Psychological attentional restoration through the haptic experience of water's motions

David Lopez-Cotarelo Flemons

Graduation Thesis

Msc Media Technology, Leiden University

Thesis advisors: Maarten H. Lamers and Roland van Dierendonck

August 2019

Abstract

The perception and experience of environments and their features can highly influence the states of mind in humans, therefore appropriately designing urban environments can be a long term effective approach to ease or aid mental strain and fatigue. New approaches need to be taken to improve or redesign the experience of urban environments, as these are often inhabited by productive yet mentally fatigued populations. Experiencing features of natural environments has been demonstrated to induce positive emotions and reduced mental strain, which strongly link to perceived well-being. This study aims to make a call for innovative interventions that accessibly integrate and facilitate the exposure of natural features within urban environments. As such, it investigates the potential for haptic experience of the material motion of water in restoring or improving psychological attention. To research this, moderate attentional fatigue is first induced in participants by their execution of a Stroop task. Subsequently, they experience the motions of water by lying on a floating platform. Alternatively, they experience a control stimulus, lying on firm ground. A Necker cube task objectively assesses their level of attention at different intervals, once after induction of attentional fatigue, and again following exposure to conditioned stimulus. In addition, an EEG sensor measures the level of attention over time during each interval that participants carried out the Necker cube task. Participants filled in a questionnaire providing an indication on their subjective state of restoration following their exposure to the stimulus from each condition. Their affinity with water-based activities was recorded with a final contextual questionnaire. The results were analysed using paired t-tests, and validated using independent samples t-tests. The results show a statistical significant change in the Necker cube task scores, but non-significant in EEG sensed levels of attention. There is evidence in support of an attentional restoration following the haptic experience of water's motions. The results from the restorative state questionnaires have statistical significance, participants perceived a subjective restoration, but it cannot be attributed specifically as attentional. Further studies should increase the amount of time in the induction of attentional fatigue to allow for a more visible and quantifiable effect of restoration.

1. Introduction

In relatively recent years, humans have developed into complex societies where urban infrastructures have been built to accommodate more elaborate lives of increasing need for transportation, commerce, and entertainment. By giving rise to civilisations, a separation from natural environments has been initiated, and subsequently a dominance over it, as civilisations required more space-optimising infrastructures that replaced those offered by natural environments . To this day, this separation and dominance remains very evident, even as cities have attempted to build more parks or green spaces, buildings that are designed to optimise space have noticeably already taken over most of the available spaces within cities, and will continue to do so by building over nature rich environments in cities' outskirts.

1.1 The problem

As the day to day lives of people in these ever-growing complex societies have become more complicated and thus busy, many have began to realise that they are becoming mentally and physically overworked. As such, this phenomenon has manifested itself with unhealthy increases in stress levels, problematic decreases in levels of attention, and worryingly more accounts of unsatisfactory perceptive well-being. As empirically investigated by Okulicz-Kozaryn et al. (2016), urban unhappiness is a fact, where lower levels of happiness in cities' populations can be partially due to the urbanist lifestyle. As it is accommodated by the urban planning and designs of cities that are mostly prioritising the efficiency and profitability of their plans with little regards towards the experience they will provide to the public.

This problem has been identified for a long time now, city councils have been making appropriate decisions to restructure their cities to favour spaces allowing recreation and interaction, such as parks, playgrounds, and squares. However, these long-term approaches haven't solved the problem, as people living in cities usually spend most their time commuting to and being in the spaces that their jobs require them to, which often enough are office type spaces. For this reason, more innovative short-term approaches have been necessary, such as the placing of plants in the work place, break rooms with features promoting co-worker interactions, as well as an access to resting spots providing isolation from the workplace or the heavily commuted city streets.

1.2 Problem approach

To fundamentally address the issue, the source of the problem should be evaluated. What urbanism has changed the most within the spaces in cities is the presence of greenery and natural environments. Therefore, it can be assumed that these spaces might have enabled experiences that contribute to the overall happiness of a city's population. This brings about a new point in the approach to solving the problem, looking for inspiration in the properties and characteristics of natural environments to build, design, and create spaces that can be enjoyed and fit within the urban lives of people. As people living in cities are generally likely to endure cognitive and sensory overload from their hectic lives within busy surroundings, spaces that offer a break for restoration would be very beneficial. The main modalities to experience such spaces tend to be audibility and visuality, however haptic and olfactory experiences can also strongly play a part. Such a prioritisation of the audiovisual is also evident in current research on spaces that enable restoration, as is further substantiated in the papers discussed in section 2.3.1. For this reason, my research in this paper will attempt to investigate the effectiveness or potential of a specific *haptic* characteristic or property of natural environments in being restorative to people living in cities. In the hope that the results will favour and promote the inclusion of haptic impressions simulating those found in natural environments within urban life in cities, by means of artistic, architectural, and design interventions.

2. Scientific literature review

2.1 Stress and attention

There are two theories that have guided research on restorative environments, each interpreting the construct of restoration in its own way. On one side, stress recovery theory (Ulrich, 1983; Ulrich et al., 1991) concerns the restoration from stress that occurs when a person confronts a demanding situation that results in a perceivable effect on his or her well-being. On the other, attention restoration theory (Kaplan, 1995; Kaplan & Kaplan, 1989) defines the restoration from attentional fatigue that takes place following a long involvement in tasks causing mental fatigue. Regardless of their differing perspectives, they are considered as complementary since they put emphasis on different aspects that make up the process of restoration (Joye, 2018).

2.1.1 Stress recovery theory

Roger Ulrich set the foundations for stress recovery theory (SRT), as he stated that an individual's first response towards an environment usually involves a generalised positive or negative affect that happens unconsciously in the processed perception of an environment (Ulrich et al., 1991). In order for positive affective responses to come about, the environment must exhibit certain preferred environmental features, such as presence of nature related content, structural complexity, spatial and depth cues, prospective views, and a feeling of refuge. The unconscious appreciation of such features requires little processing and reduces arousal, which therefore provides the chance for recovery from stress. A more conscious restoration can be achieved when a particular scene in an environment draws enough interest to consciously process its features (Joye, 2018).

2.1.2 Attention restoration theory

In contrast to SRT, ART characterises restoration as a slower process involving specific cognitive mechanisms. This theory was first introduced in 1989 by the Kaplans in their book *The experience of nature* together with another model termed 'preference matrix' that attempted to predict individuals' visual preferences in landscapes (Kaplan & Kaplan, 1989). The widely used ART model argues however, that when a human-environment relationship is defined by the four qualities of extent, being away, fascination, and compatibility, directed attentional fatigue can be countered. An environment enabling these qualities allows for the replenishment of the central executive cognitive mechanism, which has been depleted after being overworked in its function inhibiting or blocking competing stimuli (Joye, 2018).

This model has been based in research of various studies for its applicability to methodologies involving long-term experiential exposure to environments or their particular properties. Most recently and notably, a large scale experimental study involving 125 participants in Rome used ART to compare the restorative potential between natural and built historical environments (Scopelliti et al., 2019). The results favoured the higher restorative potential of natural environments, and outlined the mediative effect between time spent at the environments and the restorative potential

perceived by participants. Another study evaluated the role of emotion in the perception of environments as restorative by exposing participants to text-based primers in order to manipulate their affective states prior to them assessing both natural and urban environments on the four qualities of ART. The results supported natural environments to be more restorative than urban, and the effect (seen as larger for natural) of induced affections was found to be statistically significant on the qualities of 'being away', and most of all 'fascination' as it showed a strong relation between affective-prime and environment (Stevens, 2014).

2.2 Restorative environments and therapeutic landscapes

Restorative environments

The term 'restorative' is a word that is coined within the field of environmental psychology as encompassing the physiological and psychological recovery process experienced when a human is exposed to distinct environmental characteristics. The spaces that contain such particular properties are thus called restorative environments. A significant amount of research experiments have demonstrated that natural environments are much more likely to be more restorative than built or urban environments. This means that built environments can also be restorative, as museums (Kaplan et al. 1993) and monasteries (Oulette et al. 2005) have been shown to be. However, most research on restorative environments has addressed the restorative potential of natural environments, especially in terms of its benefits to mental health and well-being (Pearson et al. 2014).

