at the top of a small stairs and flanked by two kiosks creating a gateway that leads to the park proper. This signals the entering of a different realm or landscape.

The height difference and the setback of this height difference separates the park from the pavement as well. The first stairs separates the entrance, the second separates the waterfall from the park proper.
The trees are not merely decoration but function as a barrier, preventing people in the adjacent buildings from observing the users of the park. In turn, the trees prevent the users of the park from directly viewing the adjacent buildings. The trees create refuge for the city dwellers, a place where their attention is focused on natural elements rather than urban elements.
Besides the visual aspect of the city intruding into the park, noise from the city can intrude into the park as well negating the sense of refuge.

The trees and green walls prevent the noise from echoing while the waterfall is a source of pink noise for anyone residing in Paley Park. Together they ensure that city noise is minimised, safeguarding the sense of refuge people experience.
Figure 5.40: Lamps lighting up the waterfall at Paley Park

Summary & Conclusion

Paley Park is one of the most successful examples of pocket parks. The reason for its success is its location, the use of different design principles and elements to draw people in, and shelter them from city life.

Transition
Paley park is often referred to as an oasis in the busy city. There are several manner through which this sense is created. By setting back the entrance to the park, a distance is created between the public street. This distance is strengthened by the height difference between the street and the park proper. It provides room for a series of transitional spaces that mark the difference between inside and outside.

Zion and Breen very cleverly used the two kiosks and a gate to mark the entrance to the park proper. To visitors the gateway signals the final transition between inside and outside. It provides a limited view from the outside that allows visitors to anticipate what they could experience within the park (Kaplan, Kaplan and Ryan, 1998, p.81).

Prospect vs refuge
The image of the park as an oasis is further strengthened by cleverly using natural elements and design strategies to keep out the city. The Honey Locust trees not only create the lush image of nature but also create a visual barrier between the city and the visitors of the park.

The canopies prevent onlookers from looking into the park from above, while the gaze of the visitors is focussed on the waterfall at the back of Paley Park. Refuge is thus provided for the visitors creating a space that is perceived as pleasant.

The waterfall at the back of the park is not only a focal point, or a decorative water element but also cleverly serves as a way to drown out the noise of the city. The sound of running water is pink noise that further strengthens the illusion of the oasis.