THE BLUE BONUS

USING WATER TO ENHANCE OFFICE SPACE EXPERIENCE
Preface

For nearly one year I have spent time in office indoor environments with both mind and body. I studied as well as used its psychological benefits in order to complete this thesis. This thesis is written to complete a Master’s Degree in Civil Engineering at the Delft University of Technology. The work for this thesis is done between April 2014 and March 2015 in The Netherlands and Belgium. Although significant part of this work is based on the research of others, it is original and independent.

Being a master student in the two very distinct fields of music and engineering, I believe in the advantage of making connections between different disciplines. In my work as a student-assistant at the chair of Climate Design & Sustainability I became involved with applying Cradle to Cradle® principles in technical design. This made me more aware of the value of design for intended use and design with context in mind. A fascination for the human side of technology and building design lead to the topic and viewpoint of this thesis.

This thesis is developed under the guidance of the graduation committee, consisting of prof. ir. Peter Luscuere (chairman), ing. Stanley Kurvers and dr. ir. Sander van Nederveen. I would like to express my gratitude to all of them for their availability, useful feedback and guidance. Special thanks go out to Giancarlo Mangone, who took the time to advise me as an external specialist. I would like to thank the team of Lateral Thinking Factory in Brussels, especially Steven Beckers, Michael Moradiellos and David Delangh, for providing an excellent working environment and helpful feedback. Naturally I would like to thank my wife Gertieme; also this thesis has benefited from her support and love. Thanks go out to all others who contributed to this thesis, either by responding to a survey, by contributing to an interview, or by proofreading written parts.
Building engineers, building designers and building developers, and all others who are interested in the optimisation of buildings for user well-being are encouraged to read this thesis. Summaries are provided for those with limited time. It is my hope that all readers of this thesis will experience positive psychological effects.

Bert van Stam

March 2015
Summary

This study focuses on the concept of *bonus factors* in office buildings. *Bonus factors* are those elements of a building which have positive psychological effects on the building user: the office employee. These are called *bonus* since these factors can further increase occupant well-being after *basic* requirements, mostly of physiological nature, are met.

In a literature review, six bonus factors are found: *daylight*, outside *view*, the use of *plants* inside, a natural *climate* which is both adaptive towards the user and connected to the outdoor climate, *individual control*, and an effective *alternation of private and common spaces*. These are recognisable as separate factors, but they are interrelated in many ways.

Two theories from the behavioural sciences are useful to predict bonus factors and to understand underlying mechanisms: the *biophilia theory*, describing human’s intrinsic fascination for nature, life, and life-like processes, and the concept of the *Sense of Coherence*, examining the elements that enhance human’s well-being under the conditions of comprehensiveness, manageability and meaningfulness.

The literature review also reveals that a design approach which is both *user-centered* and *evidence-based* will lead to buildings with higher positive impacts on the occupants. It turns out to be important to present credible evidence to designers; not only in order to influence their designs, but also to give them compelling arguments towards clients. This is shown in healthcare design, but should also be applied in office building design.

From this literature review, the hypothesis emerged whether water could be employed as a bonus factor in office buildings as well. This is investigated by an extended literature review and the conducting of a survey and interviews.
The extended literature review shows that the use of water elements in landscaping are confirmed to be highly restorative and attractive, and that water elements are applied in buildings in order to increase user experience.

A survey conducted among more than 70 respondents shows that working environments with water elements are preferred highly for creative work types. Important characteristics are the sound and motion of a water feature.

Interviews with design experts reveals that under certain conditions, water can be applied effectively as a bonus factor in office buildings. A designer can employ water as a bonus factor in office buildings by starting from the client, combining different functions with a water feature in a water system, and investigating its reception among users. A water feature can have positive psychological effects when it contains flowing water, when it is placed in a common space, and when the sound level is controlled. It can have more benefit when it is combined with green and with sitting areas.
Het concept bonusfactor, toegepast in kantoorgebouwen, is het onderwerp van deze studie. Bonusfactoren zijn de gebouwelementen die positieve psychologische effecten hebben op de gebouwgebruiker (de kantoormedewerker). Deze factoren krijgen de naam bonus omdat zij het welbevinden van gebruikers verder kunnen verhogen, nadat aan basisfactoren (vaak fysiologisch) is voldaan.

Een literatuurstudie leverde zes bonusfactoren op: daglicht, uitzicht naar buiten, het gebruik van planten in het gebouw, een natuurlijk klimaat wat zowel adaptief naar de gebruiker als verbonden met het buitenklimaat is, individuele controle, en effectieve afwisseling van privé- en gemeenschappelijke ruimtes. Deze factoren zijn apart herkenbaar, maar hangen op verschillende manieren samen.

Twee theorieën uit de gedragswetenschappen zijn bruikbaar om bonusfactoren te voorspellen, en om onderliggende mechanismen te begrijpen: de biofilia theorie, die de intrinsieke fascinatie van de mens voor natuur, leven en de processen van leven beschrijft, en het concept van de Sense of Coherence (gevoel van samenhang), dat zich richt op de factoren die het menselijk welbevinden versterken, volgens de elementen begrijpelijkheid, beheersbaarheid en betekeniswaarde.

De literatuurstudie laat ook zien dat een ontwerpaanpak die zowel op de gebruiker gericht als op bewijs uit onderzoek gebaseerd (evidence-based) is, zal leiden tot gebouwen met een grotere positieve invloed op de gebruikers. Het blijkt belangrijk te zijn om gegrond bewijs aan ontwerpers te tonen; niet alleen om de ontwerpen te beïnvloeden, maar ook om hen te voorzien van overtuigende argumenten tegenover hun cliënten. Dit wordt al toegepast in ontwerpen in gezondheidszorg, maar zou ook meer in het ontwerpen van kantoorgebouwen toegepast moeten worden.
Vanuit deze literatuurstudie ontstond de vraag of ook water als bonusfactor kan worden ingezet in kantoorgebouwen. Deze vraag is onderzocht door een verdere literatuurstudie en het uitvoeren van een enquête en interviews.

De verdere literatuurstudie toont aan dat bij het gebruik van waterelementen in landschapsarchitectuur effecten van hoge restauratieve waarde en aantrekkingskracht optreden, en dat waterelementen in gebouwen toegepast worden om de beleving van de gebruiker te verbeteren.

Een enquête, uitgevoerd onder meer dan 70 respondenten, laat zien dat werkomgevingen met waterelementen verreweg de voorkeur krijgen voor creatieve werktypen. Belangrijke kenmerken zijn het geluid en de beweging van een waterelement.

Interviews met ontwerpexperts laten zien dat water onder bepaalde voorwaarden effectief kan worden toegepast als bonusfactor in kantoorgebouwen. Een ontwerper kan water inzetten als bonusfactor in kantoorgebouwen door te starten vanuit het gezichtspunt van de cliënt, door verschillende functies van water in een systeem te combineren met een waterelement, en door de ontvangst ervan bij de gebruikers te onderzoeken. Een waterelement kan positieve psychologische effecten hebben wanneer het stromend water bezit, wanneer het geplaatst is in een gemeenschappelijke ruimte, en wanneer het geluidsniveau gecontroleerd wordt. Het kan meer voordeel bieden wanneer het gecombineerd wordt met groen, en met zithoeken.
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1 Introduction

1.1 Topic and Definition

“We shape our buildings, thereafter they shape us”—it is a strong and well-known quote from Winston Churchill. There is truth in it: we are never indifferent for our environment. But who are “we”? It appears that those who shape buildings are mostly not the same ones as those who are being shaped by the buildings. Building designers and building users are distinct from each other.

In order to create a building design which works according to its design intentions, it is necessary for building designers to have knowledge from the use phase of their buildings. Exactly this is what is lacking in many situations. Building designers leave and move to their next design task well before any user has entered their building (Brager et al., 2004; Cole et al., 2008).

The gap between building designers and its users is most tangible in the psychological effects of buildings. The feedback link from the building users to the designers can be re-established with the use of knowledge from the behavioural sciences. This is the base for this research: implementing psychological knowledge in building design.

In the past decennia, the negative psychological as well as physiological effects from building design on its users have got much attention, framed by the term of ‘Sick Building Syndrome’. A positive approach is the next step. It is important to identify and assess the way how buildings could positively affect people (Heerwagen, 1998).

It is practical and useful to focus this study on office buildings. People spend a significant part of their lives in these buildings. It is in the em-
ployer’s interest to support psychological well-being, not only for humane reasons but also to assure a cost-effective operation (Kaplan, 1993).

This study focuses on the positive psychological effects from office building design elements on its users, which are called *bonus factors* in this study. The definition of this concept will be explained and developed in Chapter 2.

1.2 THESIS OVERVIEW

This research consists of two main parts. The first part is called “Beyond Comfort”. It involves a literature review in order to get a clear picture of current knowledge on bonus factors, covered in Chapter 2. Relevant theoretical concepts from the behavioural sciences are explored, evidence on design elements confirmed to be bonus factors is presented, and useful study methods to develop more evidence are discussed.

The results of “Beyond Comfort”, both in theory and evidence found, lead to the hypothesis that water could be used as a bonus factor as well. This hypothesis is investigated in the second part of this research, called “The Blue Office”. This is covered in Chapter 3, 4 and 5. Chapter 3 presents the hypothesis and the study method for “The Blue Office”. Also in Chapter 3 current practices in the usage of water as bonus factor are presented, as well as related evidence in the field of landscape design. Chapter 4 presents original research conducted through a survey. This study explores user preferences for water elements in the workspace. Applicability and relevance of the results from the survey are explored in Chapter 5, making use of interviews with design experts.

Both parts are taken together and concluded in Chapter 6. Besides a summary of conclusions, it contains a reflection on the research methods and recommendations for further study.
Beyond Comfort: Literature Review on Bonus Factors

2.1 DESCRIPTION AND OBJECTIVES

To first get a clear picture of current knowledge in the field between the disciplines of environmental psychology and building design, 49 publications are reviewed. The result of this literature review can be found in this chapter.

The objectives of this review have been:

• to identify which theoretical concepts of well-being can be used to describe psychological effects of office building design on the users;
• to investigate how workplace design factors can be classified according to their effects on the office employees;
• to find which workplace design factors are expected to have psychologically positive effects on the office employees;
• to find out which research methods are useful for studies in this field.

2.2 INTEGRATION OF DISCIPLINES

In the introduction, the value of a connection between building design and the behavioural sciences is stressed. These two disciplines have been connected for quite some time. Especially the links between sociology and urbanism or landscape architecture are often made. Sommer (1983) presents the concept of social design, as opposed to formalistic design. He describes it as architecture which integrates knowledge from the behavioural sciences. Environmental health specialists have recognized the need to collaborate with other professionals, such as landscape architects to help identify the salient features of outdoor exposures, interior designers to do the same in micro-environments, and urban and regional
planners to help link environmental health principles with large-scale environmental design (Frumkin, 2001).

However, only lately the behavioural sciences were introduced in the field of comfort in buildings. A conventional approach of comfort in buildings, as described by Cole et al. (2008), has evolved within a period of technological innovation. It resulted from the shifting of indoor environment design responsibility from architects to mechanical engineering consultants, and the shifting of control responsibility from occupants to technology. Following Cole et al., in this conventional engineer’s approach the notion of comfort is guided by three key assumptions: that occupants are passive recipients of the conditions provided in the workplace, that the primary mechanism is physiological, and the assumption that indoor environmental conditions should be held within relatively tight margins. Apart from the question whether this description does justice to a lot of valuable research on comfort in buildings, it is clear that the approach described by Cole et al. is not favourable, and it hints (in negative statement) that a more integrative approach is more appropriate.

Indeed, studies from the perspective of building design on the effect of the indoor environment on occupants identify effects which are not physiological—psychological effects are hypothesized, and the researchers suggest that integration of knowledge from environmental psychology is needed (Brager et al., 2004). In the European HOPE project, a similar issue is identified, where the questionnaires from the “indoor air and thermal comfort community” have not included one’s mood. Building researchers could learn something from other disciplines regarding study methods, according to the authors (Bluyssen et al., 2011). There are other building researchers who recognize the relevance of research and theory in fields such as psychology, biology, and behavioural ecology, in order to identify and assess the way how buildings could positively affect people (Heerwagen, 1998).

In order to effectively fulfil the aims of this study, knowledge from the discipline of building design and research, from environmental psychol-
ogy and its research methods, and for a small part knowledge from the discipline of facility management is collected.

2.3 CONCEPTS OF WELL-BEING IN BUILDINGS

2.3.1 Introduction and definition

Many building researchers and environmental psychologists tried to fit the notion of comfort and well-being in buildings in a usable theoretical framework, leading to a lot of different approaches. The focus is variously on one of the interrelated topics of employees’ motivation, job satisfaction, and well-being. Clearly it is in the employer’s best interest to support all these factors, not only for humane reasons but also to assure a cost-effective operation (Kaplan, 1993). This paragraph gives an overview of the theoretical concepts which are relevant in identifying psychological effects of office building design on the building users.

The concept of health is defined by the WHO as follows: “a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity” (Frumkin, 2001). Including more than the absence of disease, it is a broad and positive interpretation of the concept of health—in this sense the concept of health is used in this study as well. However, the term health can lead to misconceptions as it often refers to biological health only. Therefore in this study, which is more on psychological health, the term well-being will be used.

2.3.2 Motivation and needs

One of the first psychologists who studied positive qualities instead of illnesses and symptoms in people, is Abraham Maslow (1908–1970). In his approach to psychological well-being he came up with the concept of self-actualisation, being the highest level of human psychological health. In Maslow’s view, humans are motivated by the desire to achieve this self-actualisation. His framework of the hierarchy of needs has become famous and is widely used in applied psychology as well as management.
According to Maslow, there are at least five sets of goals, which may be called basic needs: physiological, safety, love, esteem, and self-actualisation. Maslow arranged these goals in a hierarchy of prepotency. This means that the most prepotent goal will monopolize consciousness, and the less prepotent needs are minimized. When a need is satisfied, the next prepotent (higher) need emerges, to dominate the conscious life in turn, since gratified needs are not active motivators. The most basic, the physiological needs, include requirements for human survival, such as air, water, food, clothing and shelter. The safety needs include security, biological health and well-being. The love and belonging needs refer to the human desire to have emotionally significant relationships and to belong to a group. Under the esteem needs, the need to feel respected, including self-esteem and self-respect, can be categorized. The highest need is that of self-actualisation, which refers to the realisation of full potential of a person (Maslow, 1943).

![Maslow's Hierarchy of Needs](image)

**FIGURE 1• Maslow's Hierarchy of Needs**

Based on this hierarchy of needs, Frederick Herzberg (1923–2000) developed the two-factor theory. In this theory there are certain factors in the workplace that can cause job satisfaction (motivators), while a separate set of factors only can cause dissatisfaction (hygiene factors). Herzberg stated that individuals generally cannot become content with the satisfaction of lower-order needs (hygiene factors) at work, but that they rather look for the gratification of higher-level psychological needs (motivators). This theory suggests that to improve job attitudes and productivity, researchers and designers must recognize and attend to both sets of characteristics and not assume that an increase in satisfaction leads to decrease in dissatisfaction. Herzberg also suggested that
satisfiers are intrinsic factors, and dissatisfiers are work-extrinsic factors (Herzberg, 1968).

Similar to Herzberg’s two-factor theory, biologist Stephen Boyden (1971, cited by Heerwagen, 2008) distinguishes between survival needs and well-being needs. Survival needs deal with aspects of the environment that directly affect human health, such as clear air and water, and opportunity for rest and sleep. Failure to satisfy one of these survival needs may lead to serious illness or death. Well-being needs affect overall health through their relationship to fulfilment, quality of life, and psychological health; failure to satisfy one of these produces the “gray life” of psychosocial maladjustment and stress related illnesses. Boyden’s discussion of well-being raises concern that there is a mismatch between humans’ evolutionary environment and current industrialized settings, and that this mismatch is detrimental to human well-being when current environments do not support the full range of evolved survival and well-being needs. Boyden and further researchers identified a collection of those well-being needs.

Examples which are relevant to building design are (Heerwagen, 2008):

- the opportunity to engage in spontaneous social encounters;
- a connection to the natural environment;
- the control over one’s level of social interaction and privacy;
- meaningful change and sensory variability;
- noise levels which are not much above or below that in nature;
- the ability to maintain and control personal comfort;
- making sense of the environment.

The psychological theories of Maslow and Herzberg are criticised and never fully confirmed with empirical data. The two-factor theory is opposed by stating that this theory only can be confirmed if Herzberg’s methodology is used—other methodologies can lead to unexpected changes of the domain. Today it is generally believed that both satisfiers and dissatisfiers can be part of the work environment. In his review of motivational theories (1996), Rob Vinke suggest that instead of the difficult and fuzzy concept of motivation, the concept of stimuli which can
make and keep employees less or more self-determining and competent should be key in a theoretical framework. Moreover, the difference between intrinsic and work-extrinsic factors cannot be fully made and is not helpful (Vinke, 1996).