Therapeutic landscapes

Such environments have also been conceptually termed therapeutic or health landscapes within the field of health geography. This concept addresses the therapeutic features of environments beyond the material, such as the social and affective. Where such "enabling places" are characterised by diverse compositions of actor-networks, which enable and support the development of particular capacities and agencies (Cameron, 2011). The imperative role of agency in the link between landscape and well-being has been thoroughly discussed in research. Landscape can be defined as a cultural product of an on-going co-creative relationship between the cultural and biological agent and the affordances offered by the landscape (Menatti et al., 2016). These affordances are argued to be action-related properties of environments, and thus involve experiences through action-based perspectives (Heft, 2010). Given this, such properties can only be experienced over time and thus contrast the static pictorial dominance of human thinking. This notion has potential for implications in the large body of past research, as it has been narrowly shaped by a static construct of natural aesthetic experience. As such, a novel theoretical framework named "processual landscapes" has emerged in more recent research, aiming for the encompassment of naturalistic aesthetic and cultural experiences that take place over time (Heft, 2010; Menatti et al., 2016).

2.3 Biophilia

Biophilia is the innate biological connection that humans have with nature. It provides an explanation to the fascinations and preferences humans have towards nature's many elements and properties as well as the various phenomena that it exhibits.

2.3.1 Biophilic design

Biophilic design is a subfield and philosophy of design that takes into account the principles of biophilia in order to apply design in the built environment in a way that is reflective of the human-nature relationship. This means that in designing, an attempt to simulate certain characteristics of natural environments that are appreciated by humans can be beneficial to their health and well-being. Currently, applications have been successful in interior design or architecture, where features of biophilic design are directed for the benefit of multiple individuals simultaneously and throughout substantial time. There has been a significant amount of research trying to identify and describe the features of biophilic design, as well has their effectiveness or potential to benefit human health and well-being. One particular research article manages to identify and categorise all biophilic features, as well as providing the current research done on each and suggesting directions for their further research (Browning et. al, 2014). This article proposes 14 patterns (features) of biophilic design which are introduced in the following table.

Table 1: 14 patterns of Biophilic Design: improving health and wellbeing (After Browning et al., 2014; Hayles et al., 2018).

Pillars of Biophilic Design	Design Elements
Nature in the space (direct experiences of nature)	1. Visual Connection with Nature. A view to elements of nature, living systems and natural processes. 2. Non-Visual Connection with Nature. Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes. 3. Non-Rhythmic Sensory Stimuli. Stochastic and ephemeral connections with nature that may be analysed statistically but may not be predicted precisely. 4. Thermal and Airflow Variability. Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments. 5. Presence of Water. A condition that enhances the experience of a place through seeing, hearing or touching water. 6. Dynamic and Diffuse Light. Leverages varying intensities of light and shadow that change over time to create conditions that occur in nature. 7. Connection with Natural Systems. Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem

Pillars of Biophilic Design	Design Elements
Natural Analogues (representations of nature)	8. Biomimicry or Biomorphic Forms and Patterns. Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature. Material Connection with Nature. 9. Materials and elements from nature that, through minimal processing, reflect the local ecology or geology and create a distinct sense of place. 10. Complexity and Order. Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature
Nature of the Space (preferred spatial experiences found in natural settings)	11. Prospect. An unimpeded view over a distance, for surveillance and planning. 12. Refuge. A place for withdrawal from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead. 13. Mystery. The promise of more information, achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment. 14. Risk/Peril. An identifiable threat coupled with a reliable safeguard.

These patterns as described in the research article provide a phenomenological overview on how these patterns are perceived and experienced by humans and how they could benefit their psychophysiological and cognitive relationships with built environments. Considering the direction of my research concerning haptic patterns or features that can be found in natural environments, the identified patterns of non-visual connection with nature, and thermal & airflow variability, specifically address the haptic properties that can be experienced in nature.

2.3.2 Restorative biophilic interventions in environmental design

Biophilic design has been investigated and promoted in its effectiveness to counteract adverse effects of urban life within the built environment on psychological and physiological well-being. Studies have discussed countless proposals for the inclusion of natural contents and features in the structural landscape of urban environments. An abundance of practical applications have been proposed in the form of artefacts and architectural structures that imitate nature's elements (biomimicry) and fractal geometries (Joye, 2007).

Study identifying biophilic restorative features

Certain studies have taken a step further in attempting to investigate the specific properties of natural environments that enable restoration in order to translate their findings into applications such as the designing of urban green space. A particular study proposes a method for the identification of an environment's specific physical attributes that are most effective in influencing the extent of preference and restoration. These attributes stem from a combination of research on aesthetics theories, aesthetically based and mathematical principles of design, and empirical research on the potential for specific environmental physical attributes to enable preference or restoration. This results in a methodological list comprised of metrics and functional definitions for the quantification of content, structure, and landscape attributes (Hunter et al., 2015). By allowing guidance on follow up insights on such metrics, behavioural responsive architecture and urban planning can be better fitted to facilitate biophilic living (Fischl, 2016).

Biophilic interactive installations
Other observational theses studies have focused on evaluating the engagement potential of interactive immersive installations that exhibit features from biophilic design in comparison to those who do not (Lanktree, 2010). Where those exhibiting biophilic features were engaged with for longer by overall participants, however the observations also indicated that age of participants was a factor influencing engagement time, as older interacted for longer and younger for shorter amounts.

Biophilic restoration in workplaces
Furthermore, studies have also addressed the well-being effects brought about by accessibility to green spaces in working environments both indoors and outdoors. One study investigated this qualitatively by use of 'go-along' interviews with employees during their outdoor breaks (Colley et al., 2016). The positive experiences reported from these interviews demonstrated how accessibility to green spaces during breaks enabled significant levels of restoration. These reports revealed the physical embodied experiences common to most employees that brought about feelings of 'being away', refreshment, reflection and fascination. As such landscape planners and companies of work buildings should preserve and provide surrounding 'wildscape' environments for the long-term benefit of its employees and its productivity.

Biophilic urban interventions
More innovative forms of 'urban greenery', have also been emerging in the form of community led garden plantations, where restoration can take place socially and culturally (Seana et al., 1999). In more densely populated cities such gardens are commonly located on building's rooftops. Other space efficient ideas have been envisioned and put into practice such as greenroofs for urban transport vehicles (Phytokinetic). Given such approaches that focus more on creating availability and thus higher quantity of urban green spaces, studies have shown that residential satisfaction and positive responses to these spaces have been linked to their overall quantity. Thus, being independent to their ecological quality or at least secondary for purposeful restoration (Berg et al., 2007). Similarly, urban spaces with a presence of water such as fountains, ponds, and canals have also been widely accommodated in cities, which also provide their inhabitants with chances for restoration.

2.4 Health, well-being, and natural environments

Domains involving well-being and health
Psychological and physiological effects of human exposure and contact with the most effective restorative environments characterised as natural and truly biophilic have been widely researched in many different possible ways. Some studies have proposed research agendas for the identification of domains where further research efforts concerning nature contact and human health that are of relevance within these domains have the potential to provide specific as well as general evidential insights that can be applied with impactful interventions benefiting public health. One study identified the potential domains of implementation and exposure science, epidemiology of health benefits, diversity and equity considerations, technological nature, economic and policy studies, and mechanistic biomedical studies (Frumkin et al., 2017).

Well-being measures and methods

Nevertheless, the impact of nature contact on human mental health remains the most investigated and is of most relevance to the scope of this study. Regarding the different elements or components that make up the construct of mental health, studies have focused on studying the effects of human interaction with natural environments on individual components of interest, as well as the more general equivalent, well-being. In many studies physiological measures are taken before and after stimuli imposition on participants, and assumptive conclusions are drawn on the psychological effects of these. In some cases, however, these conclusions are further supported by psychological measures of a more qualitative nature, or they are based solely on these. The most common physiological measures are heart rate and heart rate variability, galvanic skin conductance is a slightly less common measure, but useful nonetheless. Measuring cortisol levels in saliva is the least employed because it can only be used to draw conclusions regarding long-term psychological stress levels, and unfortunately most studies are interested in short-term measures following stimuli imposition.

Instoration benefits

It seems to be the norm for studies to assume that restorative benefits can only source from a depletion in the components of mental health. Indeed insightful significant results are probably easier to attain in such cases. This provides and explanation to the common methodological use of stressors to induce stress, arithmetic tasks to deplete directed attention, or priming techniques to influence affective states. Qualitative studies are less likely to assume this and make use of such methods. One particular study, however, compared the beneficial effects of nature using such methods to their non-use. The results showed that beneficial effects occur regardless of depletion, and that these come in the form of 'instorative' instead of 'restorative' as they improve self-regulatory capacities that are essential to impulse control and consequently mood regulation (Beute et al., 2014).