Today the partly outdated theories regarding human motivation can still help us to understand the fundamental notion of (hierarchical) differences in the psychological effects of environmental factors. Although these theories are developed to analyse and explain the social environment, they can be applied to the physical environment, according to Dilani (2009).

The notion of motivation is also used in the theoretical framework of performance, as discussed in the next paragraph.

### 2.3.3 Performance

One of the objections of the use of the concept of motivation is that it is only one of the drivers of work performance. Besides motivation, possibility plays a significant part as well. In the following formula, a common framework from organisational psychology, three drivers of performance are defined.

\[
\text{Performance} = \text{Ability} \times \text{Motivation} \times \text{Opportunity}
\]

In this function, *ability* deals with whether or not a person can do a task, while *motivation* is a measure of whether or not a person wants to do it; *opportunity* relates to accessibility.

Heerwagen (1998) uses this framework to conceptualize the relationship between buildings and performance. Building features and attributes can affect ability, motivation as well as opportunity in both direct and indirect ways. Analogous to this distinction of affecting ability, motivation and opportunity, there are design factor classifications which make difference between functional and psychological effects of building design—see § 2.4.3.
2.3.4 Attention and stimulation

Both motivation and ability are influencing the performance by steering one’s attention. Attention is the mental process of concentrating effort on something.

According to Kahneman (1973), two types of attention can be distinguished: involuntary attention and voluntary attention. Involuntary attention will be directed automatically—it is activated when something exciting suddenly happens or when one does not have to focus on something in particular. It does not demand any energy or effort from the person. Voluntary attention is intensive as well as selective: it is activated as soon as a person needs to concentrate and focus on a task and simultaneously block other disturbing stimuli (Kaplan, 1995).

Kahneman suggests that there are limits to what we can attend to at a time, and that the limits are changed by factors like our health or level of distraction. The attention can be described as a resource. The available amount of attention need to be exploited—this is what it means to pay attention. The resource depletes because directing (voluntary) attention costs effort (Kahneman, 1973).

To direct the attention one needs stimulation. The relation between stimulation and attention (or performance) have been found to be correlated, and this relationships follows a pattern known as the Yerkes–Dodson principle. In this principle, there is an optimal level of stimulation at which people perform a task to the best of their ability. Attention decreases with lower and higher stimulation than this optimal level of stimulation, and is worst at very low or at very high levels of stimulation. Too high levels of stimulation cause stress or anxiety. The optimal level depends upon the complexity of the task and the personality of the person performing the task: a more difficult task (asking more attention) requires a lower level of stimulation and vice versa (Kahneman, 1973). Moreover, researchers have theorized that productivity is influenced by people’s perception rather than their actual level of stimulation determined by physiological methods (Thomas et al., 2006).
Although Boyden distinguished between survival and well-being needs (see § 2.3.2), they often overlap. For example, people clearly need food for survival and health. However, food often serves as the basis for bonding and relationship development. E.O. Wilson coined the term biophilia (1984, cited by Frumkin, 2001) to describe human’s intrinsic fascination with life and life-like processes. This hypothesis is confirmed by empirical data. For example, a systematic review by Bowler et al. found that there is evidence of a positive health benefit from exposure to natural environments. Based on self-reported measures of emotions there is quantitative indication that an activity in a natural environment could have more positive effects than similar activities in a synthetic environment, including cognitive functioning (Bowler et al., 2010).

Applied to the context of the building, this idea suggests that building environments that contain the essential features of preferred natural settings will be more supportive of human well-being and performance (Heerwagen, 2008; Kellert & Heerwagen, 2008).
This concept is fundamental in a number of perspectives relevant to design and well-being, including:

- buildings as habitats;
- natural comfort;
- attention restoration;
- stress reduction.

These perspectives mentioned are discussed in the following sections.

**Buildings as habitats**

The recognition that buildings are habitats for people is central to the approach of Heerwagen (1998). In this paper, sources for human environmental preferences are compared with building environments. Orians (1980, cited in Heerwagen, 1998) argues that humans should have preferences for the features of the ancestral savanna environment. These features include clustered trees and semi-open spaces, providing both refuge from excessive solar gain and rain, and high levels of visual access. Frumkin (2001) finds that it seems that whenever people are given a free choice, they move to open tree-studded land on prominences overlooking water. Furthermore, natural environments are consistently preferred over built settings, and built environments with trees, vegetation, and water are more liked than those lacking natural elements (Kaplan & Kaplan, 1989, cited in Heerwagen, 1998).

**Natural comfort**

The biological perspective also gives insights into comfort maintenance, according to Heerwagen (1998), which contradicts the conventional engineer’s view on comfort in buildings as presented in §2.2. Remember that in this conventional *one size fits all*–approach, occupants are seen as passive recipients, the primary mechanism is considered physiological, and indoor environmental conditions are viewed to be held within relatively tight margins. The biological perspective suggests exactly the opposite. People differ from one another in their ambient preferences, and a given person varies over time depending upon the state of health, activities, clothing levels and so forth (Kroner, 1992, cited in Heerwagen, 1998). Moreover, occupants are active adaptors to their environments;
so relationships between inhabitants, and between inhabitants and building systems, are interactive and multidirectional (Cole, et al., 2008; Paciuk, 1990).

**Attention restoration**

Rachel and Stephen Kaplan (e.g. 1995) developed the Attentional Restorative Theory (ART), which originates in the resource model of attention (see § 2.3.4). Directed or voluntary attention costs energy and can be depleted. It is susceptible to fatigue, leading to a need of restoration in order to refill the attention reservoir.

In the ART, there are four needs regarding such a restorative experience:
- the need for being away from everyday life;
- the need for fascinating stimuli;
- the need for extent, creating a feeling of being in a different world;
- the need for compatibility and a coherent surrounding.

Following these four criteria, nature seems to be the appropriate place for restoration, according to Kaplan. For restoration and so keeping attention, it is important that natural environments are accessible at the workplace. (Dilani, 2009; Kaplan, 1995).

There are empirical findings on the benefits of restoration in nature: vacations and breaks both having significant improvement in proofreading performance, compared to vacations respectively breaks in an urban setting (Hartig 1991, cited by Kaplan, 1995). A study of Tennessen and Cimprich showed that undergraduates with more nature in their dormitory view scored significantly higher on attention and tended to rate themselves as functioning more effectively in daily life activities (Kaplan, 1995).

**Stress relaxation**

Roger Ulrich proposed a theoretical framework around the stress reducing capacity of nature. Too much stimuli in an environment can be disturbing and stress enhancing, causing a need for relaxation. Studies have found stress reducing and health promoting outcomes associated with not only being in nature, but also with passive viewing of nature.

2.3.6 Sense of Coherence

Aaron Antonovsky (1923–1994) developed the concept of a Sense of Coherence (SOC) in order to explain what makes people healthy. Similar to the approach of Abraham Maslow, he introduced the term salutogenic, meaning health promoting, as opposed to pathogenic. The SOC is a dispositional orientation that is presumed to engender, sustain and enhance health, as well as to engender strength at other endpoints, such as work. Stimuli that impact on the individual with a high SOC are perceived as comprehensible (coherent, making cognitive sense), manageable (under the individual’s own direct or indirect control), and meaningful (challenges which are worthy of engaging with and important in life) (Dilani, 2009; Strümpfer & Bruin, 2009).

FIGURE 3 • Antonovsky’s concept of Sense of Coherence

The notions of comprehensibility and manageability are also important in another theoretical framework regarding stress at work, which reminds of the Yerkes–Dodson principle. According to Vischer (2007), employees can experience stress caused by feeling little or no control over, or understanding of, the workspace provided. Prevailing theoretical models of stress at work emphasize the need for a good fit between a person’s abilities, skills and degree of control, and the work environment’s demands, complexity, expectations and challenges. A poor fit in either direction (too many skills, not enough demands, or too many demands and insufficient control) generates either boredom or stress, while a good fit leads to satisfaction. Too much disturbance leads to a
perception of the environment being less manageable—too less stimuli leads to a boring environment without meaning (Vischer, 2007).

Moreover, the three characteristics which are vital in the SOC theory can be associated with the requirements for restorative experiences from the ART (§ 2.3.5). The need for fascination and extent in a restorative experience can be compared with the requirement of meaningfulness; the need for compatibility and a coherent surrounding in restoration can be compared with the requirements of comprehensibility and manageability.

Heerwagen et al. (1995, cited by Dilani, 2009) created a framework and guideline for salutogenic building design, based on the SOC concept.

This framework highlights three factors:
• enhancing social cohesion in both formal and informal meeting points;
• providing personal control for regulating lighting, daylight, sound, temperature, and access to private rooms;
• providing opportunities for restoration and relaxation with quiet rooms, soft lighting, access to nature and a good view.

2.3.7 Comfort and satisfaction

In a broad sense, the notion of comfort refers to satisfaction with the environment. This notion of comfort and satisfaction can be found in many publications on the indoor environment, including the Centre for the Built Environment (CBE) studies (Kim & De Dear, 2012a), the European Health Optimisation Protocol for Energy-efficient buildings (HOPE) (Bluyssen et al., 2011), and the Probe studies (Leaman & Bordass, 2001).

This concept is used so much because it is both straightforward and effective as a measurement tool. Moreover, it is a relational concept, which can describe exactly what the focus is of this study: the relation between buildings and their occupants. Sommer (1983) points out that satisfaction of occupant needs is the primary justification of architecture.
Still the concept of well-being is somewhat broader than the notion of comfort, as it involves also elements such as mood and confidence. However, it is theoretically likely and there is quantitative support that satisfaction and Sense of Coherence are strongly positively correlated (Strümpfer & Bruin, 2009). It is also imaginable and empirically confirmed in many studies that satisfaction and performance are positively correlated (Kamarulzaman et al., 2011; Lee & Brand, 2005). It appears that this is an indirect, but strong relationship, via positive moods, and that positive moods turn out to be critical for related outcomes such as motivation, performance, and lower absenteeism (Mitchell, 1989, cited in Heerwagen, 1998). Leaman and Bordass (2001) mention that satisfaction, health and perceived productivity are often surrogates for each other. Moreover, referring to the effects of the indoor environment on well-being when defining well-being or health allows these concepts to be evaluated in terms of perceived comfort or satisfaction (Bluyssen, et al., 2011).

2.3.8 Summary and conclusion

In this study, the concept of well-being in the indoor environment is central. The concept of satisfaction can be used for this, because there is a strong correlation with other concepts, it is a straightforward term, and it can be used to express the relation between occupant and building.

In order to get more insight and to know how to satisfy the occupants, both Antonovsky’s Sense of Coherence and Wilson’s Biophilia hypothesis are useful. To analyse the processes behind the relationship between a person and its environment, the SOC theory gives a broad understanding of the characteristics which promote health. The SOC incorporates some other notions such as that of stress and stimulation, while it appears to be strongly correlated with satisfaction and can be applied in the building context. In order to come to more concrete building design strategies, knowledge from the biophilia hypothesis can be used, disregarding which exact psychological process is lying behind this strong bond between human and nature.
Finally, theories from environmental psychology regarding needs (e.g. Maslow’s hierarchy of needs) can provide help in classifying design factors in correspondence with their psychological effects.

2.4 DESIGN FACTOR CLASSIFICATIONS

2.4.1 Indoor environment terms and definitions

The notion of differences in the psychological effects of environmental factors suggests that also design factors can be classified according to their psychological effects. Distinctions between design factors can become more clear when first a definition is given of what design factors are.

In different studies, different terms are used for nearly the same concept: work environment, physical environment, indoor environment, workspace, and workplace. In this study, those terms are interchangeable; sometimes a specific term is used in order to highlight one aspect of
the same environment (physical environment as opposed to social or organisational environment; indoor environment as opposed to outdoor environment). Following the definition of Leaman & Bordass (2005), the meaning of those terms in this study is limited to those features of the indoor environment which are under direct influence of the designer. In order to stress this design context meaning, the term design factor is favoured, when referring to elements of the indoor environment.

Some studies use a narrow sense of indoor environment, where it refers to only the physiological components. It is clear that, when considering mainly psychological effects, the most broad sense of indoor environment regarding effects on the occupants will be used. All elements of a building design can be considered, depending on whether these elements are directly or indirectly influencing the building occupant’s well-being.

![DESIGN FACTORS • Features of the indoor environment which are under direct influence of the designer, and have (indirect) effect on the occupants.]

2.4.2 Basic versus bonus

Analogous to Herzberg’s two-factor theory and Boyden’s distinction between survival needs and well-being needs (see § 2.3.2), Kim and De Dear (2012) distinguish between basic and bonus factors, and create an in-between category of proportional factors. Their classification is theoretically based on the customer satisfaction model of Noriaki Kano, who introduced the proportional factor in his model, additional to Herzberg’s two factors. Kim and De Dear adopted and tested this model for its suitability in the context of building occupant’s satisfaction. Based on this model, analyses are done on the occupant survey database from Centre for the Built Environment (CBE), to estimate individual impacts of 15 different factors of the indoor environment on occupant’s overall satisfaction.

Basic factors are comparable with minimum requirements. Occupants only notice this kind of factor if they are deficient or defective in some
way. They do not necessarily enhance overall satisfaction, but they can cause dissatisfaction when they are not fulfilled.

When a bonus factor performs very well, there is a strong positive effect on occupant’s satisfaction. However, poor performance of a bonus factor does not necessarily result in dissatisfaction.

Finally, occupant’s overall satisfaction level changes proportionally in line with the performance of proportional factors. When they perform well, occupants will be satisfied. And when they perform poorly, occupants will be dissatisfied (Kim & De Dear, 2012a).

Many researchers make distinction between physiological and psychological effects of the indoor environment, in one or another way. This intuitive distinction follows Maslow’s classification, where the first two groups contain basic physiological, functional and biological needs, and the three next groups can be taken together as containing psychological needs.

The distinction between physiological and psychological is already clear when considering the relevant disciplines. The disciplines of ergonomy
and environmental psychology both explicitly link people and the built environment. The discipline of ergonomics focuses on optimising environments for physical well-being of people, whereas the discipline of environmental psychology focuses on optimising environments for psychological well-being of people.

Remind that studies focusing on physiological impacts of indoor environments on the occupants have found that there must be other than physiological impacts (§ 2.2). Some of these have done a first approach to explain these effects in psychological terms. Leaman and Bordass introduced a “forgiveness” score, where occupants are still satisfied with less optimal conditions (Leaman & Bordass, 2007). Leyten et al. describe the case where acceptance for physiologically less comfortable situations is promoted. People tend to be more accepting when aberrations from preferred situations can be reduced or compensated for by the occupants, when remaining aberrations are understandable, and when those remaining aberrations are judged equitable on the basis of understanding and of perceived co-responsibility through control (Leyten et al., 2014). Note the parallel with the three components of the Sense of Coherence theory.

According to Vischer (2003; 2007), there are three hierarchically related categories in environmental comfort: physical comfort, functional comfort, and psychological comfort. These categories are explained in Figure 6.

**FIGURE 6 • Vischer’s categorisation in environmental comfort**

Stokols (1992, cited by Dilani, 2009) gave design suggestions for health promoting environments from three different dimensions of health: physical health, mental health and social health. In this framework,
physical health can be promoted by ergonomic and non-toxic design, mental health can be promoted by personal control and predictability as well as aesthetic, symbolic and spiritual elements, and social health can be promoted by access to a social support network, and participation in the design process.

The framework around performance which was presented in § 2.3.3 also gives cue to a distinction in building characteristics. A building can positively affect ability by providing comfortable ambient conditions, by fitting those to the individual, and by reducing health and safety risks. A building can positively affect motivation by providing conditions that promote positive affective functioning, psychological engagement, and personal control. A building can affect opportunity by providing equitable access to safe conditions and amenities, and compensatory design options where inequities exist (Heerwagen, 1998).

2.4.4 Direct versus indirect

It is clear that there are certain psychological design factors, as opposed to functional or physiological design factors. Still the distinction can be a bit confusing, where it is not sure whether a said to be psychological factor can have physiological, or neurological, processes behind it. A distinction which may be helpful in this context is that of direct and in-
direct influence of building features, as presented by Heerwagen (1998). A direct effect on performance would be something such as glare on the computer screen, which directly interferes with the ability to work. An indirect effect, on the other hand, operates through an intermediate mechanism such as mood or motivation (Heerwagen, 1998). Throughout the work of environmental psychologists on the relations between the physical environment and well-being at work, the tempting but simplistic notion that changes in the physical setting will directly determine employee behaviour is rejected; psychological processes are indirect processes (Gifford et al., 2011). It can be clear that mainly physical features of the workplace, such as lighting, can have psychological, indirect impacts, besides their direct impacts, and that these indirect impacts can be stronger and harder to counteract.

2.4.5 Relevance for this study

When seeing the aim of this study in the light of the design factor classifications presented, it becomes clear that the focus will be on those office design factors which have psychologically (so indirect) positive effects on the occupants. These factors will be named bonus factors, to the example of Kim and De Dear (2012). Note that these design factors, as they can be physical, also can have direct, physiological consequences, besides their psychological effects. This results in the following definition of bonus factors, used in this thesis:

*BONUS FACTORS* • Design factors with psychologically positive effects on the occupants.

2.5 BONUS FACTORS

2.5.1 Introduction

What are those bonus factors? Which office design factors are having psychologically positive effects on the occupants? A literature review is done in order to answer this question. The bonus factors can be found and clustered following the theoretical concepts regarding the relationship between buildings and their occupants, as presented in § 2.3.
The biophilia hypothesis, describing human’s intrinsic fascination with life and life-like processes, can be applied to building design—those design measures are brought together under the term natural design. Analogous to the three components of the Sense of Coherence theory (comprehensibility, manageability and meaningfulness), design measures regarding the interaction between building and user, as well as those regarding office layout and architectural experience can be identified. Although being a mainly physical factor the aspect of noise and sound is discussed for its strong psychological and longer-term impacts.

2.5.2 Natural design

Knowing that there is a strong bond between human and nature, buildings can be designed such that contact with nature is easy and following examples of nature. The book “Biophilic Design” brings together a number of publications from this perspective, defining biophilic design as an innovative approach that emphasizes the necessity of maintaining, enhancing, and restoring the beneficial experience of nature in the built environment (Kellert & Heerwagen, 2008).

Besides general features of built spaces, four specific aspects of natural design are worthwhile zooming in to:

- daylight;
- view;
- indoor planting;
- the connection between indoor and outdoor climate.

General features

In general, buildings can be designed with keeping in mind both the general healthy aspects of living in nature, and the natural human preference for the features of the ancestral savannah. According to Heerwagen (2008), these include:

- high biodiversity;
- clustered trees with spreading canopies for refuge and protection;
- open grassland that provides easy movement and clear views;
- scattered bodies of water for food, drinking, bathing, and pleasure;
- multiple view corridors and distances.
These features can easily be translated to the context of buildings. Scott (1992, cited by Heerwagen, 2008) found that built spaces which contain moderate degrees of complexity, and a sense of refuge coupled with high prospect were more preferred than spaces lacking these characteristics. People especially liked spaces with vertical and horizontal expansiveness that were subdivided into smaller zones. Scott suggests that zoned spaces provide users with the potential to survey the surroundings, but still enjoy partial concealment. Many of the preferred settings also had irregular layouts (Heerwagen, 2008).

**Daylighting**

Daylight is one of the prominent features of life in nature and it is mentioned often as potential bonus factor. Kim & De Dear, when they did not find any “bonus” factor (according to their categorisation, see § 2.4.2), suggest daylight to be one, while it was not in their data (Kim & De Dear, 2012a). Daylighting is expected to have positive psychological impact, confirmed by Gifford (Gifford et al., 2011). Vischer identified daylight as one of the elements in the physical workspace affecting stress levels and satisfaction (Vischer, 2007). Dilani claims that daylight has positive effects on humans’ psychological well-being (Dilani, 2009).

Evidence of effect on cognitive functioning and performance is presented in studies by Linda Heschong (2002; 2003). Two studies looked at offices workers, measuring output by a computer system and short cognitive assessment tests. Those who were closer to windows worked faster and had better memory recall ability (Heschong, 2003). Similar results were obtained in a study with elementary school prestations (Heschong & Wright, 2002). These results can also be influenced by the related topic of a view from the window, since that distinction was not made in the studies.

The preference for and positive impact of daylight has been attributed to the variation in the quality of the daylight (Heerwagen, 1986, cited by Thomas et al., 2006). Another known process is that of circadian rhythms or sleep–wake cycles, which influence alertness and task performance. Studies have shown that light consistently entrain the circadian system...
to a 24-hour cycle, and that lighting levels required to achieve this, are much higher than the ones required for vision. A study by Figueiro et al. shows that workers with less daylight spent more time taking breaks than those with more daylight, as a way of compensating (Figueiro et al., 2002).

When it is impossible to let sufficient daylight enter the building through windows (even with smart solutions such as reflecting surfaces, glass fibre tubes or translucent aerogel), building designers can use the artificial lighting to mimic daylight circumstances. A meta-analysis showed that within the normal range, increased illumination improves performance (Gifford et al., 1997, cited by Gifford et al., 2011).

**External view**
Similar to daylight, external view is mentioned often as potential bonus factor. Besides daylight, Kim and De Dear suggested view to be a bonus factor (Kim & De Dear, 2012a). Vischer identified external view too as having impact on stress levels and satisfaction (Vischer, 2007). Leaman and Bordass mention that people like workplaces near windows, with a view out (Leaman & Bordass, 2007). The European HOPE study revealed that the more satisfied people are with their view, the more satisfied they are with their comfort (Bluyssen et al., 2011). In this way, external view seems to be a bonus factor according to the definition of Kim and De Dear (2012). A 1990 survey in the Center for Building Performance and Diagnostics identified 10–20 percent lower sick building symptoms among employees with window proximity and seated views (CBPD/DPE, 1994, cited by Loftness & Snyder, 2008).

The preference for windows appears to be influenced by the size of the room and the view from the window (Butler & Steuerwald, 1991, cited by Stone, 1998). When the view is on natural spaces, it gives a feeling of being connected to nature (Dilani, 2009; Heerwagen, 1998). Viewing nature scenes is associated with enhanced mental alertness, attention, and cognitive performance, as measured by tasks such as proofreading and by formal psychological testing (Frumkin, 2001). In two studies of Kaplan is found that those who had window view on nature had fewer reported
ailments and overall job satisfaction higher (Kaplan, 1993). A study of Tennessen and Cimprich showed that undergraduates with more nature in their dormitory view scored significantly higher on attention and tended to rate themselves as functioning more effectively in daily life activities (Kaplan, 1995). Huisman et al. mention that view on nature has more positive healing effects than a view on a brick building wall, and that artificial substitutes for window views representations of nature are preferred (Huisman et al., 2012). A study by Stone failed to confirm a relation between window view and performance, but that these results might have been influenced by the tasks used and the short time individuals worked on these tasks, according to the author. It is possible that performance might be influenced indirectly by window presence via mood (Stone, 1998).

When it is not possible to have window views on nature, the observation of Heerwagen (2008) can be followed, where people tend to decorate their workplace with natural decoration.

**Indoor plants**

When discussing design in accordance with nature, the use of green inside comes immediately to mind. According to Huisman et al., indoor plants have positive effects on human health and well-being (Huisman et al., 2012). In their overview of the effects of the indoor office environment towards employees, Kamarulzaman et al. also mention the effect of plants (Kamarulzaman et al., 2011).

Office employees report that plants make them feel calmer and more relaxed, and that an office with plants is a more desirable place to work (Frumkin, 2001). Larsen et al. found that attractive settings positively affected participants’ ratings of well-being and that the presence of indoor plants increased the comfort and attractiveness of office environments (Larsen et al., 1998, cited by Lee & Brand, 2005). An experiment by Lohr found that subjects working in a windowless room with plants worked more efficiently, had lower blood pressure readings, and felt more attentive than subjects working in the same room without plants (Lohr et al., 1996, cited by Heerwagen, 1998). Mangone et al. found
that the presence of a substantial quantity of plants in the work environment has a significant positive effect on thermal comfort, and suggest that this effect is psychological in origin (Mangone et al., 2014).

The building design can facilitate the use of plants inside. Sommer (1983) mentions that, in order to enable workers to care for plants, sufficient natural light is helpful, as well as window ledges.

**Natural climate**
The indoor climate is the result of a lot of design factors, including ventilation strategy, window size, and thermal mass. Two features of this indoor climate are relevant as potential bonus factors: the role of the user, and the connection with the outdoor climate. Both are discussed here.

People appear to be flexible regarding their environmental conditions, following the concept of natural comfort. Adaptive theory states that the temperature at which people are most comfortable is related to the temperatures they are used to experiencing, and this is a result of both behavioral adaptation and psychological adaptation. This theory is confirmed with observations (Brager et al., 2004). Kim and De Dear (2012b) propose the related concept, the role of user expectations, as an explanatory factor in adaptive comfort.

The terms *acceptance* and *forgiveness* are used to describe human flexibility regarding environmental conditions when they are more closely linked to conditions outside, as it is in naturally conditioned buildings (Leaman & Bordass, 2007; Leyten et al., 2014). It is even suggested that short periods of being outside the boundaries of thermal comfort can be beneficial as an exercise for the human body, and can be preferred like saunas, sunbathing and downhill skiing are preferred (Stoops, 2004). Also Nelson et al. (1987, cited by Gifford, 2011) mention that optimal performance may be found outside the comfort envelope.

Cole et al. suggest that passive building techniques regarding heating and cooling emerge from a perspective where the building user is active, and lead to naturally conditioned buildings. Interior conditions are by so
more closely linked to daily and seasonal variations in conditions outside (Cole et al., 2008).

Which design measures are likely to result in a natural climate, in which users can adapt and where conditions are linked to those outside? Leyten et al. define a set of robust measures, which are likely to result in much more occupant health and satisfaction. These are called robust because buildings with these characteristics are likely to live up to the design purpose in real life situations. The set of robust building characteristics include the use of adaptive comfort, using thermal effective building mass, minimising external and internal heat load, occupant control of temperature and operable windows (Leyten et al., 2014).

Leaman and Bordass (2001), although using other terms, suggest the same. They mention amongst others thermal mass, stable and comfortable thermal conditions, and the presence of operable windows as measures which can make high satisfaction easier to achieve.

Kim and De Dear, in their quest for bonus factors according to their categorisation (see § 2.4.2), did a follow-up study in comparing naturally ventilated buildings with mechanical ventilated buildings. They found that the highest rated buildings were naturally ventilated and mixed mode buildings. They also found that temperature and noise appear to be bonus factors only in naturally ventilated buildings: when these building underperforms on those factors, it is being forgiven by the occupants, while high performance on those factors will lead to higher overall satisfaction (Kim & De Dear, 2012b). This raises the question what is the real bonus factor in a building: temperature, noise, or the use of natural ventilation techniques.

A similar observation is done by Leaman and Bordass (2007). From their study follows that the most comfortable and productive buildings have some degree of natural ventilation. The green buildings (meaning: sustainable in design intent, mostly having natural ventilation) are rated higher in summary ratings, but when some of the more detailed responses across the two groups are examined, differences are much less clear-cut. Leaman and Bordass explain the difference between summary
variables and detailed variables by posing that the summary variables include context (Leaman & Bordass, 2007).

Loftness and Snyder mention not only natural ventilation, but also natural cooling and and natural heating all are demonstrated in different studies to lead to health and productivity gains (Loftness & Snyder, 2008).

So in studies, natural ventilation and the use of operable windows is mentioned often as having positive effect. Also the use of thermal mass and natural heating and cooling are mentioned. However, the conclusion should not be that these design measures need to be applied everywhere in order to achieve a natural climate. These design measures are proposed in a specific climatic context. As reason behind those design measures is suggested that indoor climate conditions fit the outdoor climate in a natural way and be climate-responsive. Then the fundamental quality, leading to bonus factor effects, is whether a building effectively creates a comfortable indoor climate which is variable and connected to the local outdoor climate. The effectiveness of a building’s climate concept can be checked by comparing it with that of the local vernacular architecture (Rudofsky, 1965).

**NATURAL CLIMATE • A comfortable indoor climate which is variable and connected to the local outdoor climate.**

### 2.5.3 Interaction and control

The theme of interaction between buildings and their users is very closely related to the previously discussed natural climate, which makes the user more active and closer to natural outdoor conditions. The biophilia hypothesis can lead us to the consideration that human beings want to interact with their environment and that responsive design will be beneficial (Salingaros & Masden, 2008). But also in the light of the Sense of Coherence theory, the theme of interaction is relevant. In § 2.3.6 is mentioned that, following the SOC theory, comprehensibility and manageability are important principles in enhancing occupant’s well-being.
This knowledge from environmental psychology is confirmed in the context of the building. In trying to give an explanation for the adaptive theory, Brager et al. (2004) confirm that there were differences in satisfaction which could not be entirely accounted for by conventional thermal comfort theory, and hypothesize that control and predictable behaviour are important reasons for greater acceptancy. These mechanisms are generally expected to function in other control and interaction features of buildings.

**Types of control**
Following Lee and Brand (2005), distinction can be made between objective and subjective levels of control. Objective levels of control describe actual availability and ease of adjustment of various aspects of the work environment, whereas subjective levels of control describe the perceived personal influence over, importance of, and neutrality of consequences from applying various control behaviors (Lee & Brand, 2005). Both are related, because perceived levels of control decrease when controls do not respond; however, perceived control can be lower than actual control when the understandability of control systems is too complex.

A similar distinction is made by Paciuk (1990), using the terms available control, exercised control and perceived control. These concepts are respectively preconditions for each other: no exercised control without available control, and no perceived control without exercised control (Paciuk, 1990). Since possible psychological effects are discussed, the subjective comfort (and perceived control) is more relevant than the objective comfort (and available control) in this study.

**Hypothesised**
In general, personal control is expected by many building researchers to have positive effects (Lee & Brand, 2005). According to Joiner and Ellis (1985, cited by Vischer, 2007), a workspace should not be designed to be a one-time, final and permanent ergonomic support for all office tasks, but rather needs to be adaptable and negotiable to be most supportive to users. Bluyssen et al. (2011) found that people dissatisfied with personal control, have lower reported comfort, and vice versa. The forgiveness
phenomenon, described by Leaman and Bordass (2007), is suggested by them to be caused by the presence of intrinsically satisfying features, by the understandability of the building, and by the quickness of response. This is similar to the description (in § 2.4.3) of acceptance, given by Leyten et al. (2014): possibility for individual interaction, understandability and control are mentioned. Leaman and Bordass (2001) mention that high levels of perceived control are normally associated with high levels of comfort.

Operable windows are discussed before as having positive influence; it is not clear for which part this influence is caused by the feeling of being connected to the outdoors, and for which part it is caused by the individual control it provides to the occupant. It is expected to play at least some role regarding personal control.

Regarding thermal comfort, personal control and responsiveness are both mentioned as “killer” variables, which means that they are affecting perceived productivity the most (Leaman & Bordass, 2005). Personal thermal control is also mentioned as a robust measure, so likely to result in higher satisfaction (Leyten et al., 2014).

**Experimental evidence**

This is partly confirmed in experiments. Paciuk found that the degree of influence in shaping thermal conditions correlated with satisfaction. However, the actual use of this control seemed to be negatively related to satisfaction (Paciuk, 1990). In support of these inconsistent effects from providing control over aspects of the physical environment, Veitch and Gifford (1996, cited by Lee & Brand, 2005) found that if participants had personal control over lighting, they performed tasks more poorly and slowly compared to those who did not have such controls. This might be due to the fact that the actual use of personal control is a signal that there is something disliked in the environmental conditions. However, the experiment conducted by Lee and Brand suggested that perceived control was significantly positively correlated with job satisfaction and perceived performance. In a German study of Wagner and Gossauer it became clear that the perceived effectiveness of attempted
temperature changes has stronger influence on workplace satisfaction than the thermal sensation itself. The best ratings were given to buildings with a hybrid concept which includes cooling and at the same time allows an intervention of the occupants to change the indoor conditions (Wagner & Gossauer, 2008).

Not only control over thermal conditions appear to be relevant. MacLaney and Hurrell (1988, cited by Lee & Brand, 2005) used multidimensional measures of work control, including task control, decision control, control over the physical environment, and resource control, to assess the influence of control on task outcomes. Their results showed a positive relationship between personal control and job satisfaction. Thomas et al. (2006) also confirmed choice possibilities and personal control over lay-out as contributing significantly to satisfaction.

In the context of healing environments, it appears that providing a patient with a choice is a key element. The patient’s lack of control is considered as a major problem in hospital settings, which promotes stress and anxiety in patients. Design features suggested to enhance control include control over bed position, and control over temperature, lighting, sound, and natural light (Huisman et al., 2012).

Vischer identified personal control to lighting as one of the elements in the physical workspace affecting stress levels and satisfaction (Vischer, 2007). Veitch et al. found in a renovation situation that workstation-specific lighting with individual control was better perceived than purely room-wide lighting: pleasure, room attractiveness, lighting satisfaction, overall environmental satisfaction, job satisfaction, and organizational commitment were all higher for the people in offices with workstation-specific luminaires (Veitch et al., 2010). Also Dilani (2009) cites evidence for a positive correlation between satisfaction and personal control over lighting.