Qualitative components of well-being

Research studying the mental health effects of nature exposure qualitatively have made use of experience based interviews and questionnaires on participants to assess the extent of effect on the subjective measures of perceived well-being and emotional connection (Bell et al., 2015), happiness and nature connectedness (Capaldi et al., 2014), creativity (Williams et al., 2018), and symbolic-meaningful and emotional connection (Lengen 2015). Although the extent of effect is very often positive, it must be noted that some studies have also shown how demographic and socio-demographic factors in participants can influence this extent, in some cases even negatively. Personality (Capaldi et al., 2014), gender and health (Thomas, 2015) and relationship and household status (Carrus et al., 2017) are some of the factors that have been demonstrated to be deterministic of extent.

2.5 Haptic experiences

The current body of research done on restorative environments of which those comprised of natural content are most investigated, have been, in large part, narrowly concerned on the beneficial health effects that are accrued through the visual sense. A relatively limited amount of studies have involved the aural sense as a focused type of stimuli, and an even smaller amount have involved the other senses of taste, smell, and touch. Since the experience of restorative environments is in essence multi-sensory, some studies have proposed that further research requires approaches that involve the holistic congruency of all senses, or that as first step down that avenue, the disregarded modalities be exclusively explored (Sona, 2018). In effect, one recent study on the benefits of nature experiences outlined and reviewed current literature addressing each of the senses through which nature benefits are delivered (Franco et al., 2017). The review provided a useful overview of current gaps in the research of natural restorative environments. As such, following the large amount of literature that has been explored for the purpose of establishing a direction in this paper's research, a choice to investigate the mental health effects delivered through haptic experience has been formed.

Somatic experience
To begin the understanding of what physically constitutes the human haptic experiencing of self body and its surrounding environments, the following paper has been considered. This paper offers a good overview and introduction to the haptic system and its components (kinaesthesia, proprioception, vestibular system) that is present in all bodies and is responsible for creating the feeling of embodiment (Paterson, 2009). Where kinaesthetic component provides for the sense of the body's movement, proprioception gives the feeling of muscular position, and the vestibular system allows for a sense of balance. The haptic system as a whole gets information about the body and the environment and their interrelated interactions. Furthermore, the paper emphasises the importance of sensory-somatic experience in the congruent link between other types of senses, and how such experiences constitute what is termed as 'haptic knowledges' that are learnt in sensory harmonisation to make up the true embodied experience and resulting knowledge of an environment. Somatic experience through the human skin and body can be broken up into different 'haptic sensibilities' that are in charge of spatial perception (O'Neill, 2001). These sensibilities involve sensing movement, either of one's own body, of surrounding entity, or interdependent movements between body and entity. Other sensibilities involve textural or thermal sensing that take place through the skin, as these are sensed simultaneously and holistically with one another, they can also nevertheless be sensed in conjunction with sensed movements.

2.5.1 Therapeutic biophilic haptic experiences

With the variety of combinations of haptic sensibilities that humans can corporeally experience their surrounding environments, those composed of biophilic content, and thus ultimately natural spaces, are the most capable and likely to afford the engagement of a significant amount of these sensibilities and their combinations. This usually results in an embodied process of perception leading to a processual experience over time of the natural environment, in which the variety of affordances in such environments bring about conscious and unconscious agency linking therapeutic variations of well-being to the experience (Menatti et al., 2016).

One example of how such sensibilities result from natural environmental affordances is explored in the following phenomenological paper. The paper addresses the haptic experience of nudity at the

beach as an exploration of how it feels to be nude and how nudity is experienced in such natural environment (Obrador, Pau., 2007). It argues how nudity at the beach or even semi-nudity is an extremely common deliberate action towards experiencing the environment through even more haptic means as compared to wearing clothing, as the whole body is allowed to intake the haptic qualities of the environment.

Focusing on haptic experiences that are conveyed through natural environments characterised by highly biophilic content, studies have examined their potential to instil well-being, affect mood, reduce blood pressure, and influence arousal. A particular study further explores the haptic experience of the human body with regards to the therapeutic experience of scuba diving (Straughan, 2012). The paper positions its research within the conceptual context of embodiment, addressing corporeality when engaging with the diving environment. The paper argues for the importance of an embodied engagement with environments that are considered restorative for their ability to instil a sense of well-being. Although its findings are phenomenological in nature, it provided a first indication towards the link between the achievement of higher levels of perceived restoration and consequent increases in well-being and the embodiment in natural environments through haptic sensing. Thus, it could be supporting the idea that to achieve higher levels of restoration (as possible when exposed to natural environments) the haptic sense plays an important role as it fully connects and further immerses the human to the environment; fundamentally acting as an essential complement to sensed audiovisuals.

Other studies have focused on investigating the health benefits gained through natural textured touch sensibilities. The most researched being animal therapy, where studies have shown that petting animals regardless of the individual's attitudes towards them can result in lower blood pressure and heart rate, lower stress by evidence of decreases in salivary cortisol, and low regulation of anxiety and arousal (Franco et al., 2017). Interestingly, petting soft toys were found to be considerably ineffective to match such beneficial results, which suggests that these benefits cannot be uniquely attributed to the act of petting, and as such also proposes that biophilic tendencies exist through haptic sensing. Alternative studies have investigated the therapeutic role of different natural textures thanks to their capacity to incite such biophilic haptics. One study explored the potential for textured ground terrain to enable somatic and emotional experiences that can promote regular exercise and physiological health (Brown, 2017). Another two studies researched health benefits of touch based contact with plants and their foliage. Where results demonstrated significant physiological benefits interpreted psychologically as calming and relaxing (Yamane et al, 2003; Koga et al., 2013).

2.5.2 Therapeutic and restorative blue space

Blue space is a term used in the field of urban design to classify spaces that exhibit visible water, such as fountains or ponds in squares or parks, or canals and harbours. As research on restorative natural environments has predominantly addressed green spaces, relatively limited amount of studies have been surfacing during the past decade with the intention to investigate the specific factors constituting the relationship between water or blue space and human health. A study in 2011 reviewed current literature relating to this knowledge gap and proposed a concept matrix to identify the well-being benefits of blue space. The matrix can also be applied to other types of restorative spaces. The review concluded by stating the lack of studies that have been carried out researching emotional and experiential responses to blue space (Völker et al., 2011).

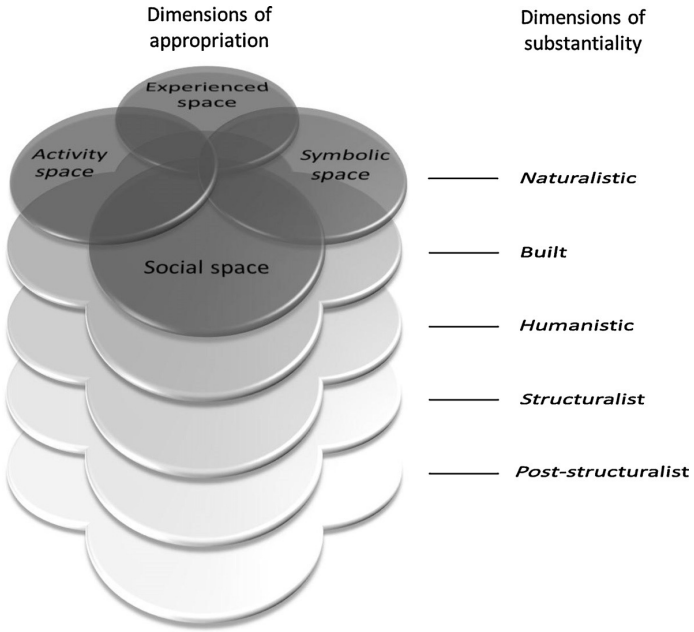

Figure 1: Concept matrix for classification of well-being benefits of restorative spaces (taken from Völker et al., 2011)

A study done a year later identified the restorative qualities of blue space within urban environments through observational and preferential studies. The observational study helped identify the characteristics of public spaces with presence of water that were most appreciated and experienced by people. The preferential study aimed at identifying the degree of preference for such features, by showing participants images of urban blue spaces, which mentally placed them in those spaces to rate subjective well-being. Some of the more relevant qualities assumed to favour restoration that were identified were: area of water coverage, water quality and reflectivity, water movement, and water physical and visual accessibility (Pradhan, 2012). These qualities can be considered biophilic since they are likely to be associated as evolutionary.