**Interaction with user**

The presence of personal control possibilities is not enough. Leaman & Bordass (2001) stress the importance of usability of controls and interfaces for occupants. Simpler systems can give better results in terms of
user satisfaction than more elaborate systems. Three conditions are mentioned: predictable and reasonably acceptable default states, opportunities to make interventions, and ability to act quickly and to know immediately that an appropriate response has occurred. The authors also claim a significant positive relationship between the occupant’s perceptions of performance and how rapidly they think that buildings’ systems respond to their needs (Leaman & Bordass, 2001). This is in line with psychological theories which stress the significance of understandability and manageability.

**Conclusion**

Seen all the research and publications discussed in this paragraph, the following can be stated:

- It is very likely that higher levels of personal control lead to higher satisfaction.
- Control must be clear, responsive and simple in order to be effective.
- This mechanism does not only function in thermal comfort, but also in the topics of personal layout, lighting and other environmental characteristics.

### 2.5.4 Office layout

In general, office layout is expected to influence occupant’s satisfaction and behaviour (Vischer, 2007). Workgroup setting and layout in space plan are mentioned by Leaman and Bordass (2005) as “killer” variable, so being very important in achieving high levels of satisfaction and performance. According to Kamarulzaman et al. (2011), the layout should help workers perform their tasks, make communication and supervision easy, and provide comfort.

Already in the paragraphs before, some office layout features are considered regarding their psychological impact. Following natural landscaping, observation of periodic movements, irregular patterns, organic shapes, good visual overviews and places for shelter are preferred (Heerwagen, 1998; Dilani, 2009).
A feeling of control over one’s privacy appears to be important for occupants. Privacy is important both for being able to concentrate and to have personal space. Occupants appear to like the possibility to control their level of social interaction: the situation in which the building layout provides them the opportunity to have either less or more social interaction whenever they want. The provision of both meeting areas encouraging social interaction, and concentration areas facilitating privacy, contribute to one’s privacy control. This prevents a sense of crowding or trespassing of private sphere, and a feeling of being lonely and isolated (Heerwagen, 2008; Dilani, 2009). Many office design guidelines for healthy building include the provision of meeting areas where occupants have the possibility for spontaneous encounters (Cole et al., 2008; Mulhall & Braungart, 2010). The availability of break areas is also confirmed by Thomas et al. (2006) to contribute significantly to satisfaction in the workplace.

Privacy as well as the previously discussed personal control are both easier to achieve in cellular office layouts, when compared to open plan offices. These layouts are mentioned by Leyten et al. (2014) as a robust measure, and by Leaman and Bordass (2012) to make higher satisfaction easier to achieve. However, it must be mentioned that the ideal office layout depends on the type of work needed to be done in the building.

In a study by Peponis, two conventional models to study office space are discussed, and extended in a case example. Common is the flow model, where an office layout reflects the required flow of information, e.g. by placing people who need to communicate near each other. Another common model is the serendipitous communication model which, providing interaction nodes such as cafes, helps to bring people together outside of normal workspaces, and encourages frequent unplanned interaction. In the design example presented by Peponis, design objectives are stated together with the client, leading to objectives such as “making the work process visible”, “expressing company identity in space”, “supporting diverse work styles”, and “inspire clients and staff”. The work process in company is analysed to be reflected in space (Peponis, 2007).
Discussing more than aforementioned general principles in designing office space goes beyond the scope of this research. Still, it is important to know that there is a quantity of research and anecdotic evidence in this field, however, that it is hard to make specific results externally valid.

2.5.5 Architectonic experience

Vischer (2007) also mentioned architectonic elements such as colours, decoration and art in her suggestions of features of buildings which can influence occupant’s satisfaction and behaviour. Dilani (2009) state that colours can have psychological effect—warm colours being stimulating, and cold colours relaxing. Garris and Monroe (2005, cited by Kamarulzaman et al., 2011), state that colour influences not only mood, but also wellness and productivity. For easy orientation, landmarks such as sculptures, paintings, aquariums or different colours in buildings can serve as reference points, according to Dilani (2009). Better wayfinding can reduce stress levels, following Huisman et al. (2012). Thomas et al. (2006) found that those who have artwork in their workplace were more positive about it. This all is in line with the SOC theory, where comprehensive environments can enhance well-being (see § 2.3.6).

In fact, the whole concept of architectonic experience and aesthetics is relevant here. The philosopher Alain de Botton, in his book “The architecture of happiness”, state that aesthetics are a promise of happiness. He searches for the virtues which are present in aesthetic buildings, and suggests the following five to be those virtues (De Botton, 2006):

- order combined with complexity;
- balance between contrasting elements;
- elegance that appears effortless;
- coherence with the building context;
- self-knowledge, as a virtue for the designer, entailing an understanding of human psychology.

Following the biophilia hypothesis, Heerwagen (2008) mention the effect of soft, organic shapes and of movement patterns. De Botton also suggests that one is always tempted to associate everything one sees with
the emotions connected to similar-shaped elements of life (bodies, faces), even unconsciously (De Botton, 2006). This goes beyond the common interpretation of biophilia, in suggesting that humans are not only looking for nature, but also suggest it where it is not directly present.

Most architects are integrating the psychological sciences in this way already, asking the question: how do the building users or visitors experience the space? There is a large amount of examples on this topic. However, the architect’s answer to this issue appears to be very different and personal. Only general principles as explained by De Botton are clear. Therefore a further discussion of this topic will fall outside the scope of this study. Mentioned must be that psychological effects can be expected from every aesthetic choice; and that, besides studies on the relationships between colours and moods, there is hardly any direct evidence on specific features.

2.5.6 Noise and sound

Although not being a positive factor, the presence of noise is very important as a building feature having psychological effect on the occupants. It is the main complaint area where the cause is psychological—people do not feel at ease when there are high noise levels constantly. Dilani et al. (2009) state that noise at the workplace causes stress, and decreases concentration and perception of life quality. Kamarulzaman et al. (2011) mention similarly that noise reduces productivity and satisfaction.

When regarding acoustic privacy, it is a problem both coming and going. According to Hedge, acoustic privacy is a major complaint area. For example, overhearing conversations at the reception desk was a main problem in waiting rooms in hospitals (Huisman et al., 2012).

Positive measures to lower noise levels are possible. Mentioned already is the cellular office plan, which enhances acoustic privacy. In the document description of the Cradle to Cradle registry, features designed to provide a quiet environment are suggested to improve productivity by protecting occupants from chronic noise (Rotterdam School of
Although noise is disliked in general, it is a complex phenomena and there are sounds which are considered to have positive influence. According to Dilani, the experience of sound is highly individual, depending on volume, predictability and possibilities for control. Music can promote health by contributing to a decreased activation in the sympathetic nervous system (Dilani, 2009). In general, Heerwagen (2008) suggests multi-sensory stimulating environments, involving also the hearing. Carefully designed multi-sensory stimulating environments have been found to increase people’s satisfaction over their environment. Natural sounds, such as water sounds, can also increase people’s environment preferences. Research also suggests that natural soundscapes are more restorative than typical urban or park soundscapes (Ratcliffe et al., 2013). However, there is limited evidence found on this topic.

2.5.7 Summary and conclusions

Overview of bonus factors
The quest was for bonus factors in office buildings: those features of the indoor environment of offices which are under direct influence of the designer, and have psychologically positive impact on the occupants. This review is done from the viewpoints of natural design, interaction and control, office layout, architectonic experience, and noise and sound. It appeared that the same bonus factors appeared from different viewpoints. The most effective viewpoint is that of natural design; it lead to most of the bonus factors, and these bonus factors were also found from other viewpoints (such as interaction and control).

When summarising these bonus factors, it must be clear that in any case it is needed to provide a comfortable and safe indoor environment in terms of physiology and functionality, according to current norms and standards. This includes adequate lighting, thermal conditions between certain boundaries, and a good air quality.
On top of these basic conditions, the following bonus factors were confirmed in literature:

• daylight;
• external view (preferably on nature);
• indoor plants;
• a natural indoor climate;
• individual control;
• a mixture of private and social areas.

Besides these confirmed bonus factors, there are other design factors which are very likely to be bonus factors, following theory or anecdotal evidence. These are related or can be combined with one of the bonus factors mentioned above. These potential bonus factors are:

• a comprehensive layout with zoned spaces, order and variation;
• using the right colours to affect moods;
• soundscapes for relaxation and acoustic privacy.

Some topics were expected to be found, but mentioned barely in the literature examined, such as the possible influence of odors. Also on the presence of water little evidence is found, although it is sometimes suggested, valued highly as biophilic design element, and often used by architects.
Comparison

Kellert (2008) presented a list of elements and attributes of biophilic building and landscape design, adopted in Table 1. These elements are proposed from the definition of biophilic design and therefore not necessarily supported by evidence. Although the author himself presents this list as “work in progress”, it is valuable enough. For example, the list is supported by Yao’s biophilia database (Yao, 2003, cited by Wilson, 2008). It is striking to see the many similarities with the results of this search for bonus factors. This suggests that searching for positive psychological effects from the environment directs in the same way as biophilic design does. This is not surprising seen the definition of biophilic design: focusing on the beneficial experience of nature in the built environment (Kellert & Heerwagen, 2008).

<table>
<thead>
<tr>
<th>ENVIRONMENTAL FEATURES</th>
<th>NATURAL SHAPES AND FORMS</th>
<th>NATURAL PATTERNS AND PROCESSES</th>
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<tr>
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<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 (mainly vertebrate)</td>
<td>Central focal point</td>
</tr>
<tr>
<td>Sunlight</td>
<td>motifs</td>
<td>Patterned wholes</td>
</tr>
<tr>
<td>Plants</td>
<td>Blomorphy</td>
<td>Bounded spaces</td>
</tr>
<tr>
<td>Animals</td>
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<td>Transitional spaces</td>
</tr>
<tr>
<td>Natural materials</td>
<td>Biomimicry</td>
<td>Integration of parts to</td>
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<tr>
<td>Views and vistas</td>
<td>...</td>
<td>wholes</td>
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<tr>
<td>Fire</td>
<td></td>
<td>Complementary contrasts</td>
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<table>
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<tr>
<th>LIGHT AND SPACE</th>
<th>PLACE-BASED RELATIONSHIPS</th>
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<tr>
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<td>Filtered and diffused light</td>
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<td>Order and complexity</td>
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<td>Light and shadow</td>
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<td>Change and metamorphosis</td>
</tr>
<tr>
<td>Spaciousness</td>
<td>Cultural connection</td>
<td>Security and protection</td>
</tr>
<tr>
<td>Spatial variability</td>
<td>Indigenous materials</td>
<td>Mastery and control</td>
</tr>
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<td>Spatial harmony</td>
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<td>Inside–outside spaces</td>
<td>Landscape features that define building form</td>
<td>Exploration and discovery</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>Information and cognition</td>
</tr>
</tbody>
</table>

**TABLE 1** • Elements and Attributes of Biophilic Design (adopted from Kellert, 2008)
Design approach

Besides the design qualities itself, the design approach was a recurring theme in the literature reviewed. It appears that the designer’s starting point is decisive in obtaining good results. If the architect does not see himself only as an artist, but puts the end user central and involves evidence from scientific research in his design, more positive design outcomes are more likely (Gifford, et al., 2011; Mulhall & Braungart, 2010). Incorporating scientific evidence in the design allows for more transparency, clear goals, and leads to better designs in healthcare (Berg & Winsum–Westra, 2006).

A similar approach is advocated by Richard Sommer in his book “Social design” (Sommer, 1983) and by the authors of “Biophilic Design” (Kellert, 2008). It is a fundamental conclusion of this literature review.

A design approach which is USER-CENTERED and EVIDENCE-BASED will lead to buildings with higher positive impacts on the occupants.

The relevance of user-centered design is reflected in, amongst others, De Botton’s building virtue of self-knowledge (De Botton, 2006), in Sommer’s plea for the involvement of users and behavioural scientists in the design process (Sommer, 1983), and in the Cradle to Cradle approach of defining the use at the start of a design project (Mulhall & Braungart, 2010). An extra argument for focusing on the employees is that in most cases of knowledge worker organisations, salaries represent the majority of expenditures (Sommer).

Evidence-based design is a term primarily used in healthcare design, in the context of healing environments (Berg & Winsum–Westra, 2006). It is a field of study emphasising credible evidence to influence design (Huisman et al., 2012). It is important to use this approach also in the context of offices. Sommer (1983) makes a case for the integration of scientific research into the design, especially to integrate knowledge from the behavioural sciences, in order to make the buildings fit better to their users. Zeisel (2006) shows that designers and researchers follow similar thought patterns and can learn from each other. Moreover, the gap between designers and users can be bridged by researchers.
2.6 RESEARCH IN THE DESIGN CONTEXT

2.6.1 Paragraph overview

Evidence-based design require evidence in the design context. Two categories of sources for evidence can be distinguished: the evaluation of existing designs, and experiments by (more or less) manipulating work environment settings. Both categories are discussed here. In both research types, there are several methodologies available to collect data. These data collection methods are discussed here as well.

2.6.2 Post-occupancy evaluation

Since the actual use of buildings mostly starts after designers have left the buildings, there is normally little feedback from actual building performance, compared to design intentions. This provides little opportunity to learn how a project worked in practice. The approach of post-occupancy evaluation (POE) was developed as a means of dealing with this issue (Sommer, 1983). POE is a generic term for all ways of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time (Oseland, 2007). It is an approach often used in the context of evidence-based design. The researchers of the European HOPE project also suggest using POE in the context of office design (Bluysen et al., 2011).

A POE provides feedback of how successful the workplace is in supporting the occupying organisation and individual end-user requirements. POE usually involves feedback from the building occupants through questionnaires, interviews and workshops, but may also involve more objective measures such as environmental monitoring, space measurement and cost analysis. The results of POE are mostly not directly used to change the design itself, but merely to influence future designs (Oseland, 2007; Sommer, 1983).

2.6.3 Experiments

Results from laboratory experiments are difficult to apply to real world office environments. When adapting environments for laboratory stud-
ies, an unreal world is being studied. Moreover, often the occupant’s unexpected behaviour in dealing with his unaccustomed environment can spoil the experiment results (Sommer, 1983).

An alternative are field experiments, attempting to maintain typical working conditions and environments as much as possible. Sommer (1983) calls this empirical research, as opposed to experimental research. Leaman and Bordass (2005) also mention their preference for real-world research. Mangone et al. used a quasi-experiment in a real-world setting to find evidence for (psychological) effects of indoor environment features. There are multiple test rooms or locations; participants remain in their existing workspace, while the environmental circumstances can be changed throughout the experiment, alternating between the different locations (Mangone et al., 2014).

It can be difficult to generalise the results of these field experiments. When supported with other information, statistical or theoretical, these methods can be powerful in the combination of real-world research, practical possibilities, and validity.

2.6.4 Data collection methods

User data
Zeisel (2006) presents four methods for obtaining user data in the context of building design:

• observation of physical traces;
• observation of environmental behaviour;
• focused interviews;
• standardised questionnaires.

Physical traces from user activity in the environment can be observed; thought can be of use erosions, leftovers, arrangements, decorations, public messages, or missing traces.

The observation of environmental behaviour of occupants is also a powerful method to investigate how a building functions and interacts with the user. The behavioural observation method is also mentioned as useful in the design context by Bluyssen et al. (2011).
In order to get a deeper understanding of definitions, emotions and intentions, focused interviews are useful. Ouweland et al. made extensive use of the focused interview method in their study, to get a deeper understanding of conceptual relationships. They used a means–end chain, for which in the interview the question “why is that important for you?” is asked repeatedly (Ouweland et al., 2014).

Standardized questionnaires can be used when problems or concepts are defined; the results are easier to analyse in larger quantities (Zeisel, 2006). It is important to ensure high response rates to avoid bias (Leaman & Bordass, 2005). A specific way of using standardised surveys is the presentation of photographs for rating them. This is used by Ouweland et al. (2014) and White et al. (2010).

**Building data**

Leaman and Bordass (2005) stress the importance of the inclusion of technical and energy surveys to provide operational detail and to get a deeper understanding of the effect of the building in the users.

Building data can include temperature, noise levels, lighting levels and indoor air quality, but also space metrics and space utilisation. More recently, POEs tend to include sustainable measures such as energy consumption, waste levels, and water usage. (Oseland, 2007). The combination of surveys or questionnaires and building measurements are used in the large building research projects such as the CBE studies (Kim & De Dear, 2012a), and the Probe studies (Leaman & Bordass, 2001).

### 2.6.5 Validity of data

It is tempting to try to analyse effects of building features on productivity by measuring productivity only in objective, quantative ways: by counting phone calls, calculation mistakes or turnover. However, these methods do not take into account the qualitative aspects involved in most of the office jobs of today, such as creativity and communication. Moreover, several studies find no relation between the objective environment and performance, while the experience of the environment and performance are related in general (Leyten et al., 2012). It is impossible
to measure productivity objectively while taking into account every aspect of the job (Leaman & Bordass, 2005).

Subjectively-obtained data are not necessarily inferior to objective data (Leaman & Bordass, 2005). In the first place, all data (including objective data) need to be interpreted correctly. Moreover, when the user is in the center of the design, the concept of building performance includes the satisfaction of users as well. This can best be measured directly on the users themselves. It is also necessary to use subjective data when searching for behavioural patterns, interactions and reasons. Whilst research has shown that there is a pattern of people over-estimating their own productivity levels, there is a significant correlation with actual productivity (Oseland, 1999, cited in Thomas, 2006).

Baird and Dykes found in their building assessments that users appear to be quite capable of scoring the performance of the buildings they occupy to a relatively fine degree: scores could spread over full range no matter the extra comment being positive or negative. They also found that the total amount of positive and negative comments can predict satisfaction scores, however, that the comments are generally speaking somewhat more negative (Baird & Dykes, 2012).

Advantages of using perceptions for productivity or comfort data include the simplicity of the questions, so that they can be easily incorporated in other surveys and a fair comparison is possible, and that large samples are cheap. Disadvantageous is that it is difficult to include any other reference point in the questions than the past experience of the user, and that the context at the time of the survey can have effect (Leaman & Bordass, 2005; Bluyssen, et al., 2011).

So, subjective data can and need to be used in these types of research in order to know more about user perceptions and to get a deeper understanding of the effects. It is then important to control for context, to avoid quick generalisations, and to pay attention to unusual outcomes (Leaman & Bordass, 2005).
The biophilia theory describes human’s intrinsic fascination with life and life-like processes. Apparently this is an effective way to explain the way office design features can have psychologically positive effects on the building users. When being inside a building, people still want to be connected with the outdoor environment and nature. Known ways to make this connection, having positive psychological effects, are views on nature, daylight, and green inside.

Water is another vital element of nature and is essential in the cycles and changes in nature—Leonardo da Vinci mentioned it “the driving force of all nature.” Aquatic environments play a role in the biophilic habitat theory, considering the human preferences for the features of the ancestral savannah environment and human survival. This includes the presence of water as a requirement for survival, and for providing a green and fruitful environment (Hartig et al., 2011): no blue, no green! Frumkin (2001) finds that whenever people are given a free choice, they move to open tree-studded land on prominences overlooking water.

It is therefore no surprise that water is considered as one of the most important elements in biophilic building design (Kellert, 2008). This is recognised by architects and landscape designers who use water to enhance the space experience both outdoors and indoors, in the form of fountains, ponds, and other water features. The recognition that water has a specific value in human habitat leads to our hypothesis.
3.1.2 Definition

Surprisingly, no research or evidence is found on positive psychological effects of the environmental use of water in building design. Therefore it is worthwhile to do a follow-up study on this topic. The study is defined by its hypothesis and restricted to the field of the preceding research part: office buildings.

3.1.3 Study design

The study intends to support evidence-based and user-centered design, as recommended in the conclusions of Chapter 2. This has consequences on the research strategy of this study: it starts with the building designer and finishes with the building designer, but it is centered around the building user and his experience. First, current design practices of water elements, intended as bonus factor, are distinguished. From these current practices, there will be searched for evidence of bonus effects of those practices. Finally, the evidence will be used and synthesised to come with recommendations for building designers how they can employ water as a bonus factor.

3.1.4 Data collection methods

The central part of the research is the data collection stage, where evidence of bonus effects of the use of water in the indoor environment is searched.

The quest for evidence starts with studying secondary sources: existing research which can be relevant to these questions. There will be looked for both theoretical and experimental studies on the effects, preferences and experience of water in the environment, and the processes behind. The result of this literature review can be found in § 3.3.
In addition to this literature review, original research will be conducted to find more specific evidence. This original research includes a survey regarding building user’s preferences regarding water in their environment, in relation to different work types. This research is reported extensively in Chapter 4.

After the analysis of the evidence data, another data collection method is employed. Interviews are held with experts in order to search for good recommendations for application of the knowledge obtained. This process and its results is reported in Chapter 5.

An overview of the research design, the data collection strategies used, and the relations with the conclusions from the previous study can be found in Figure 9.

**FIGURE 9** • Study set-up and relations with previous study

### 3.2 CURRENT PRACTICE

#### 3.2.1 Paragraph overview

Water and its systems are present in every building. When searching for water elements which are currently used with the intention to have bo-
nus effects, it is good to first see the context of functions of water usage in buildings, and current trends around water use and scarcity. This will help develop relevant studies; moreover, in the end it will help to come to better recommendations where a water element is not just an add-on, but integrated in the building.

### 3.2.2 Functions of water use in buildings

Conventional office buildings have a water system where freshwater comes in and is being used for all functions of water in the building. After use, the water is discharged through sewage. Use types include domestic and rest-rooms use (mostly toilet flush and drinking), use for indoor climate control (cooling), for landscaping, and kitchen use. The amount of water used for cooling and for landscaping depends largely on climate and building type (EBMUD, 2008).

Besides tap water, other sources of water entering office buildings are possible. Bottled water comes in buildings for the use of drinking only (used in water coolers or coffee machines). Some buildings make use of rainwater harvesting as another source for non-potable use such as toilet flush.

Water can also be used for storage of thermal energy in buildings. The water is mostly stored in the building or the soil beneath; fluxes in and out are negligible. Water can also be used for fire suppression in buildings; in some forms this involves permanent storage of water as well.

### 3.2.3 Ecological aspects

On the global scale, potable water is becoming more and more scarce. However still not on problematic scale, this development can also be detected in The Netherlands and Belgium. The effort needed to provide enough drinking water, by extracting, purifying and distributing it, is becoming larger and larger, and more and more expensive. In order to secure the future supply of drinking water, the groundwater resources must be used economically (European Environment Agency, 2007).
The use of water has large ecological impacts. For the purification of water, large natural areas are needed. The groundwater, pumped up for use, is not supplemented fast enough because of the many paved areas, especially in large urban areas, and the straightening of streams, prohibiting enough opportunity for the water to infiltrate in the ground. This causes the groundwater level to decrease, which has impact on the strength and subsidence of the soil. Moreover, the more water is used, the more sewage water must be treated. This treatment also brings about costs and ecological impacts (European Environment Agency, 2007; AMINAL, 2001).

When considering different ways of using water in the building context, it is good to keep in mind that it is recommended to save on freshwater.

### 3.2.4 Water elements with intended bonus effects

An inventarisation of water elements with intended bonus effects is done by a web search, using search term combinations of “building”, “water”, and terms such as “natural”, “productivity”, “relaxation”, and “experience”, and by deeper investigating of the results.

This inventarisation revealed that the different ways of using water for positive psychological effects can be brought down to four categories:

- drinking sources;
- greenblue integrations;
- places of experience;
- visual decorations.

These four categories are all related, and not exclusive. This categorisation is only meant to give insight in the different ways water is employed as a bonus factor inside buildings. It is possible that an element fits in more than one category—in fact, such elements could be the best performing examples of water bonus features.

**Drinking source**

Water coolers or water dispensers are in the first place directly functional, providing drinking water. At the same time these elements
function as a social gatherplace. Apart from their chosen location, these elements are usually not integrated in the building design.

Greenblue integration

In nature, water can function as transport medium, as vital source for green, and as a habitat for fish. These biological forms of water are brought indoors in several ways. Two systems will be mentioned here as examples—other (alike) systems are possible.

The wastewater of the building can be treated on-site in an ecological way in order to be reused. This treatment can be outside or inside the building envelope. Ecological treatment means that specific plants are used in a helophyte filter to remove contaminants from the waste water, resulting in potable water. For example, this technology is used in the NIOO–KNAW building in Wageningen. The technique is commercialised by Living Machine, who have installed it in numerous buildings over the USA. With these systems, not only elements of nature, but also processes of nature are brought closer to the daily life of building users. It creates pleasant and attractive public spaces in or around the buildings (Living Machine, 2014; NIOO, 2011).

Another system which integrates the blue and the green is an aquaponic system. This is a food production system which integrates aquaculture (raising aquatic animals in tanks) and hydroponics (cultivating plants in water). Water from the aquaculture system is fed to a hydroponic system where the byproducts are broken down by bacteria into nitrates and nitrites, which are utilized by the plants as nutrients. The water is then recirculated back to the aquaculture system (Wikipedia, 2014). Aquapon-
ic systems can be kept outside or in separate spaces such as greenhouses, but can also be brought to the working environment. The technology is available in different forms, including very small modular elements, and is applied often as a form of urban agriculture. It can create attractive places and enhance colleague cohesion by growing food together. Commercial examples include the AquaFarm by Back to the Roots, and VertiFarms (Back to the Roots, 2014; VertiFarms, 2014).

Place of experience

In order to enhance space experience, water is often used in dynamic ways where it flows or splashes through space. This create multi-sensory experiences which are visually appealing, involving touch, create an acoustic background, and affect air humidity. These are “fascinating” experiences, considered by Kaplan (1995) to be restorative and inspiring, enhancing work outcomes. The acoustic background can be seen as a form of soundscape, which is suggested to have positive effects (Dilani, 2009, Ratcliffe et al., 2013), and can create acoustic privacy (see § 2.5.6).

Applications are very diverse; two examples are fountains and flowforms. Fountains are used very often in public areas. Larger fountains produce higher sound levels, which can be above comfort limit when close; however, small fountains or water cascades are possible. Flowforms are shells in which water runs in a rhythmic way in loops. They can create small cascades of water, imitating natural streams, and can be used closer to the workspace. Mostly, flowforms are used in gar-
dening, but they can also be used in buildings (Foundation for Water, 2014).

Enhancing space experiencing can also be done the opposite way: not by creating a water experience in the building, but by situating the building on the existing fascinating place. A famous example is the Fallingwater House by Frank Lloyd Wright. This design made the fascinating spot suitable for living and enhanced the experience.

**FIGURE 12 • Examples of water experience elements. From left to right: Indoor fountain; Flowform handrail at ING Headquarters Amsterdam (image source: flowform.net/ projects/ing-bank); Fallingwater House; Water stairs at Hattersheim Town Hall, designed by Atelier Dreiseitl.**

**Visual decoration**
When the experience of water is limited to vision, it can be considered as a decorative element. Bubble tubes or water walls are often used forms of decoration with water. Aquariums can also be seen as forms of visual decoration, when they are completely closed and maintenance is not done by building users. To a lesser extend, these water elements as well could be fascinating and enhance work outcomes (Kaplan, 1995).

**FIGURE 13 • Office space with water walls, tubes, and aquariums**
3.3 LITERATURE REVIEW EXISTING EVIDENCE

3.3.1 Introduction

In the literature study on bonus factors, it surprised that no research or evidence was found on positive psychological effects of the environmental use of water in building design. Therefore a deeper investigation is done. It appeared that there is research done on the effects of environmental water in landscapes. Apart from theoretical development from the biophilia hypothesis (as presented in § 3.1.1, Hypothesis), and general and anecdotal evidence on the social effects of water coolers, still no research on the psychological effects of water inside buildings is found.

An overview of the evidence found in studies on the effects of environmental water in landscapes will be presented here, as well as evidence on social effects of water coolers.

3.3.2 Positive effects in landscapes

Völker and Kistemann brought together much of the studies on positive effects of water surfaces in landscapes in a systematic review. They found that in general the presence of water is a strong predictor for preference of landscapes. When compared, landscapes containing water are often more preferred and valued restorative than landscapes without water. The diversity of these landscapes containing water (varying from beaches and riversides to waterfalls and lakesides) indicates the high level of attraction of water (Völker & Kistemann, 2011).

Also the different types of water presence in landscapes is preferred as a view from the window. People prefer to see water, for instance a lake, river, or the sea. In the research of Kfir et al., outside views containing the sea got higher ratings than those without. Also Tuaycharoen and Tregenza found that the most highly scored scenes were those with some form of water. Research of Shafer et al. shows that adding a lake to an image of a landscape scene, which originally does not contain water, leads to considerable higher preference ratings. The study of Hellinga on
outside view ratings gave the same results: the best rated views were those containing water (Hellinga, 2013).

Researchers also searched for the underlying mechanisms why water could be beneficial. Specific aspects mentioned in the perception of water are its sounds, colours and clarity, associations and context, and visual motion. Among the different types of sound water movements can produce, the calm sounds are considered restorative. Also the visual properties (light reflection patterns) and the association with cleaning properties (and bathing) are suggested as explanation for the preference for and health effects of aquatic environments (White et al., 2010). According to Völker and Kistemann (2011), some studies mention colour and clarity as important characteristics for positive perceptions of water: a brown, unclear stream is not considered healthy.

Water appears to have emotional benefits as well, when it stimulates social interaction and personal inspiration. The restorative and recreational benefits of water are experienced much, but hardly measured scientifically. Direct health benefits are suggested (Völker & Kistemann, 2011).

### 3.3.3 Validity of results

It is not likely that these results are biased by a familiarity effect. Most participants in the study of White et al. were not living near the marine environment, and a study by Berman et al. among participants from the middle of continental America showed similar results (White, et al., 2010). Moreover, Purcell et al. negated the familiarity hypothesis in their study on the correlation between restorative value, preference and familiarity. They found that while restorative value and preference were strongly correlated, both variables had a weak correlation with familiarity. They mention that variations in studies on these topics are bigger inside groups than among groups of different geographic location (Purcell et al., 2001).

Some studies did not use direct exposure to nature, but representations of natural scenes. For example, White et al. (2011) used the viewing of
photographs for rating by participants. Felsten showed that this is a valid study method, as he found that viewing representations of nature gives the same results on perception and preference as being in nature. Also, according to Felsten, perceived restorativeness and real restorative effects are related (Felsten, 2009).

Van de Berg et al. (2003, cited in Völker & Kistemann, 2011 and in Purcell et al., 2001) found no significant evidence for restorative effects of water in the environment; this might be due to the high stress levels participants were exposed at in this study. Moreover, as Völker and Kistemann remark, a missing recognition cannot disprove a mechanism hypothesised or shown in other studies.

3.3.4 Effects inside buildings

Physical effects
In § 2.4.4 is explained that psychological effects are always indirect, and are partly resulting from physical features of the workplace. So, in order to get to know the psychological effects of water elements inside buildings, having a clear view of the physical effects of water elements will be beneficial. These will be shortly discussed here—deeper investigation of these effects fall outside the scope of this research.

In § 3.2.2, the direct functional ways in which water is usually employed in buildings are discussed—these involve drinking, cleaning, discharging of waste material, and thermal control.

Water elements, intended as bonus factor, can have physical effects as well. The cleaning properties, when present, are limited to the element itself, since the flow of water is mostly fixed in elements (basins or gutters) designed for this. However, through evaporation, water elements can affect the air humidity in the rest of the space. This influence is only noticeable when the water element involves heavy movement and turbulence, such as larger fountains and waterfalls. Air humidity can have positive effects by removing fine dust from the air, and influencing environmental and perceived temperature. The evaporation can also be used to bring substances in the air, such as perfumes or beneficial micro-
organisms. Air humidity can also be too high, leading to unwanted condensation and mold. However, since the evaporation rates of water elements are limited, it is not likely that a fountain or waterfall will be the only source of such problems (United States Environmental Protection Agency, 2013).

**Social effect of water coolers**

The water cooler is a well-known symbol of social gathering at the workspace. Sufficient availability of drinking water fits in a design strategy where private and social areas are combined in a clear way: at a water cooler, one can expect to have social encounters (which contributes to bonus effects, see § 2.5.4). It fits well with the biophilic theory of human habitat, where drinking places are gathering points (Heerwagen, 2008). It is almost superficial to mention that drinking enough water has numerous health benefits—discussing these effects would go beyond the scope of this study.

The social effect of water coolers is also often suggested to have positive effects on productivity: knowledge sharing in an informal way improves internal communication and employee morale (e.g. Pentland & Heibeck, 2009).

### 3.3.5 Negative effects and dislike of water

When looking for the potential benefits of water, one must not ignore the other side of the coin. Besides biophilic, water can be a biophobic element as well, as it can spread diseases and cause floodings (Hartig et al., 2011). When used in buildings, people are quickly worried about cleanliness. The use of fountains in gardens can lead to noise disturbance for neighbours (Rechtbank Amsterdam, 2011).

Especially in The Netherlands people in general have a complicated relationship with water, seen the risk of floodings over lowlands. However, in the last decennia the general opinion seems to be more towards a biophilic relationship with water (Zwart, 2003).
When contributing to design with water, with the intention to have positive effects, it is good to keep in mind that the environmental use of water can also have negative effects.

3.3.6 Conclusion

In general, waterspaces in landscapes are preferred, considered restorative and proven restorative. Health benefits of water in the environment are suggested. Inside buildings, social effects from water coolers can improve productivity. This all is in line with hypotheses from biophilic theory.