Out of the little research done on restorative blue spaces, most have addressed the benefits that are achieved through the visual modality. Fortunately, two very recent studies explored the therapeutic meaning of blue spaces and the emotional responses that are channeled through their embodied experience (Foley, 2017; Doughty, 2018). They argue how psychophysiological well-being is attained as a result of a variety of possible emotional connections that humans can have with water. These connections are best established by physical experience, and most effectively complimented by the experience of the water's materiality. In such a case, swimming provides the full embodiment of its materiality since it enables a balance between psychological and physiological therapeutic benefits. Such statement is evidenced by the longstanding affinity most humans have with the activity of swimming.

2.6 Outcome of scientific literature review

Resulting from the structured literature review and process to discover an unexplored avenue for further research within the field of restorative environments, one has been identified. In this paper, the beneficial effects to human well-being of the embodied experience of water will be investigated. This will be done by exclusively researching the psychological effects of the reciprocal corporeal experience of water's movements.

3. Research framework

To study the possible psychological effects resulting from the haptic experience of water's motions, a research framework needs to be established that can allow a demonstrable change in the measure of a specific psychological state. A psychological state commonly investigated in past research of restorative environments is directed attentional fatigue, a state that ensues from a prolonged use of directed attention. The choice to focus this study on a change on such mental state is based on the strong relevance that attentional capacity has within the process of human-environmental restoration. As outlined by attention restoration theory (ART), directed attentional fatigue is strongly affected by qualities of the human-environmental relationship. As such, following this focus gives purpose to this study within the real-world, where the human-environmental relationship has often been ignored and disrespected.

3.1 Experimental setting and conditions

In order to assess a change in capacity for directed attention participants need to be exposed to a control stimulus as well as the stimulus hypothesised as restorative. In search for results with the most real-world applicability, the experimental research takes place outside of a lab setting, where other non-studied features of real-world environments are inclusive to the experience of the studied feature, yet taken into consideration and controlled if necessary. To expose participants to the motions of water the use of platforms that float on water canals were found most suitable, as they allow plenty of space to deploy the experimental setup as well as contain the whole body of each participant. In addition, the use of such platforms proved to be most convenient as it allows for the experiment to take place in a variety of locations, therefore not being bound to a specific location enabled a greater reach for more participants. Exposing participants to a control stimulus would take place close to the floating platform, on a piece of firm and leveled ground, as this provides the greatest haptic contrast to a floating platform that moves to the motions of water.

3.2 Attentional fatigue induction

In order to measure a restorative change in capacity for directed attention some degree of attentional fatigue must be induced in each participant prior to exposure of the stimuli of each condition. This allows for a change to become more measurable, visible, as well as processable. There are common attention-demanding tasks used to induce attentional fatigue, such as arithmetic tasks and classification tasks. To increase the effectiveness of attentional fatigue induction, the tasks must be as repetitive, monotonous, and time consuming as possible, as this creates more of a chance for the participants to feel bored and thus require increasing efforts in maintaining a level of attention and capacity that will gradually deplete itself over time.

3.3 Attentional performance tasks

To measure changes in mental vitality, the capacity to voluntarily direct attention, there are a series of cognitive performance tasks that have been widely used in environmental psychology research that attempt to objectively quantify this mental capacity. These are the Necker cube task (Hartig et al. 2003), the free recall or backward digit span task (Cowan et al. 2001), the symbol digit modalities task (Tennessen et al. 1995), and the Stroop effect task (De Young, 2016). Each one of these tasks depletes attentional capacity by imposition of repetitive tasks requiring constant voluntary attention. For this study, one of these tasks will be employed to quantify the level of attentional capacity present in participants at specific intervals throughout the experiment.

3.4 Physiological measures

In addition, physiological measures have also been widely used to quantify and draw conclusions on changes in mental states. Measures in changes of heart rate and variability, blood pressure, salivary or sweat based cortisol levels, and galvanic skin conductance have been shown to indicate changes in stress levels. However, the focus of this study is on the more specific concept of attentional fatigue, which can also be linked to stress as it can result from stressful situations. But it more commonly ensues from non-stressful situations that can take place often throughout an individual's day. In the search of an additional measure that can specifically quantify levels of attention throughout time, EEG sensing was deemed most suitable. Electroencephalography provides a way to non-invasively measure electrical brainwave activity from which observations on levels of attention can be drawn most notably by the analysis of beta bandwidth waveform signals that are measured amongst other signals differing in bandwidth ("Beta Waves", ScienceDirect). As an increased activity in such beta waves are an indication of active thinking and focus, level of attention can be inferred from such signals.

3.5 Self-reporting and contextual questionnaires

Measuring levels of attention through physiological and psychological measures allows for the most objective observations, however, issues can arise in the collections of such data as validity can always be questioned if certain variables are unable to be controlled. In addition, it is often the case that such measures require a considerable range in the data collected from which observations and statistically significant conclusions can be made. For this reason, including a self-reporting questionnaire within the experimental method is an added subjective measure that can prove to be meaningful in the case that the other measures fail to be so. There are a variety of self-reporting surveys and questionnaires used in previous studies that attempt to qualify the levels of perceived restoration experienced by participants following exposure to environmental qualities. Each questionnaire addresses the qualification of different psychological states, beliefs, and preferences that participants have at a moment in time towards their experienced environment.
These are, for example, the Zuckerman Inventory of Personal Reactions (ZIPERS) (Zuckerman, 1977), the Perceived Restorativeness Scale (Hartig et al., 1991), the Restorative Components Scale (Laumann et al., 2001), the Perceived Restorative Characteristics Questionnaire (Pals et al., 2009), and the Restorative State Scale (Berg et al., 2014). The more recent questionnaires are often based or inspired on the older ones, as the older ones were developed to generally fit the assessment of most environments, the recent ones assessed the perceived restorative characteristics or affective states of involved in the experience of more specific environments, such as with the PRCQ that was made to assess zoo attractions.

Participants should also be asked to fill in a contextual questionnaire after ending the experiment in order to avoid making them biased, considering that the questionnaire can give away the purpose or objective of the study. The contextual information most relevant for collection is each participant's affinity and level of engagement with water activities such as swimming, sailing, boating, or other water sports. As the level of affinity, or lack thereof, is an important uncontrolled variable that can affect the results of both quantitative and qualitative measures. Being aware of this affinity will help explain why certain results from participants could oppose the hypothesis of this research.
Furthermore, another relevant uncontrolled variable is the level of attentional capacity already present in each participant prior to beginning the experiment. Knowing if participants already have a lowered attentional capacity could help determine whether the results are affected by it. This will be assessed with three questions asking if there was any engagement in a previous attention demanding task as well as its duration and extent.

3.6 Research questions and hypotheses

Given the outlined research framework of this study, the research scope can be formulated into a research question and subquestion, as well as hypotheses.

- Research question: Can the haptic and corporeal experience of water's motions through a floating platform be more effective at restoring attentional fatigue than the experience of being on firm ground?
- Hypothesis: Experiencing water's motions will prove to be to a small degree more effective at restoring attentional fatigue than experiencing no motions on firm ground.
- Subquestion: Does the experience of water's motions through a floating platform promote attentional restoration?
- Hypothesis: The experience of water's motions will promote attentional restoration

4. Methods

With a research framework in mind, an experiment method is developed in order to test the aforementioned hypotheses. The following section will describe the details of the experimental setup. The devised experiment procedure will be outlined and specified, the participant recruitment method will be explained, and the chosen measures as well as the relevant equipment will be stated and justified.

4.1 Experiment procedure

The general experiment design will involve a within subject cross-over randomised design.
In devising an experimental procedure to assess changes in attentional capacity following a stimulus the following order of tasks must be carried out for each condition. First, the induction of attentional fatigue through a prolonged attention-demanding task. Then, to measure the level of fatigue induced an attention performance task is completed while simultaneously recording EEG data throughout. The exposure to the stimulus of the condition follows, as well as another attention performance task coupled with EEG recording as a final measure to determine the level of attentional restoration. To finalise the procedure of the condition, the self-reported questionnaire is filled in. The following table provides a detailed overview of the entire experiment procedure as carried out by experimenter and participant. Note that the 3 minute duration of attentional fatigue induction with the Stroop task was matched to the duration of the participant's exposure to the conditioned stimulus.