The evidence shows that water elements are suitable for relaxation and work breaks. It is not shown whether the use of water elements in the working environments itself will have positive effects. However, this can be expected, since research on the effects of other biophilic elements, such as green and plants, show that restorative effects go hand in hand with positive psychological effects at the working place (see § 2.5.2; Mangone et al., 2014).
Existing evidence shows that water elements are suitable for relaxation and work breaks. Following the hypothesis in § 3.1.1, it is interesting to investigate if water elements also can lead to higher appreciation of the working environment itself. This is the topic of this survey.

The survey is focused on the preferences of users. Although preference itself can be influenced by personal taste and perceptions, it can be measured directly (without interfering variables) and easily in larger quantities. The validity of measuring preference is discussed in § 2.6.5. From this discussion followed that in using subjective data, it is recommended to control for context, to avoid quick generalisations, and to pay attention to unusual outcomes (Leaman & Bordass, 2005).

Besides differences in the working environment, the survey also takes into account differences in work types. Using a work type distinction in the survey has several reasons. One of the findings in § 2.5.4 is that the ideal lay-out of a building can depend on the type of work done in this building, and this finding fits in the recurrent theme of interactivity between building and user. So it will add value if a survey investigating the value of indoor water elements also takes into account different work types. Moreover, multiplex questioning enable stronger conclusions, provided that the different work types together form a coherent whole.

**RESEARCH QUESTION** • How are blue indoor environments (featuring water) preferred for different work types, compared to typical and green indoor environments?
4.2 METHODOLOGY

4.2.1 Introduction and paragraph overview

The survey as presented to the respondents can be found in the appendix. Its final set-up emerged from considerations on general approach and survey type, approach for the different questions, image content, distinction of work types in the questions, and an introductory text. All these considerations are presented in the following subparagraphs. Also considerations on the procedure and distribution are presented in this paragraph, under 4.2.9.

4.2.2 Survey type

**Study and measure type**

This study is a structured questionnaire: all participants get the same survey questions. This enables for effective analysis of results. Space to add comments and motivations is provided in order to give extra insight in the results and participant considerations.

The participants are asked to give their preferences for different environments regarding different work types. The preferences are expressed in a ranking, which is an ordinal level of measurement 1. This ordinal measure is chosen to avoid false suggestions of accuracy. The aim in this study is to know whether a change in the working environment has positive or negative effects—it would be arbitrary to measure exact levels of preference which could be influenced by many other factors. Moreover, asking for a ranking instead of exact levels of preference increases ease of responding.

**Online execution**

The survey is conducted as a web-based questionnaire. This has advantages regarding distribution, control and administration. The distribution could be done via e-mail, having the advantage of reaching much potential participants in a short time. In web-based question-

---

1 An ordinal level of measurement is qualitative. It allows for rank order, but not for relative degree of difference between the different ranks, as qualitative measures do.
naires, answers can be validated (e.g. whether or not it is a number, when asked for a number). Moreover, the data of the respondents is immediately available and does not need much processing to be analysed.

**Visual approach**
The main surveying approach is visual. The use of images rather than text for representing different indoor environments gives a stronger and more concrete idea for the respondents to react on. Images also minimise room for different interpretations of the respondents to the questions. It increases the ease of responding and reduces nonresponse.

A visual approach is in line with the underlying mechanisms why water could be beneficial. Associations with positive uses of water (such as cleaning and drinking) are supposed to be one of these mechanisms. These associations could be evoked more strongly and are more similar when people have a more clear picture in their mind—text could be interpret differently or trigger false associations. Also the visual properties of water are mentioned as important mechanisms behind beneficial effects of water, which can be represented directly in images.

### 4.2.3 Working environments

**Selection**
For this survey, computer generated images rather than real pictures have been used. This has the advantage of maximum control over the visual content without losing information quality.

Four variants of working environments are distinguished. A typical working environment is used as a reference for comparison. Two blue environments are created, based on the different categories of water features (§ 3.2.4). A blue environment in which water is used as a place of experience (water wall with open water) is visualised, as well as an environment where water is used for visual decoration (aquarium). The use of water as drinking source is not considered in this survey, since there is already some evidence on its social and health effects, and further investigation would be outside the scope of this study (see § 3.3.4). Water features which are greenblue integrations are not represented. Instead a
green-only variant is used, which is the fourth variant. The green-only variant is used to be able to compare the effect of blue environments with green environments.

This leads to the following four variants:

• Typical;
• Aquarium;
• Water wall;
• Plants.

**Image requirements**

The images are created based on seven requirements which result from the research definition and from previous research. These requirements are the following:

• The indoor environments in the images, especially the water features, should be realistic and based on currently existing elements of the indoor environment.
• The images should be completely similar, except for the parts that are varied for the purpose of the study.
• The differences in the images, subject of study, should be unambiguous and large in order to maximise effect².
• Nonrelevant design elements which could have unknown effect on user preferences (such as colours) should be left out as much as possible.
• Insights of the previous study on bonus factors should be used in order to create environments which are attractive. Elements to be used include a view on sky and green, and a spatial zoning inside the room.
• The images should be accompanied with titles in order to ensure the same interpretation of the images with all participants.
• Furniture which make the different work types used in the questioning equally possible should be visible.

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² White et al. (2010) found stronger effect for higher doses in pictures.
The differences in work type are reflected in four different questions on the same set of images. Participants are sequentially asked for their rating of the images for different work types.

The different work types used are combinations of extremes on the two axes in a spectrum of different office work types: individual versus in-
teractive work, and concentrated versus creative work. The combination of these four can be used as representative for office work in general.

![Office work types spectrum](image)

**FIGURE 15 • Office work types spectrum**

### 4.2.5 Motivation question

Each question for rating the images on a specific work type is followed by a clarification question. Through this question more information on possible mechanisms can be obtained. This follow-up question asks for respondent’s motivation for their preference for the environment they gave the highest rating. This question is more concrete than a question which asks for motivation in general, and therefore will evoke more response. It is restricted to the environment with the highest rating to prevent overasking of the participants. The motivation for the highest rating is the most interesting in the context of this study, which is on positive effects.

### 4.2.6 Specific application question

A specific application of the use of water in the indoor environment is addressed in a separate question: on-site wastewater treatment with the use of plants (discussed in § 3.2.4). This technology could be applied in buildings, but does not necessarily be featured or presented to the building users. Both positive and negative responses to the featuring of his
technology are well imaginable. That is the reason for including this question in the survey. The goal of this question is to get more insight in people’s first reactions.

The fact that both positive and negative responses are well imaginable means that the description of the system and the way of asking should be carefully chosen in order to not influence the outcomes. Two options (the system in a separate room, and the system clearly featured in a public area) are given in neutral and short descriptions. Only after respondents have made their choice, a follow-up question becomes visible. This question asks for a motivation of the choices and gives checkboxes with three different thinkable reasons, as well as space to enter a different motivation.

4.2.7 Demographic questions

General demographic questions are included to control for the influence of these factors, and to get more information on the characteristics of the sample. The following four items are considered relevant and included:

- age;
- sex;
- average number of working hours;
- predominant work type.

The work type question includes the work type distinction used in the image question. Familiarity of the participants with certain environment is not considered relevant. Preference and familiarity only have a weak correlation, according to Purcell et al. (2001). Moreover, the images have maximum similarity, avoiding such types of bias.

4.2.8 Survey introduction

The survey starts with an introduction on the first page. This introduction gave some background information: the name and position of the researcher, the research topic and the expected time spent on respond-
ing. This information is provided to avoid confusion and to reduce non-
response.

The description of the research topic is kept as short and neutral as pos-
sible, giving the topic of “office work environment and work types”. This
is done in order to not influence or trigger certain outcomes.

4.2.9 Procedure and distribution

In the process of designing the questionnaire, it is tested several times
on proof participants. This is done to get maximum clarity in question
set-up, question wording, and question order.

A selection of people with office work experience is used, both from The
Netherlands and Belgium. Participants are invited via e-mail to fill in the
survey, and asked to pass it through to their colleagues.

4.3 RESULTS AND ANALYSIS

4.3.1 Demographic information

The survey is filled in by 71 respondents: 29 females and 42 males
(40 resp. 60 %). Respondent ages vary between 19 and 66 years, with a
weighted average of 34.

![Participant age distribution](image)

**FIGURE 16 • Participant age distribution**

Most of the respondents work for most part of the week; the weighted
average number of work hours a week is 30.
Almost all participants had an indoor job (97%), and most of the participants worked in an office (83%). The female participants had less often an office job than the male participants (66% against 95%).

The total number of votes for each of the four ratings (1st, 2nd, 3rd, and 4th) for each work environment according to the four different work types are shown in Table 2. This data is visually represented in four graphs, according to the four work types, in Figure 19.

**FIGURE 17 • Distribution of participant work hours a week**

**FIGURE 18 • Distribution of predominant work type among female, male and all participants**

4.3.2 Interior ratings

The total number of votes for each of the four ratings (1st, 2nd, 3rd, and 4th) for each work environment according to the four different work types are shown in Table 2. This data is visually represented in four graphs, according to the four work types, in Figure 19.
TABLE 2 • Work environment ratings according to work type

FIGURE 19 • Work environment ratings per work type
Summary values

When using an ordinal measure, data can be summarised with the use of modes (not with averages). From the graphs in Figure 19 can easily be seen that for most work environments, one rating is voted most for each environment. This rating could be called the modal rating. For example, for concentrated individual work, the modal rating of the plant environment is the 1st place, the modal rating of the typical environment is the 2nd place, the modal rating of the aquarium environment is the 3rd place, and, finally, the modal rating of the water wall environment is the 4th place.

In this example, each of the four ratings are a modal rating for each of the four environments. It is also visible that for the plant, aquarium and water wall environment, the modal rating is voted by far the most. For example, where 37 people rated the plant environment first, the other ratings of the plant environment were voted not more than 20 times (54% of the number of the modal rating). Both facts suggest that respondents where consistent in their voting.

Similar results are obtained for concentrated interactive work. The modal ratings of the different environments are the same as the modal ratings of the different environments for concentrated individual work. The only exception is the aquarium environment, where the modal rating for concentrated interactive work is both 2nd and 3rd (instead of clearly 3rd, as it is for concentrated individual work).

Generally the same holds for the creative work types. The modal ratings for both creative work types are again very clear in the case of the typical environment (4th) and the aquarium environment (3rd). For creative individual work, both the plants and water wall environments have a modal rating of 1st, and the difference with the number of respondents voting these environments as 2nd is very small. For creative interactive work, this is clear again: the modal rating of the water wall environment is clearly 1st, and the plants environment has a modal rating of 2nd.

---

3 The mode is the value that appears most often in a set of data.
slightly above the number of people voting the plants environments as 1st.

From all these modal ratings, a most voted ranking can be composed for each of the work types. The resulting rankings are presented in Table 3, where the modal ratings which are clear-cut are marked with a shading. It appears that for this ranking the difference between interactive and individual work does not have much influence, while the difference between concentrated and creative work comes out clearly.

```
<table>
<thead>
<tr>
<th></th>
<th>Concentrated Work</th>
<th>Creative Work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Individual</td>
<td>Interactive</td>
</tr>
<tr>
<td>1st</td>
<td>Plants</td>
<td>Plants</td>
</tr>
<tr>
<td>2nd</td>
<td>Typical</td>
<td>Typical</td>
</tr>
<tr>
<td>3rd</td>
<td>Aquarium</td>
<td>Aquarium</td>
</tr>
<tr>
<td>4th</td>
<td>Water wall</td>
<td>Water wall</td>
</tr>
</tbody>
</table>
```

TABLE 3 • Most voted ranking according to work type; shading means strong support

4.3.3 Correlations

To see if the respondents gave the same answers to the four rating questions, subsamples based on the modal ratings from concentrated individual work and creative interactive work are investigated, as well as other subsamples based on much chosen ratings for concentrated individual work and creative interactive work. The investigation of the votes in the categories concentrated interactive work and creative individual work is not necessary, since the correlations under investigation would work both ways. The vote subsamples which are studied are the following:

- All modal ratings for concentrated individual work: those who voted the plant environment 1st, the typical environment 2nd, the aquarium environment 3rd and the water wall environment 4th;

---

4 The method of using the mode could be used the other way around, focusing on ‘modal environments’ for each rating instead of ‘modal ratings’ for each environment. For example: among all 1st place ratings for concentrated individual work, the plant environment is voted the most, and the modal environment for the 1st place is the plant environment. This procedure would give the same results.
• Two second most voted ratings for concentrated individual work: those who voted the typical environment 2nd, and the water wall environment 4th;

• All modal ratings for creative interactive work: those who voted the water wall environment 1st, the plants environment 2nd, the aquarium environment 3rd, and the typical environment 4th;

• The second most voted rating of the plant environment for creative interactive work (2nd).

For all these subsamples, the relative difference in votes from the total sample is calculated, and compared with the average relative difference in votes from the total sample.

For all these subsamples, the same rating for the same environment in the three other work types show the lowest relative difference in votes from the total sample. Still these rating show a significant relative difference. For example, if the subsample of the 3rd place votes for the aquarium environment for concentrated individual work is considered, the relative difference of the 3rd place votes for the aquarium environment for the three other work types vary from 30% to 40%, while the average difference among all votes is 42%. All the subsamples considered show this trend. A stronger correlation between the both creative work types, between the both concentrated work types, the both individual work types or the both interactive work types is not shown.

A specific finding is done on concentrated individual work: all the respondents that rated the water wall environment second, rated the plants environment first.

4.3.4 Factors of influence

The results of a number of demographic subsamples are compared with results of the total sample. The answers on the demographic questions on age, sex, predominant work type, and average work hours a week are used to create these subsamples.
Age
Based on the age, two subsamples are investigated: below average (19–33 years; N=46) and above average (34–66; N=25). The modal ratings of these subsamples do not show any difference with the modal ratings of the total sample as presented in Table 3.

Sex
The votes from the male and female subsamples do not show a consistent significant difference with the votes from the total sample. The modal ratings from the female subsample are different for the typical environment for concentrated individual work (1st instead of 2nd), and for the plants environment for creative interactive work (3rd instead of 2nd), but these are both instances where the total numbers lie close, both in the total sample and in this subsample.

Work type
Based on the question regarding the predominant work type of the respondent, subsamples are created of respondents that predominantly:
- worked indoors (N=69);
- performed office work (N=59);
- performed concentrated office work (N=48);
- performed concentrated individual office work (N=38);
- performed concentrated interactive office work (N=10);
- performed creative office work (N=11);
- worked individually (N=47);
- worked in interaction (N=12).

From all of these subsamples, the modal ratings are the same as those of the total sample. There is one exception to this.

From the subsample of participants who predominantly performed creative office work, the modal ratings on concentrated individual work differ from the same modal ratings of the total sample. These modal ratings on concentrated individual work lie more close to the modal ratings of the total sample on the both creative work types. The effect is not shown on concentrated interactive work.
Work hours
Based on the average number of working hours a week the respondents entered, two subsamples are created: average number of working hours below average (0–24 hours; N=23) and above average (25–60 hours; N=48). The modal ratings in both subsamples are exactly the same as those in the total sample. However, these subsamples show that the results are more clear-cut for the above-average group, and that the number of votes on different ratings for each category lie more close for the below-average group.

4.3.5 Rating motivations
Each of the rating questions was followed by a motivation question (“Why do you prefer the environment you rated 1st?”; discussed in § 4.2.5). This evoked much response; most of the respondents explained...
clearly their motivation for rating a certain environment first. These textual responses are analysed and tagged with keywords. The occurrences of all those keywords is counted on all work types. One explanation could be tagged with more keywords, when more reasons are mentioned; an explanation could also be tagged with no keywords (for example when saying “I like it”). The keywords are clustered in categories. The total number of keyword occurrences are presented in Table 5, split out for the work types. The keyword occurrences can also be filtered according to the different work environments, relative to the total number of 1st place votes for each of the environment. This is presented in Table 6. For a better overview, the least chosen keywords are left out from this table.

<table>
<thead>
<tr>
<th>Tag</th>
<th>Concentrated Individual</th>
<th>Concentrated Interactive</th>
<th>Creative Individual</th>
<th>Creative Interactive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature</td>
<td>14</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>Inspiration</td>
<td>5</td>
<td>6</td>
<td>32</td>
<td>16</td>
<td>59</td>
</tr>
<tr>
<td>Stimulation</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Interesting</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Focus</td>
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<td>2</td>
<td>2</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Dynamic</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>11</td>
<td>30</td>
</tr>
<tr>
<td>Movement</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Restorative</td>
<td>26</td>
<td>11</td>
<td>5</td>
<td>1</td>
<td>43</td>
</tr>
<tr>
<td>No distraction</td>
<td>22</td>
<td>28</td>
<td>9</td>
<td>8</td>
<td>67</td>
</tr>
<tr>
<td>Healthy</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Look</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Sound</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

**TABLE 5** • Motivation keywords used for the different work types

Besides these tagged motivations, some practical reasons were given. Most of these practical reasons mentioned were not intended to have
influence in the survey results—one respondent choose the water wall environment because it offered “a low bench to sit on”; one respondent choose the aquarium environment because in the plants and water wall environment “the whiteboard could not be used”.

Some persons choose the typical (2 times) or the aquarium (1 time) environment because they already could enjoy the nice view from the window. These motivations mention that in the case of a worse view, they would choose the water wall environment or the plant environment.

The top three of most used tags is formed by the keywords *restorative*, *no distraction* and *inspiration*. Motivations are tagged *restorative* when they use concepts like relaxed, quiet, and stress reduce. Motivations which are tagged *no distraction* often use these words literally, or equivalents such as *no jammers*. Also the word *inspiration* and equivalents such as *enhance my creativity or make me create ideas* are used often.

The words *restorative* and *no distraction* are mostly used in the concentrated work contexts; the tag *inspiration* applies to mostly comments in the creative work context.

<table>
<thead>
<tr>
<th></th>
<th>Typical</th>
<th>Plants</th>
<th>Aquarium</th>
<th>Water wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature</td>
<td>0</td>
<td>18</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>0</td>
<td>11</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Inspiration</td>
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<td>Dynamic</td>
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<td>5</td>
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<td>19</td>
</tr>
<tr>
<td>Movement</td>
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<td>0</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Restorative</td>
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<td>21</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>No distraction</td>
<td>70</td>
<td>21</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>Sound</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>83</td>
</tr>
</tbody>
</table>

**TABLE 6** • Motivation keyword occurrences per environment, in % of total number of first ratings for this environment.

The different environments are favoured for different reasons, as can be seen in Table 6. The typical environment is mostly favoured for the absence of distracting elements: a substantial 70 % of those who rated the typical environment 1st, mentioned the absence of distraction as a reason. The most given reasons for preferring the plants environment are
again the absence of distraction (21 %), the restorativeness (21 %), and the associations with nature and inspiration (both 18 %). The aquarium environment preference is explained for the association with inspiration (31 %) and the absence of distraction (28 %). Most respondents that preferred the water wall environment, mentioned the sound (83 %). They motivated their choice for the water wall for the inspiring characteristics (33 %), and the association with a dynamic environment (19 %). The association with sound is also mentioned often in a negative sense, when choosing a different environment than the water wall.

4.3.6 Preference greenblue integration

Preferences
The survey contain one extra question on a specific type of greenblue integration: water treatment through vegetation. The main question asks the respondents to choose between a building where the water treatment system is placed in a separate room, or a building where the system is clearly featured in a public area.

From the total population, 70 % voted for the building where the water treatment is visible. There was little variation in this number among the subsamples, except for the respondents who work less hours a week. Of those respondents, 83 % voted for the building where the water treatment is visible. However, since the number of respondents in this subsample is small (N=23), this observation cannot lead to strong conclusions.
Motivations

A follow-up question asked the respondents to motivate their choice. Possible motivations for the choice are presented with checkboxes, so that more motivations could be checked at the same time. Also the possibility was offered to give an other motivation for the choice. The total number of checks for each of the given motivations is presented in Figure 22.
A minority preferred building A (where the system is hidden). These participants hardly gave more than one reason for this. Therefore, the total number and the differences in the total number of checks for each of the reasons are small. The other reasons given are the following:

A. I want to concentrate on my work.
B. It is distracting.
C. It will probably cost too much maintenance and money.
D. It is difficult to keep the system clean, so it will soon be unattractive.

Reasons A and B are related to the upper statement in Figure 32 (“I do not need to be confronted...”). Reasons C and D are practical issues. So, it seems that the respondents who dislike the featuring of a water treatment system, do this because they think it does not have any positive (or even does have a negative) effect on their work.
More respondents preferred building B, and these persons also gave sometimes multiple reasons for preferring building B (2 or 3). The differences in the total number of checks for each of the reasons are more clear. The other reasons given are the following:

A. It will be a good relaxing environment for breaks.
B. I prefer natural environments.
C. It will give the company a good image by showing their sustainability.
D. I find it interesting and it makes me aware of the environment.
E. It looks good.

Reasons A and B are related to the upper statement in Figure 32 (“I am interested in natural processes...”), where A gives a different characteristic regarding the nature-character. Reasons C and D are respectively related to the two other statements in Figure 32 (“I think it is interesting for visitors” and “I want to be more aware...”). One person added to his answer “as long as it does not smell”, and so including a practical issue. All these motivations and comments are summarized in Figure 23.

<table>
<thead>
<tr>
<th>NOT FEATURING</th>
<th>FEATURING</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Negative or no positive effect on work</td>
<td>• Nature-character</td>
</tr>
<tr>
<td>• Negative associations</td>
<td>• Company image</td>
</tr>
<tr>
<td>• Practical issues</td>
<td>• Environmental awareness</td>
</tr>
</tbody>
</table>

**FIGURE 23** • Summary of motivations for whether or not featuring water treatment

### 4.4 DISCUSSION AND CONCLUSIONS

#### 4.4.1 Main conclusions

From the most voted rankings, presented in Table 3, multiple conclusions can be drawn.

- The addition of plants to a typical environment increase occupants preference of the work environment, disregarding work type.
• A blue workplace is preferred for creative work, but disfavored for concentrated work. This effect is so strong that the water wall environment is rated above the plants environment for creative work; and the water wall environment is rated below the typical environment for concentrated work.

• There seems to be a dose–effect relation regarding the preference of blue workspaces: the preference or disfavoring of the water wall (as a water experience) is stronger than that of the aquarium environment (where water is used as decoration).

When not only looking at the summary values, but having the total overview of results, another conclusion can be drawn. It appears that the water wall environment evokes strong response. Where the modal rating of the water wall is 1st, there is still a considerable number of votes for 4th, and vice versa. This is different from the plant environment: where the modal rating is 1st, the plant environment is hardly voted 4th.

4.4.2 Correlations between work types

Analysis of the subsamples showed that the respondents tend to vote a bit the same among all four work types. This correlation is weak but noticeable, and similar among all four work types. This seems to contradict with the finding that the modal ratings show the same ratings among the both creative work types and the both concentrated work types; this seeming contradiction will be discussed in § 4.4.6.

4.4.3 Creative subsample

The results from the subsample of respondents who predominantly perform creative work deviate from the results from the total sample. These respondents gave for concentrated individual work the same ratings to the different environments as for the creative work types. Possible reasons for this could be:

• The question was the first question in the survey; all respondents might automatically project their own work type on this question since they were not yet confronted with the difference between creative and concentrated work.
• These respondents from the creative subsample had a different type of concentrated work in mind than the other respondents.
• The respondents from the creative subsample consider creativity important in any type of work.

Because the subsample size was small, this effect could not be generalized. It is therefore a finding which invites new research.

4.4.4 Motivations

The analysis of the rating motivations showed that motivations related to the restorative characteristics of the work environments, and the absence of distraction, are mostly used in the context of concentrated work. Rating motivations related to the inspirational characteristics of the work environments are mostly used in the context of creative work. This supports the hypothesis (from § 2.5.4, repeated in § 4.1) that different work types ask for different work environments, for different reasons.

Most of the given motivations also support the theory of biophilia. Not only the environments with nature are rated higher, the respondents also mention that it is because it contains nature, and they assign these natural environments different positive characteristics. The Attention Restoration Theory, described in § 2.3.4, is also supported by findings. A substantial part of the motivations for the plant and water wall environments are related to the restorative characteristics of these environments.

From the suggested mechanisms why blue environments could be preferred higher (see § 3.3.2), the motion (giving a dynamic feel) and sound of the water are mentioned often by respondents. However, these are also the characteristics which could be negatively associated with distraction. The absence of distraction in a clean environment is also mentioned often. This is in line with the rating numbers for the water wall, where both the 1st and the 4th rating are voted much. It seems that the special characteristics of water experience elements in the work-
space, motion and sound, evoke strong response. People either love it or hate it.

Both characteristics which evoke strong response, the motion and the sound, are worthwhile to study further. People have very different expectations from these characteristics. This is in line with what is found at Dilani (2009), stating that the experience of sound is highly individual, depending on volume, predictability and possibilities for control.

The positive value of a non-distractive environment is not found in the earlier quest for bonus factors. It is not completely clear whether these motivations are mentioned referring to the sound and motion qualities of the other work environment. When this is not the case, it seems that this finding can lead to some other bonus factor: minimising the level of distraction from an environment. This could be related to the “comprehensive layout”, mentioned as a possible bonus factor in § 2.5.7.

On the other hand, when these distraction characteristics are referring to sound and motion, it will be interesting to find out in a next study whether the very different expectations of sound and motion from respondents will be met. When confronted in reality with the same sounds and motions, will people indeed respond differently? Or are the different expectations due to different experiences in the past? In that case, it is necessary to be able to finetune specific characteristics of the sound and the motion, in order to find the specific sounds and motion which have positive effect.

The ability of the sound of the water to provide an acoustic background, to mask conversations, is mentioned by one respondent. This is in line with the finding in § 2.5.6 that people do not feel comfortable when they think others can hear them, or when they hear others talk (Hedge, 1982, cited by Gifford, 2011).

4.4.5 Green water treatment system

From the responses to the extra question on the greenblue integration, being a water treatment system can be concluded that most people are positive towards featuring such a system. Still, a considerable part need
to be convinced about the benefits of such a system, when planning to implement this in a building. They need to be assured it will not negatively affect their work, and practical issues need to be solved, or prevented.

These opinions are likely to be affected by past experiences and expectations. Therefore these outcomes could vary significantly among different groups of building users.

4.4.6 Validity

Consistency
The modal ratings show the same ratings among the two creative work types and the two concentrated work types. The fact that the direct correlation inside these two work types is not stronger than the direct correlation between creative and concentrated work types does not contradict to this. It only shows that the respondents who gave these modal ratings, are not the same across the work types. The fact that still the outcomes are clear shows that the sample size has been large enough.

The fact that respondents could give different votes for the work environments across the different work types, combined with the observation that most of the respondents entered a clear motivation, suggest that participants made deliberate choices in the survey. This contributes to the reliability of the results.

The fact that almost all subsamples results are in line with the results from the total sample (both in the environment rating questions and the water treatment question) show again that the sample size of the survey population is large enough to draw conclusions.

Sample
The target group is a sample of office employees who are considered to have significant internet access and experience. Therefore the use of internet for this survey is not expected to lead to a sample bias.
Subjectivity

As already mentioned § 4.1, this study’s approach, identifying user preferences, has its downsides. Preferences can be influenced by personal taste, perceptions and user expectations (as mentioned by Kim & De Dear, 2012b).

The fact that survey results could be influenced by many factors, including respondent’s expectations, means that it is recommended to not just ask for a rating, but to ask why, and to combine quantitative research (such as survey) with qualitative research (such as interviews). The variety of possible influence factors also means that conclusions should be drawn reticently.

Still this does not mean that these preferences, even when being heavily influenced, are unreal. It does mean that everything is taken into account. The preference outcomes from such a survey come close to preferences on work environments in real situations, which are always influenced as well of course, sometimes even irrational. This is the situation a designer or building developer has to deal with; it is useful to identify these preferences.

These preference outcomes are not only mapping the situation a designer has to deal with; in other research it also appears that preferences are related with satisfaction and well-being. It is likely that, when optimising for user preferences, the well-being of users will benefit from this (see § 2.3). This likelihood is even increased when the results are consistent with other research and supported by theory. In this case, the results are in line with anecdotal evidence, the biophilia theory and findings in landscape planning (see Chapter 3).
5 The Blue Designer: Recommendations for Application

5.1 INTRODUCTION

How can water be used as a bonus factor in building design? This question has been investigated in the chapters 3 and 4. It is important to disclose this knowledge to those who can use it: building designers. This chapter aims to search for the relevance and applicability of the research results in the design practice. Indeed, as already stated in the introduction, it is important to bridge the gap between building design and building research.

Recommendations for designers, based on the results of both survey (presented in Chapter 4) and literature review (presented in § 3.3), can be found in the next paragraph.

The same results are presented to design experts. These experts are interviewed to get more insight in the relevance of these results for the design practice. The results of these interviews can be found in § 5.3.

Both sources of recommendations are synthesised in § 5.4. This final paragraph of this chapter aims to give a clear and workable overview of the results that are relevant to building designers who want to employ water as a bonus factor.

5.2 EVIDENCE-BASED RECOMMENDATIONS

Evidence from studies in the field of landscape design shows that water elements are suitable for relaxation and work breaks. The survey on user preferences shows that blue workplaces are preferred for creative work, but disfavoured for concentrated work. This could be directly applied in
office lay-out design. To effectively be able to implement this, it is important to define intended use of the different building spaces.

However, since the responses on the water elements were very strong, it is very important to use these elements very careful in the design. The designer should be sure that the water elements will have positive effects.

From the responses to the motivation question (“Why do you prefer...”) it became clear that the sound is an important issue. Therefore the acoustic properties of spaces and elements should be carefully considered in the design. How the building users will react to sound is a complex phenomena where the effects are not always clear. Therefore it is important to give the building users control (which is one of the bonus factors from Chapter 2); they should be able to regulate their exposure to sound.

From the responses to the extra question in the survey (on the green water treatment system) can be concluded that most people are positive towards new, relatively unknown applications. However, not everyone is positive and convinced at once. These persons should not be ignored, but need to be informed clearly about the implementation of any new building element: higher comprehensibility will lead to higher satisfaction (from the Sense of Coherence theory, see § 2.3.6).

5.3 EXPERT OPINIONS

5.3.1 Method

Three design experts are confronted with the results of the survey, presented in Chapter 4, and asked about their opinions on the applicability and relevance of this research. The interview questions and their full responses can be found in the appendix. The experts are asked about their first response to the results and whether they recognise these from their work, about their opinions on application of the results on the ratings as well as the results on the motivations of the survey respondents,
about their ideas of important practical issues, and if they had suggestions for further research which can be useful for designers.

The responses to these questions are summarised in this paragraph.

5.3.2 Interviewees

The design experts interviewed are Steven Beckers, Max van Huut and Mark Pimlott, all architects with an innovative approach.

Steven Beckers is an architect with a global approach on sustainability in architecture and urban planning. He is an independent registered Cradle to Cradle® architect and consultant and founding partner of Lateral Thinking Factory, supporting and developing multidisciplinary projects with an integrated, circular approach (Lateral Thinking Factory, 2015).

Max van Huut is architect at Alberts & Van Huut. He worked on many different projects, including houses, offices, factories, schools, churches, hospitals and many conversions and renovations. For him, integration of nature and architecture is very important and results in a constant strive for beauty as a means for creating sustainable and ecological architecture (Alberts & Van Huut, 2015).

Mark Pimlott is an artist, architectural designer and teacher. His work in photography, film, installation, interiors and public art attempts to make the specific characteristics of places visible and available to new uses and understandings (Pimlott, 2015).

5.3.3 General reaction to research results

The three design experts reacted differently to the results. Two of the three recognised most of the results from their work. The other design expert was struck by both the high rating for plants, for it was not integrated very well in the overall office interior in the image used, and the high rating for the water environments for creative work, for the sound it produces might be distracting. It was also mentioned that respondents from other climates, such as a Mediterranean climate, might give very different results.
5.3.4 Applicability for architects

**Design process**

It was mentioned that questionnaires are already applied frequently by architects in order to identify client wishes and company work styles. Through the responses of the both design experts, it became clear that client wishes are leading and that this knowledge on bonus factors should also be presented to them. It was also mentioned that a building design process which starts from the deeper motivations (such as inspiration, nature) is possible and desirable in order to get more innovative office design.

**Design applications**

Seen the different responses to water features in the working environment itself, this is not a desirable office design in most situations. Water features could be used in common spaces instead: in that situation, building users could benefit from these bonus factors whenever they want, but also escape from it whenever they want. The use of water features in common spaces is already applied in hotel lobbies or business centers. It creates a special atmosphere and gives a strong feeling of being connected to nature, while the sound is effective for preventing unwanted conversation overhearing and hiding street noises.

When applying water features, it is suggested to use only flowing water. It is also mentioned by the interviewees that it is good to combine water with green (see § 3.2.4 for examples of this).

All possible technical issues with water features, such as leakage prevention and maintenance, could be solved beforehand in the design and should not prevent implementation.

The sound of water features appeared to be a very important characteristic, having much influence on the water feature being liked or disliked (see § 4.4.4). In the interviews it is mentioned that the sound of a water feature can be entirely designed as well: it can vary from a gurgling waterfall to a small trickle on a stone. So the sound characteristics of a water feature can completely be designed according to certain specific preferences.
Communication with client

Water features are not used very much in office buildings since most clients do not want it. They are mostly afraid for complaints related to smell and maintenance issues. These preconceived ideas of clients and developers are preventing innovation. At the same time it is observed that where water features are implemented, people’s reactions are very positive. Studies such as this one are useful for providing the architect arguments to convince the clients.