Step Nº	Experiment steps	Participant location	Senses deprived	Duration (seconds)	Imperative step details
1	Handing over smartphone and pocket contents	Firm ground	None	30	Make sure their valuables are safe, to be kept by experimenter at all times
2	Briefing of experiment's tasks	Firm ground	None	60	Tasks are explained, Stroop task should be carried out as fast as possible, necker task should involve the participant to actively hold the perspective of the cube from shifting

3	Stroop task	Firm ground	Hearing	180	Hand over noise cancelling muffs to deprive of hearing. Hand over tablet with task, remind to do the task as fast as possible!
4	Necker cube task	Firm ground	None	60	Place EEG device on head! To be done quickly after Stroop task! Instruct to click a pen each time perspective shifts. Count and record each click! Time the 30 seconds of each one task session
5	Exposure to control / stimuli	Firm ground / floating platform	Hearing and Sight	180	Instruct to lay down legs stretched in location relevant to condition. Sight is deprived with a sleeping mask, and hearing with noise cancelling muffs. Time 3 minutes, tap on shoulder when time is up!
6	Necker cube task	Firm ground / floating platform	None	60	Place EEG divice on head! Quickly hand over the necker task, time 30 seconds for each task session! Count and record pen clicks
7	Self reported restorative state questionnaire	Firm ground / floating platform	None	60	Hand over tablet where questionnaire can be filled in
8	Pause between change of experiment conditions	Firm ground	None	300	Instruct participant to walk around a bit and sit down to reorientate the mind
9	Stroop task	Firm ground	Hearing	180	Hand over noise cancelling muffs to deprive of hearing. Hand over tablet with task, remind to do the task as fast as possible!
10	Necker cube task	Firm ground	None	60	Place EEG divice on head! To be done quickly after Stroop task! Instruct to click a pen each time perspective shifts. Count and record each click! Time the 30 seconds of each one task session
11	Exposure to control / stimuli	Firm ground / floating platform	Hearing and Sight	180	Instruct to lay down legs stretched in location relevant to condition. Sight is deprived with a sleeping mask, and hearing with noise cancelling muffs Time 3 minutes, tap on shoulder when time is up!
12	Necker cube task	Firm ground / floating platform	None	60	Place EEG device on head! Quickly hand over the necker task, time 30 seconds for each task session! Count and record pen clicks
13	Self reported restorative state questionnaire	Firm ground / floating platform	None	60	Hand over tablet where questionnaire can be filled in
14	Demographic and contextual questionnaire	Firm ground / floating platform	None	60	Switch tab on tablet for participant to fill in contextual questionnaire

The total time required for a single participant to complete the entire experiment is 1530 seconds/ 25.5. minutes.

The duration of the experiment is announced to participants as taking 30 minutes to account for discrepancies. In order to consider for the different degrees of motion that the water platform exerts on participants, a smartphone running an accelerometer app that records acceleration over time is placed on the platform next to the laying participant during the 3 minutes of exposure. Randomisation for the eradication of order effects is done by means of alternating the starting condition in each succession between participants. Recording of EEG data must be done simultaneously as participants execute the attention performance task. For participants to experience the aimed stimulus of each condition, they had to wear a sleeping mask depriving of sight, and noise cancelling muffs to deprive of hearing, to emphasise the haptic sensation of the stimuli.

Figure 2 and 3: Photo of participants laying down experiencing the stimuli of each condition (firm ground/floating platform) while being deprived of hearing and sight.

4.2 Method of participant recruitment

There is no specific target group of participants for this experiment, the study aims to apply the research question to the general public, however it is likely that most participants are students between 20 and 30 years old as they are found and approached through my personal network. For the recruitment of participants two online spreadsheets, one for each location (Enschede and The Hague) were created for potential participants to include their names within time slots of 30 minutes. The spreadsheets were shared through communicative social media channels, such as a University of Twente bachelor program Facebook group composed of 600 members, and two WhatsApp groups of roughly 30 and 40 students of the Media Technology program. Unfortunately, given the time consuming nature of this experiment and the site specific location required to carry it out, the sharing of spreadsheets in search of voluntary participants was not successful. Instead, close friends and acquaintances volunteered by means of messaging as they became aware of my research through those means.

4.3 The Stroop task

The chosen attention demanding task to induce attentional fatigue is the famous Stroop task. This task requires participants to make use of their directed attention for as long as the task lasts. A level of directed attention must be sustained as the task requires that the participant indicates which colour is seen but not read. The task displays words naming colours, but the font colour of those words can be in a different colour than the colour that is read. Thus, given that the human brain can

generally read and process words faster than it can process a perceived colour, the participant is tasked to inhibit the faster response and direct attention towards the observed colour. The choice for this task is based on its repetitive nature, as well as its ease of explanation and execution favouring the experiment duration which can be time demanding for participants. It has been widely used in past psychological research experiments. The execution of this task was done using a tactile input tablet, whereby participants pressed the letter on the keyboard corresponding to the first letter of the colour perceived.

4.4 The Necker Cube Pattern Control task

As the main measure of this study, the Necker Cube task was chosen to serve as a measure of participant's attention performance at given intervals throughout the experiment. This task, while also immune to practice effects (Jaggard, 2014), was chosen for its simplicity, reliability, and validity as it has been widely used as measure of attention in many previous studies within the field of environmental psychology and restorative environments. This measure, although proven valid by its wide use, is not fully objective since it is still a self-reported task. There is an uncertainty that participants forget to click the pen when perceiving a reversal or choose not to. The task essentially measures the capacity to inhibit perspective reversals in a wireframe cube pattern. As such, the lower the capacity to inhibit these reversals the more indication there is of a lowered capacity for directed attention. In the execution of such task, participants are handed over a book cover on which a wireframe cube is drawn. They are asked to actively attempt to control and avoid the reversal of the pattern, and when they notice a reversal, to click a pen for the experimenter to record the count of reversals. Participants carry out this task twice shortly following one another for 30 seconds each, then the average count is calculated between the two counts.

4.5 EEG sensing

The addition of a physiological measure within the method of this research was aimed to complement the measure of participant's attention performance, as the measurements were carried out simultaneously. EEG data is recorded over time using the NeuroSky's Mindwave Mobile2 Headset, which records an algorithmically calculated measure of attention that is based on the sensed brainwaves of different bandwidths, but most notably the beta bandwidth as this frequency is associated with higher levels of focus and directed attention. This "Attention meter" displays the level of attention over time with a score between 0 and 100. The baseline level of attention is within the score of 50-60, therefore scores above this range would be indicative of increased levels of attention. As a complementary measure while participants execute the Necker cube pattern control task, it attempts to provide an even more objective measure of the level of attentional capacity present in participants at given intervals. To record and display the measured EEG data an application called NeuroExperimenter was used on a laptop with Windows 10 OS. The measurement process begins by placing the EEG headset on the participant's head, fitting the front sensor above the left eyebrow making sure it is pressing lightly against the forehead, as well as placing the clip on the left earlobe to create a ground connection for noise reduction. The headset, being already bluetooth paired to the laptop, is activated/deactivated for measurement and recording by pressing the connect/disconnect button on the application. Each time a new measurement needs to be recorded, a new file name and path needs to be declared within the settings window, otherwise the application overwrites the earlier recorded measure.

4.6 Restorative State Scale and contextual questionnaire

A self-reported questionnaire was chosen to evaluate the level of perceived restoration participants experience following the stimulus exposure of each condition. The Restorative State Scale questionnaire (Agnes, 2014) was chosen amongst the others for its usability to measure participant changes in restorative state over time, being suitable to compare the restorative states following the two compared conditions of this study. As other self-reported questionnaires focused on short-term evaluations of environments and their perceived restorative characteristics. Even though this questionnaire was the most recent to be developed, and thus has not been fully validated by its use in many other studies, its development was inspired by Kaplan & Kaplan's (founders of attention restoration theory) definitions of the different deepening and interrelating levels of the restorative nature experience. This questionnaire contained statements descriptive of states of mind such as 'my mind is not invaded by stressful thoughts' that participants rated from disagree to agree on a 5-point Likert scale (Appendix C).
Upon ending the experiment, a contextual questionnaire was filled in by each participant. This questionnaire asked for standard demographic data such as age and gender, as well as six other questions structured as multiple choice and 5-point Likert scale to gather context on the level of affinity and frequency that participants have with water based interactions, as well as their engagement and extent in any attention demanding activity 2 hours prior to beginning the experiment (Appendix D). Both questionnaires were filled in by participants using a provided tactile tablet.

5. Results

The conduction of the experiment took place at different locations in order to reach a substantial amount of voluntary participants. The experimental setup required the use of a floating platform as this is the main medium for the stimuli that is investigated. Therefore, the choice was bound to locations that had floating platforms that could be used in occasion without the interference of other people walking or sitting on it. The main locations chosen were rowing clubs in the cities of Enschede and The Hague, these had floating platforms with enough space and sufficient noticeable movement from the water. Some participants took part in the research at other locations, these were in Utrecht and Amsterdam, using floating platforms that floating houses and boathouses used for docking and transit.

These various sessions conducting the research experiment yielded 30 participants (n=30). Nearly all measures were completely and correctly collected, with the exception of the EEG data recordings. With 8 participants, the data recorded by the application that was logged into a file got overwritten by the experimenters accidental reconnection with the EEG sensing headset. This human error in the collection of data caused either one or two of the EEG recordings to be lost in each of those participants. The cause of such error, apart from human error, was very likely to be in the high temperature and low screen visibility of the laptop used, as was caused by its prolonged exposure to the sun in the locations that provided few spots in the shade. For the prevention of such human error the experimenter made sure to deploy the experimental setup in areas of shade whenever possible. To prevent the overwriting of logged files, the experimenter also, following a logging of data, made sure to immediately declare a new name and file path within the settings window of the recording application.

5.1 Variable validation

Given this study is carried out as within subject design, the beginning condition is changed in the sequencing of participants to avoid possible order effects. To compare whether the order of beginning condition has any significant effect on the results an independent t-test is done on each variable grouped by starting condition. The tests show no significant effects caused by the order as shown in table 1.

Table 1: Independent samples t-tests with stimuli order as grouping variable

Variables	P-value	DF
C_RESTOR (n=30)	0.077	28
X_RESTOR (n=30)	0.116	28
C_EEG_AVG_RES (n=22)	0.027	20
C_EEG_SD_RES (n=22)	0.141	20
X_EEG_AVG_RES (n=23)	0.351	21
X_EEG_SD_RES (n=23)	0.188	21
C_RSS_AVG (n=18)	0.069	16
X_RSS_AVG (n=18)	0.144	16

The variable C_RESTOR indicates the restoration score (post condition score - pre condition score) from executions of the Necker cube task in the control condition. The X_RESTOR also indicates this restoration score in the experimental condition. C_EEG_AVG_RES and C_EEG_SD_RES indicate the calculated restoration averages and standard deviations (post condition - pre condition) from the EEG recorded levels of attention during the control condition. X_EEG_AVG_RES and X_EEG_SD_RES also indicate these in the experimental condition. C_RSS_AVG indicates the averages of the Likert scale ratings of each question in the restorative state scale questionnaire. X_RSS_AVG also indicates these in the experimental condition.

5.2 Necker cube pattern control task results

A paired sample t-test is conducted on the main variables resulting from the Necker cube pattern control task scores. The test compares mean values of the restoration scores from the control condition (C_RESTOR) and the restoration scores from the experimental condition (X_RESTOR). The results demonstrated a significant mean difference in the scores, with a higher mean in the experimental condition which is indicative of a higher restoration following the condition. In addition, the t-test proves this difference to be statistically significant (p= 0.011) as shown in table 2.

Table 2: Paired samples t-test of restoration scores from experimental and control conditions (n=30)

Variable	P-value	DF
C_RESTOR - X_RESTOR	0.011	29

5.3 EEG sensing results

A paired samples t-test is carried out on the variables measured with the EEG sensor. These are the restoration averages and standard deviations from the levels of attention recorded over time in the control condition (C_EEG_AVG_RES and C_EEG_SD_RES) and the experimental condition (X_EEG_AVG_RES and X_EEG_SD_RES). Table 3 shows the test results proving that the difference between conditions in averages and standard deviations are non significant.

Table 3: Paired samples t-tests of averages and standard deviations of EEG sensed levels of attention (n=23)

Variable	P-value	DF
C_EEG_AVG_RES - X_EEG_AVG_RES	0.869	22
C_EEG_SD_RES - X_EEG_SD_RES	0.701	22

5.4 Perceived restoration questionnaire results

An additional paired samples t-test was conducted on the averages from nine Likert scale questions resulting from the Restorative State Scale questionnaires participants filled in after each condition. The averages from the control condition (C_RSS_AVG) and the experimental condition (X_RSS_AVG). The results from table 4 demonstrate that there is an effect in perceived restoration between the two conditions that is of statistical significance. The average ratings of the Likert scale questions resulting from the experimental condition demonstrate that it is perceived as more restorative compared to the control condition. It must be noted that the sample size is 9 because the t-test is done on 9 mean values for each condition, which results from the 9 questions answered twice by all 30 participants.

Table 4: Paired samples t-test of averages from the nine Likert scale questions of the Restorative State Scale questionnaire (n=9)

Variable	P-value	DF
C_RSS_AVG - X_RSS_AVG	0.0001095	8

5.5 Contextual questionnaire

The contextual questionnaire showed that most participants were of the male gender except 6 females, also, most ranged between the ages of 23 and 31 with the exception a 54 and a 55 year old as well as two 38 year olds. The question determining the frequency of water based physical interactions of participants showed that most engage during summer either occasionally or often, with 4 participants engaging throughout the year, of which 1 once a month, and 1 once a week. Two participants stated a very unfrequent interaction, on rare occasions during summer. The type of interaction all participants engaged in is swimming, 8 other participants also do sailing. Nearly all participants stated their particular enjoyment of these interactions with a rating of 4 and 5 out of 5, with the exception of 2 participants rating a 2 and 2 participants rating a 3. A little over a third of the participants (12) had engaged in an attention demanding task prior to the experiment, of which the duration ranged between 30 minutes and 4 hours, these also rated this task as extremely or quite attention demanding.

5.6 G-forces experienced on floating platforms

An additional measure was taken during participant exposure to the experimental condition, acceleration over time. As the motions of water are experienced through a floating platform, an accelerometer recorded fluctuations in acceleration on the platform to best account for the degree of motion experienced. The accelerometer returned values of G-force over the x,y, and z axis as well as a total G-force value, this total value was recorded every tenth of a second and was therefore averaged to obtain a single representative value that is indicative of the overall experienced g-force by participants while laying on the floating platform. To test whether such a variable had any effect on the measured variables, the measured data was split and grouped by g-force with 0.03 as a delimiter, g-forces higher than this value were grouped, as well as those lower or equal. An independent samples t-test was conducted on these two sample groups. The results show a significant effect in the restoration scores (X_RESTOR). This result could suggest that the amount of movement experienced through the floating platform could have an effect on the degree of attentional restoration of participants, in this case the the processed results show the more movement the higher the perceived restoration. However, no significant difference was found in the averages (X_EEG_AVG_RES) and standard deviations (X_EEG_SD_RES) on restorative levels of attention, and in the averages from the ratings of the self-reported perceived restoration questionnaire (X_RSS_AVG).

Table 5: Independent samples t-tests with g-force magnitude as grouping variable

Variables	P-value	DF
X_RESTOR (n=30)	0.035	28
X_EEG_AVG_RES (n=23)	0.292	21
X_EEG_SD_RES (n=23)	0.317	21
X_RSS_AVG (n=18)	0.102	16

6. Discussion

The following section discusses the validity of the experimental design and chosen measures, as well as any identified shortcomings. Recommendations for continuation of similar research in future studies are also suggested.

6.1 Validity of Necker cube task and Stroop task

Concerning the use of the main opted measure for this study, the Necker cube pattern control task measuring the level of attentional performance as an indication of attentional capacity or fatigue in participants, certain improvements can be made that would increase the accuracy and validity of such measure. To increase validity, the execution of the task needs to be done correctly by the participant. Even though before starting the experiment the experimenter briefs and explains what is required to carry out the task correctly, each participant interprets and executes the task with little to no prior practice. This means that a learning curve or adaptive method of execution was observed and stated by participants the more they did the task. The main cause of the adaptation, as stated by some participants, involved the unspecified but required technique to control the pattern reversal of the cube. Participants noticed that by focusing their attention in different ways on the cube (on its faces, vertices, or edges) this would allow for more or less reversals to take place. As such, participants believed they were left to discover a technique to prevent such reversals, which by

doing so could have affected the validity as well as accuracy of the reported reversals. In fact, an active technique to inhibit such reversals is not necessary, but a mere passive gaze on the cube as a whole and an overall focus of attention on the task would be sufficient for accuracy.