5.3.5 Suggestions for further research

All design experts gave suggestions for further research, which could be beneficial for architects. They suggested research on:

• the use of water elements to balance the air humidity, possibly in combination with natural materials such as clay\(^5\);
• the possibilities and effects of technologies which give the feeling and idea of water, but not real contact, for example with tubes around the room;
• different possibilities how water could be used for adiabatic cooling indoors, while getting over the legionella problem\(^6\);
• the effects of moving elements in the workspace (either disruptive or inspiring);
• the impact of comfort on creativity and productivity in general;
• the integration of plants and water features in building design, to have it more than just an add-on;
• different ways how integrated gardens might be applied and situated to improve the interior climate the best.

\(^5\) Anecdotic evidence exists for this application, in combination with lava stone (see Technisch Gebouwbeheer, 2013).

\(^6\) This is already explored in studies, for example in a Building Technology graduate project (Wijte, 2012).
5.4 OVERVIEW OF RECOMMENDATIONS

5.4.1 Introduction

In order to give a clear and workable overview of the research results that are relevant to building designers, a list of design guidelines is presented, as well as a list of sources of design inspiration. Both are derived from the research results and insights from the literature review.

The guidelines are made as comprehensible and concrete as possible. They are composed from conclusions on two levels: on the design process, and the design itself. First these conclusions are presented. The guidelines are arranged according to their place in the design process. In order to not disturb the overview, the references to sources elsewhere in this report that support the statements and guidelines are put together in Table 8.

The sources of design inspiration mention examples of building designs which employ water in some beneficial way, and is not necessarily limited to office buildings only.

5.4.2 Conclusions

**DESIGN** • A water feature can have positive psychological effects when it contains flowing water, when it is placed in a common space, and when the sound level is controlled. It can have more benefit when it is combined with green, and with sitting areas.

**DESIGN PROCESS** • A designer can employ water as a bonus factor in office buildings by starting from the client, combining different functions with a water feature in a water system, and investigating its reception among users.

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7 This distinction already came up in § 5.3.4, where interview reactions were on the design process, design applications and the communication with clients.
5.4.3 Design guidelines

1. Start from the client
   Whether water will be effective as a bonus factor will depend on the type of work that is done in the building. Also, client's wishes are leading. This also applies to possible sustainability performance intentions.

2. Make a water inventarisation
   Make an inventarisation of all functions where water is needed in the building. Think of cleaning, restroom and kitchen functions, discharge, drinking, fire suppression and climate control.

3. Design a new water system
   Investigate the possibilities to combine different functional utilisations of water, as well as the possibilities to combine these with extra features such as rainwater harvesting, on-site water treatment, fish tanks, and features for experience such as fountains and water walls. Design a system where these functions are integrated and could be experienced.

4. Design a water feature as part of this system
   A water feature is the part of a water system where it can be experienced by the users. When designing it, the following requirements apply:
   • The water in the feature should be flowing in some way.
   • The water feature should be placed in a common space.
   • The sound created by the water feature should match the building user's preferences or be controllable.
   • The water feature can be enriched by adding green.
   • The possibility to experience the water feature could be provided by planning comfortable sitting areas in the water feature's vicinity.

5. Investigate how it will be received by the users
   When planning to implement something innovative, investigate the preferences and reception of it by the client and building users. A survey can be conducted very easily and gives insight in the particular situation. Moreover, involving clients in such a way will increase acceptation.

6. Develop the design
   In the development of a design, it is important to pay attention to technical details, and to consider management and maintenance.
<table>
<thead>
<tr>
<th>Guidelines and statements</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Start from the client</strong></td>
<td></td>
</tr>
<tr>
<td>Client’s wishes are leading</td>
<td>Interviews (5.3.4)</td>
</tr>
<tr>
<td>Optimal working environment depends on company and work type</td>
<td>Literature review (2.5.3 and 2.5.4) Survey (4.4.1)</td>
</tr>
<tr>
<td><strong>2. Make a water inventarisation</strong></td>
<td></td>
</tr>
<tr>
<td>Water is used for different functions</td>
<td>Description of practice (3.2.2)</td>
</tr>
<tr>
<td><strong>3. Design a new water system</strong></td>
<td></td>
</tr>
<tr>
<td>Different water functions and features should be integrated in one system for better effects</td>
<td>Interviews (5.3.4)</td>
</tr>
<tr>
<td><strong>4. Design a water feature in this system</strong></td>
<td></td>
</tr>
<tr>
<td>People like to be next to a water feature for creative work or breaks; it has a relaxing and inspiring effect</td>
<td>Literature review (3.3.2) Survey (4.4.1) Interviews (5.3.3 and 5.3.4)</td>
</tr>
<tr>
<td>The water should be flowing</td>
<td>Description of practice (3.2.4) Interviews (5.3.4)</td>
</tr>
<tr>
<td>The sound of the water feature is important for the user: it can be both annoying and relaxing</td>
<td>Literature review (2.5.6) Survey (4.4.4) Interviews (5.3.4)</td>
</tr>
<tr>
<td>The bonus effect can be increased by adding green</td>
<td>Literature review (2.5.2, 3.3.2) Description of practice (3.2.4) Interviews (5.3.4)</td>
</tr>
<tr>
<td><strong>5. Investigate how it will be received by users</strong></td>
<td></td>
</tr>
<tr>
<td>Involving users will increase acceptance</td>
<td>Literature review (2.2, 2.5.3)</td>
</tr>
<tr>
<td>Reception can vary; a survey can be conducted easily and gives good insight</td>
<td>Literature review (2.6) Survey (4.4.5)</td>
</tr>
<tr>
<td><strong>6. Develop the design</strong></td>
<td></td>
</tr>
<tr>
<td>Technical details and maintenance issues are important, but always possible to overcome</td>
<td>Interviews (5.3.4)</td>
</tr>
</tbody>
</table>

*TABLE 8 • Design guidelines and references to supporting information*
5.4.4 Design inspiration

A. Waterschapshuis Vallei & Eem, Leusden (NL)
   Experience of rain water harvesting through sloped glazed roof above central atrium

B. Vive Verde EcoCentre, Lake Worth (Florida, USA)
   Living Machine: on-site waste water treatment with plants created as architectonic experience

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Source: www.ibelingsvantilburg.nl/index.php?action=project&project_id=72
Source: www.livingmachines.com/Portfolio/Developments/Vive-Verde-EcoCentre,-Lake-Worth,-FL.aspx
C. **LuFa Farms, Montreal (Canada)**

Building integrated agriculture: greenhouse on top of a building

![Greenhouse on top of a building](image)

D. **Hoofkdantoor ING Bank, Amsterdam (NL)**

Water in flowforms on rooftop gardens; water flowing in rails through staircase

![Water in flowforms on rooftop gardens](image)

E. **Fallingwater, Fayette County (Pennsylvania, USA)**

Indoors connected with outdoor waterfall

![Indoors connected with outdoor waterfall](image)

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10 Source: en.wikipedia.org/wiki/LuFa_Farms

11 Source: albertenvanhuut.nl/architecture-and-interior/office-buildings/ing-headquarters-amsterdam/

12 Source: www.fallingwater.org
F. **Townhall, Hattersheim (Germany)**
Integration of stairs and water stream with the use of flowforms

G. **Willis Building, Ipswich (UK)**
Indoor swimming pool in office building (not in use any more); roof garden
6 Conclusion and Reflection

6.1 SUMMARY OF CONCLUSIONS

6.1.1 The concept of bonus factors

*Bonus factors* are defined in this study as building design factors with positive psychological impact on the occupants. These are called *bonus* since these factors can further increase occupant well-being after *basic* requirements, mostly of physiological nature, are met. Psychological effects are often indirect, but could be strong. The distinction of these bonus factors within all design factors is legitimate since different environmental show different effect on the occupants.

6.1.2 Bonus factors: the results

Six bonus factors are found in the first part of this research, “Beyond Comfort”. These are recognisable as separate factors, but they are inter-related in many ways.

- *Daylight* in buildings clearly has positive effect on occupant well-being. The mechanisms are both psychological and physiological, and important characteristics are the light level as well as the daily variation (for example Thomas et al., 2006).

- An outside view is found to have positive psychological impact on the building users. This often comes with windows, but not always (for example with skylights). Especially a view on nature has positive effect (for example Loftness & Snyder, 2008). It is also observed that occupants compensate a lack of view by decorating their spaces (Heerwagen, 2008).

- There is clear evidence that an office indoor environment with *plants* is more attractive and comfortable for its users. A dose–effect relation is
observed: the more plants, the stronger the effect (for example 
Man- gone, 2014).

• A natural climate which is both adaptive towards the user and connected to the outdoor climate leads to higher satisfaction. Every climate asks for different technical measures. Natural ventilation techniques are often applied. In order to implement this effectively, a good understanding and application of the main climatic principles is required (for example Leaman & Bordass, 2007).

• Such a natural climate involves automatically individual control. Also on other aspects of the indoor environment, such as lighting, lay-out and privacy, the individual control turns out to be a key factor predicting higher satisfaction (for example Lee & Brand, 2005). Users need to manage and comprehend their working environment. This involves responsive design with clear and simple control possibility (Leaman & Bordass, 2001).

• An effective alternation of private and common spaces offers the building users the possibility to go where they want and the control over their environment and level of privacy (Heerwagen, 2008). Common spaces can be used for informal meetings, circulation, creative work or work breaks. Private spaces are useful for concentrated work. Buildings should consist of both, the distinction should be clear (as with individual control), and the connection should be close (Thomas et al., 2006).

6.1.3 Water as a bonus factor

Evidence

A seventh bonus factor can be added to the six found in the literature study. The second part of this research, “The Blue Office”, shows that the use of water elements in common spaces are confirmed to be highly restorative and attractive. This involves drinking sources such as water coolers, greenblue integrations such as aquaponics, places of experience such as fountains and visual decorations such as bubble tubes. For private spaces, where occupants need concentration, water elements can be considered distractive. Sound and motion are important characteristics (see Chapter 4 and White et al., 2010).
**Design recommendations**

A designer can employ water as a bonus factor in office buildings by starting from the client, combining different functions with a water feature in a water system, and investigating its reception among users.

A water feature can have positive psychological effects when it contains flowing water, when it is placed in a common space, and when the sound level is controlled. It can have more benefit when it is combined with green, and with sitting areas (see Chapter 5).

6.1.4 Biophilia and Sense of Coherence: useful concepts

The biophilia theory describes human’s intrinsic fascination for nature, life, and life-like processes. This theory turns out to be helpful to predict bonus factors and understand underlying mechanisms of those bonus factors. Still it does not mean that everything natural is preferred: biophobia is another relevant concept and applicable to natural elements such as lightning and dangerous animals. The use of water in buildings is an example which evokes strong response: people either love it or hate it. The Attention Restoration Theory can be helpful to understand the attractive value of natural elements. Those elements of nature which are considered restorative are preferred and beneficial as well.

Another useful concept from the behavioural sciences is that of the Sense of Coherence. It examines the salutogenic elements: the elements that enhance human’s well-being. People’s SOC is promoted to the regard they perceive their environment as comprehensible, manageable and meaningful. In the design context, this means to ensure personal control, providing restoration opportunities and enhancing social cohesion (Dilani, 2009).

6.1.5 Other potential bonus factors

In this study some complex phenomena are encountered, which have potential to be bonus factors as well. Since effects and mechanisms are not completely clear, application of these factors do not automatically
lead to success. Further research and smart application are needed to guarantee positive psychological effects from these phenomena.

Sound and movement are two characteristics of the water wall which are regarded in the survey responses as having positive effect (inspiring), but also as having negative effect (distracting). This could be generalised to all moving or sounding elements in a building, whether moving or sounding intentionally or as a side effect from another function.

Comprehensiveness of space is an important element, following the Sense of Coherence theory. It is however not entirely clear in what ways a space could be made more comprehensive and so leading to higher psychological well-being. Clear wayfinding will help comprehensiveness anyway (Huisman et al., 2012).

The use of colours is mentioned by several researchers as having effect by evoking different associations (for example Dilani, 2009). However, effects can differ among companies regarding the relation with its image and culture, and can differ between persons.

6.1.6 Research approach

A main conclusion from the literature review on bonus factors (Chapter 2) is that a design approach which is both user-centered and evidence-based will lead to buildings with higher positive impacts on the occupants.

It is not surprising that a research which starts from the perspective of the building user concludes that the user perspective is useful for a design approach as well. Still, this conclusion suggests that this starting point of this research has been valid and adequate. At the same time it suggest that a connection between scientific research and design is effective, and so supports the conclusion on evidence-based design.

It turns out to be important to present credible evidence to designers; not only in order to influence their designs, but also to give them compelling arguments towards clients. This is shown in healthcare design,
but should also be applied in office building design (Bluyssen et al., 2011).

Which scientific knowledge is useful for the design context? Leaman and Bordass (2005) stress the value of real-world research, supported with other information (statistical or theoretical). In these situations, part of the data will be subjectively-obtained. However, these data, when properly used, are not necessarily inferior and in fact could be very useful to get practical insight.

6.2 REFLECTION ON DATA COLLECTION METHODOLOGY

For the original research, a survey, supplemented with interviews, is used. This methodology is chosen in order to come effectively to useful results, within the scope of this study. It turns out to be a method with which a substantial amount of data can be obtained in a relatively short time.

In order to improve the ease of responding, the following measures were taken:

• minimising barriers to response by creating web-based survey, directly accessible;
• starting with an introduction text which explains the goal of the survey and presents what respondents could expect;
• limiting the survey length by minimising number of questions;
• minimising reading time by using images;
• showing progress throughout survey with progress bar on every page;
• using concrete questions (for example the motivation questions).

It turns out that there was much response, and these responses were extensive: respondents seem to have taken the time to give detailed answers to the questions. It is not clear which of the above-mentioned measures are the direct cause of the high response. Evidently the ensemble of these measures shows to be effective.

The use of computer-generated images rather than photographs seems to be effective as well. There were minimal unintended disturbing effects
interfering with the results. Most results were clear-cut and consistent, and respondents showed that they understand the important issues in question in their motivations.

A survey which asks for opinions and perceptions is always limited in validity. It is expected but not certain that perceptions are in line with real effects. Therefore the survey research can use good support from experiments on the effect of different environments. Insights obtained from the survey can be used to design the experiments.

6.3 FURTHER STUDY

Throughout this research, elements have been found which ask for new research because there were still open questions, because the results were remarkable, or because the results needed extra support.

All above-mentioned potential bonus factors (§ 6.1.4) need extra research for conclusive evidence on its effects. The effects of odors on psychological well-being (as part of a multi-sensory environment) is also a topic where much is still unclear.

In the analysis of the survey responses was found that the subsample of people who performed predominantly creative work gave different outcomes (see § 4.4.3). This unexpected effect could be further studied in order to know whether this is a side effect of something else or a real effect by itself; in the latter case possible causes of this effect can be examined. Results of this research could contribute to the knowledge on the relation between different work types and design.

It was also found in the survey that the same elements were valued very differently by different respondents: one persons considers it disturbing, the other considers it inspiring. More research is needed whether these differences are because of different associations and experiences of the respondents, or these differences also appear as real effects. Subsequently a study could be performed on the parameters which influence like or dislike of these elements.
In § 5.3.2, different suggestions from design experts are presented, either on practical applications of water features and indoor gardens and their possible combinations with functional use, or to know more about the real effects on work performance of different design features.

Related to these questions on different perceptions on the same elements are some remaining unclarity on the different ratings of work environments for different work types. The use of the terms disturbing and inspiring suggest that for creative work, external stimuli would have positive effect, while for concentrated work, external stimuli would have negative effect. This could be supporting the theory of the Yerkes–Dodson principle, explained in § 2.3.4. There a difference is made between easier tasks and more demanding tasks regarding optimal stimulation; the optimal level of performance for easier tasks lies at higher levels of stimulation. This suggests that creative thinking would be less demanding than concentrated thinking; a challenging statement. To further study this, this a deeper understanding of brain usage for creative and concentrated work is needed.

6.4 POSITION WITHIN RESEARCH FIELD

This research is oriented around the concept of bonus factors in office buildings. This means that the focus is on positive effects. The use of the term bonus also means that these factors are only relevant after basic factors (requirements in terms of accessibility, safety and comfort) are met. This thesis strongly uses knowledge from the behavioural sciences in order to implement this in the context of building design, and advocates this approach to re-establish the link between building designers and users.

Design elements which are expected or confirmed to be bonus factors in existing research are presented in the first part of this research, “Beyond Comfort”. In the second part, “The Blue Office”, this study introduces the topic of the use of water as a bonus factor within the field of building design. It shows that it is applied by designers in this way, and supports this application with first evidence from original research. Experiments are suggested as follow-up studies on this subject.
Literature