For the improvement in the design of this task, the experimenter should make it explicit for participants that they should not aim to find a technique to inhibit the reversals but that they should focus their gaze on the cube as a whole or to quickly choose a specific point on the cube to fix their gaze on. The inclusion of a visibly drawn point on the cube could potentially resolve the issue, however, to the knowledge of this research, such a solution has not been employed by other studies, and would thus require testing for validity. In addition, to decrease the possibility of participants adapting their pattern control techniques, a series of practice rounds with a discussion on the execution would be beneficial prior to beginning the experiment. However, given the already time consuming nature of the experiment's design this was not opted for, instead, participants were made sure to at least understand and perceive the mental reversals in the patterns of the cube wireframe and the requirement to inhibit the reversals when possible. Furthermore, participants required to complete the task twice within a measurement session (30 seconds each, 60 seconds total). The amount of time was not increased to make sure that the measurement of attentional capacity or fatigue was done as fast as possible, as it naturally restores itself over time.

Most notably, following an analysis of the processed results, the restoration scores of 6 participants in the control condition (C_RESTOR) and 2 participants in the experimental condition (X_RESTOR) were of negative value, meaning that no restoration took place following the conditioned stimuli. Such measures could be justified by the possible validly questioned executions of the task by participants as aforementioned. However, it could also have been caused by the inability of the Stroop task to induce sufficient attentional fatigue for it to allow a significant measurable difference with the measurement following exposure to the stimuli. The Stroop task is adequate to induce attentional fatigue because of its repetitive and monotonous nature, however, for it to induce more effectively it must be as time consuming as possible. Evidently, increasing the duration of the induction could have solved this possible issue, but given it was already the most time consuming step in the experiment that is matched in duration with the exposure to the stimuli, it would have drastically increased the whole experiment's duration.

6.2 Validity of EEG measurements

The process of measurement of attention levels over time of participants using the EEG sensor experienced some flaws. Firstly, the quality of the EEG headset apparatus was low in relation to other apparatus options, this is due to its low cost. This, together with the fact it only employs one single node sensor that is placed on the forehead instead of various nodes placed along the scalp, means that the measurements are not very precise, as it would be less effective at reducing noise and validating sensed brainwave values. However, its portability and ease of deployment made it possible for use in the outdoor conduction of this study's research experiment.

Secondly, the quality of the laptop used to log the data sent from the EEG sensor was also suboptimal. To log data with the EEG sensor an application that runs only on Windows operating systems was necessary, therefore an old laptop had to be used that had a weak battery. In a few occasions of successive experiment conductions with participants, the limited battery power supply of this laptop caused the inability to record EEG data from some participants. And since the experiment was conducted outdoors, there were no possibilities to reach a power supply for charging. As explained at the beginning of the method section, a combination of human and apparatus error also caused the loss of various EEG data recordings. This combination of flaws reduced the amount of usable processed data, from 30 to 22 data points in the control condition

(C_EEG_AVG_RES and C_EEG_SD_RES) and to 23 in the experimental condition (X_EEG_AVG_RES and X_EEG_SD_RES) this gave a sample size of 23 for the t-test analysis (as can be seen in the degrees of freedom and sample sizes of corresponding t-tests in the results section).

As suggested improvements to these flaws, an upgrade to higher quality equipment would be most adequate in future research. Unfortunately, given the time limit to conduct this study and the limit in means to acquire better apparatus, quality upgrades were not possible. With regards to the degree of effect of settled quality on the validity of the collected data, an overview of the pre-processed results as well as their graphical representations show that in a few participants some of the measured levels of attention exhibit abnormal decreases and in some cases a sustained higher level in intervals where the participant was not focusing attention (during the roughly 5 seconds of break between the two necker cube tasks carried out in a measurement session). Such discrepancies could be due to the lack of precise measurement offered by the low quality of the EEG headset, as well as a possible accidental displacement or sudden movement of the sensor node that is placed on the forehead.

6.3 Evaluating results of perceived restoration and contextual questionnaires

Doing a cross analysis of processed results from the psychological and physiological measures with the results from the perceived restoration and contextual questionnaires a certain observation can be made. Two participants reported in the contextual questionnaires the following. One reported to hardly ever physically engage in water activities, only rarely in summer. The other, even though reporting to occasionally engage in water activities in summer, reported to not particularly enjoy doing so. The responses of other participants showed particular interest and more affinity with water activities. In observation of the Necker cube task restorative scores of these two participants following the experimental condition of exposure to the floating platform, the scores are the only negative scores out of all participants (-1.5 and -2.5). This clearly indicates that preference and amount of affinity with water activities can be influential and deterministic in enabling restoration through haptic experience of water's motions. In addition, the self-reported perceived restoration questionnaire results of these two participants show no to little difference between the conditions.

7. Conclusions

After an analysis of the results, the following observations are formed.
The amount of participants gathered (n=30) provides a sufficient sample of data to draw definitive and significant conclusions on the research of this study. Ultimate findings can be made that provide the possibility of discussion on the outcomes of this study. The research question as well as the subquestion will be answered by interpretation of results gathered.

- Research question: Can the haptic and corporeal experience of water's motions through a floating platform be more effective at restoring attentional fatigue than the experience of being on firm ground?

It was hypothesised that the haptic experience of water's motions would be more effective to a small extent at restoring attentional fatigue than the experience of no motions on firm ground. The results show that the difference in measured psychological and physiological variables between the two conditions are significant in the psychological measures but non-significant in the physiological. Even considering the significant difference in means of the psychologically measured

restorative scores, with a higher mean in the condition assessing restoration from haptic experience of water's motions, the processed results of all measures combined do not provide a solid enough base for a conclusive support of the hypothesis. However, the results from the psychological measure do provide a significant support of the hypothesis. Given that this measure has been proven in validity by its use in many past studies of attention restoration, its results should be regarded as most relevant to future research. The results are very suggestive towards the hypothesis that experiencing the motions of water through a floating platform does have a more effective attention restoring effect in comparison to restoring on firm ground. On the other hand, an interpretation of the physiological measures contradicts the hypothesis, as the average of averages of attention level is higher and the average of standard deviations is lower in the control condition. However, such physiological measures remain questionable in validity.

- Subquestion: Does the experience of water's motions through a floating platform promote attentional restoration?

It was hypothesised that the haptic experience of water's motions will promote attentional restoration. By interpretation of the processed psychological results, all participants except two showed restorative outcomes following exposure to water's motions. An explanation is suggested by the data collection of contextual and perceived restoration questionnaires for the absence of restoration in two participants. The level of affinity and preference of participants for engagement in water activities is suggested as a determinant for the haptic experience of water's motions to promote restoration of attentional capacity. The two participants showed relatively lower levels of affinity and preference for engagement in water activities, which potentially justifies their lack of restoration following exposure to water's motions. The physiological measures show an average absence of restoration following exposure to the stimuli, such measures remain validly questionable.

References

Bell, Sarah L., et al. "Seeking Everyday Wellbeing: The Coast as a Therapeutic Landscape." *Social Science & Medicine*, vol. 142, Oct. 2015, pp. 56–67. *Crossref*, doi:10.1016/j.socscimed.2015.08.011. [1]

Berg, Agnes E. Van Den, et al. "Preference for Nature in Urbanized Societies: Stress, Restoration, and the Pursuit of Sustainability." *Journal of Social Issues*, vol. 63, no. 1, 2007, pp. 79–96., doi: 10.1111/j.1540-4560.2007.00497.x.

Berg, Agnes E. Van Den, et al. "Evaluating Restoration in Urban Green Spaces: Does Setting Type Make a Difference?" Landscape and Urban Planning, vol. 127, 2014, pp. 173–181., doi: 10.1016/j.landurbplan.2014.04.012.

Beute, Femke & De Kort, Yvonne. (2014). Natural resistance: Exposure to nature and self-regulation, mood, and physiology after ego-depletion. Journal of Environmental Psychology. 40. 10.1016/j.jenvp.2014.06.004.

"Beta Wave." *Beta Wave - an Overview | ScienceDirect Topics*, www.sciencedirect.com/topics/medicine-and-dentistry/beta-wave.

Brown, Katrina M. "The Haptic Pleasures of Ground-Feel: The Role of Textured Terrain in Motivating Regular Exercise." *Health & Place*, vol. 46, July 2017, pp. 307–14. *ScienceDirect*, doi:10.1016/j.healthplace.2016.08.012.

Browning, W.D., Ryan, C.O., Clancy, J.O. (2014). 14 Patterns of Biophilic Design. new York: Terrapin Bright Green llc.

Cameron Duff, Networks, resources and agencies: On the character and production of enabling places, Health & Place, Volume 17, Issue 1, 2011, Pages 149-156, ISSN 1353-8292, https://doi.org/10.1016/j.healthplace.2010.09.012.

Capaldi, Colin A., et al. "The Relationship between Nature Connectedness and Happiness: A Meta-Analysis." *Frontiers in Psychology*, vol. 5, 2014. *Frontiers*, doi:10.3389/fpsyg.2014.00976.

Carrus G, Scopelliti M, Panno A, Lafortezza R, Colangelo G, Pirchio S, Ferrini F, Salbitano F, Agrimi M, Portoghesi L, Semenzato P and Sanesi G (2017) A Different Way to Stay in Touch with 'Urban Nature': The Perceived Restorative Qualities of Botanical Gardens. Front. Psychol. 8:914. doi: 10.3389/fpsyg.2017.00914

Colley, K., Brown, C. & Montarzino, A. (2016) Restorative wildscapes at work: an investigation of the wellbeing benefits of greenspace at urban fringe business sites using 'go-along' interviews. Landscape Research 41(6), 598-615., doi:10.1080/01426397.2016.1197191.

Cowan, Nelson. "The Magical Mystery Four." *Current Directions in Psychological Science*, vol. 19, no. 1, 2010, pp. 51–57., doi:10.1177/0963721409359277.

Daniel A. Sarr & Klaus J. Puettmann (2008) Forest management, restoration, and designer ecosystems: Integrating strategies for a crowded planet, Écoscience, 15:1, 17-26, DOI: 10.2980/1195-6860(2008)15[17:FMRADE]2.0.CO;2

De Young, Raymond. “Stroop Effect: Stroop Test.” *Stroop Effect | Stroop Test*, 2016, seas.umich.edu/eplab/demos/st0/stroopdesc.html.

Doughty, Karolina. (2018). From water as curative agent to enabling waterscapes: Diverse experiences of the 'therapeutic blue'.

Elizabeth R. Straughan, Touched by water: The body in scuba diving, Emotion, Space and Society, Volume 5, Issue 1, 2012, Pages 19-26, ISSN 1755-4586, https://doi.org/10.1016/j.emospa.2010.10.003

Fischl, Géza. “Biophilic Living: a Behavior Responsive Architecture.” Academia.edu, 2016, www.academia.edu/28161143/Biophilic_living_a_behavior_responsive_architecture.

Foley, Ronan. “Swimming as an Accretive Practice in Healthy Blue Space.” *Emotion, Space and Society*, vol. 22, Feb. 2017, pp. 43–51. *ScienceDirect*, doi:10.1016/j.emospa.2016.12.001.

Frumkin, Howard, Gregory N. Bratman, Sara Jo Breslow, Bobby Cochran, Peter H. Kahn Jr, Joshua J. Lawler, Phillip S. Levin, et al. “Nature Contact and Human Health: A Research Agenda.” *Environmental Health Perspectives* 125, no. 7 (July 24, 2017): 075001. https://doi.org/10.1289/EHP1663.

Franco, Lara S., et al. “A Review of the Benefits of Nature Experiences: More Than Meets the Eye.” *International Journal of Environmental Research and Public Health*, vol. 14, no. 8, Aug. 2017. *PubMed Central*, doi:10.3390/ijerph14080864.

Hartig, Terry, et al. “Tracking Restoration in Natural and Urban Field Settings.” *Journal of Environmental Psychology*, vol. 23, no. 2, 2003, pp. 109–123., doi:10.1016/s0272-4944(02)00109-3.

Hartig, T., Mang, M., and Evans, G. W. (1991). Restorative effects of natural environments experiences. *Environ. Behav.* 23, 3–26. doi: 10.1177/0013916591231001

Hayles, Carolyn & Aranda-Mena, Guillermo. (2018). Well-being in vertical cities: beyond the aesthetics of nature.

Heft, H. (2010). Affordances and the perception of the landscape: an inquiry into environmental perception and aesthetics. In C. Ward Thompson, P. Aspinall & S. Bell (Eds.), Innovative Approaches to Reseraching Landscape and Health - Open Space: People Space 2. Abingdon: Routledge.

Hunter MR and Askarinejad A (2015) Designer’s approach for scene selection in tests of preference and restoration along a continuum of natural to manmade environments. Front. Psychol. 6:1228. doi: 10.3389/fpsyg.2015.01228

Jaggard, Charles. (2014). The Effect of Intentionally Engaging Attention when Viewing Restorative Environments: Exploring Attention Restoration Theory.

Joye, Yannick & van den berg, Agnes. (2018). Restorative Environments: An Introduction. 10.1002/9781119241072.ch7.

Joye, Yannick. “Architectural Lessons from Environmental Psychology: The Case of Biophilic Architecture.” *Review of General Psychology*, vol. 11, no. 4, 2007, pp. 305–328., doi:10.1037/1089-2680.11.4.305.

Kaplan, S., Bardwell, L. V., & Slakter, D. B. (1993). The museum as a restorative environment. *Environment and Behavior, 25*(6), 725-742. http://dx.doi.org/10.1177/0013916593256004

Kaplan, R., & Kaplan, S. (1989). The experience of nature: A psychological perspective. New York, NY, US: Cambridge University Press.

Koga, K. & Y. Iwasaki (2013). Psychological and Physiological effect in Humans of Touching Plant Foliage - using the Semantic Differential method and Cerebral Activity as Indicators. *Journal of Physiological Anthropology, 32* (1), 7.

Lanktree, Marion. "Investigating Interactive Biophilic Design in Interior Environments." 2010, doi: 10.22215/etd/2010-08859.

Laumann, Karin, et al. "Rating Scale Measures Of Restorative Components Of Environments." Journal of Environmental Psychology, vol. 21, no. 1, 2001, pp. 31–44., doi:10.1006/jevp.2000.0179.

Lengen, Charis. "The Effects of Colours, Shapes and Boundaries of Landscapes on Perception, Emotion and Mentalising Processes Promoting Health and Well-Being." *Health & Place*, vol. 35, Sept. 2015, pp. 166–77. *ScienceDirect*, doi:10.1016/j.healthplace.2015.05.016.

Menatti L and Casado da Rocha A (2016) Landscape and Health: Connecting Psychology, Aesthetics, and Philosophy through the Concept of *Affordance*. *Front. Psychol*.7:571. doi: 10.3389/fpsyg.2016.00571

Obrador, Pau. (2007). A Haptic Geography of the Beach: Naked Bodies, Vision and Touch. Social & Cultural Geography - SOC CULT GEOGR. 8. 123-141. 10.1080/14649360701251866.

Okulicz-Kozaryn, Adam & Mazelis, Joan Maya. (2016). Urbanism and Happiness: A Test of Wirth's Theory of Urban Life. *Urban Studies 55*(2), 349-364. http://dx.doi.org/10.1177/0042098016645470.

O'Neill, Máire Eithne. "Corporeal Experience: A Haptic Way of Knowing." *Journal of Architectural Education*, vol. 55, no. 1, Sept. 2001, pp. 3–12. *Crossref*, doi: 10.1162/104648801753168765.

Ouellette, P., Kaplan, R., & Kaplan, S. (2005). The monastery as a restorative environment. *Journal of Environmental Psychology, 25*(2), 175-188. http://dx.doi.org/10.1016/j.jenvp.2005.06.001

Pals, R., et al. "Development of the PRCQ: A Measure of Perceived Restorative Characteristics of Zoo Attractions." Journal of Environmental Psychology, vol. 29, no. 4, 2009, pp. 441–449., doi: 10.1016/j.jenvp.2009.08.005.

Paterson, M. (2009). Haptic geographies: ethnography, haptic knowledges and sensuous dispositions. *Progress in Human Geography*, *33*(6), 766–788. https://doi.org/10.1177/0309132509103155

Pearson DG and Craig T (2014) The great outdoors? Exploring the mental health benefits of natural environments. *Front. Psychol*. **5**:1178. doi: http://dx.doi.org/10.3389/fpsyg.2014.01178

"PHYTOKINETIC Greenroofs for Urban Transport Vehicles." *Phytokinetic Greenroofs*, phytokinetic.net/#why.

Pradhan, Prajal, 2012. *The role of water as a restorative component in small urban spaces*. Second cycle, A2E. Alnarp: SLU, Landscape Architecture (until 121231)

Scopelliti M, Carrus G and Bonaiuto M (2019) Is it Really Nature That Restores People? A Comparison With Historical Sites With High Restorative Potential. Front. Psychol. 9:2742. doi: 10.3389/fpsyg.2018.02742

Seana Irvine, Lorraine Johnson & Kim Peters (1999) Community gardens and sustainable land use planning: A case-study of the Alex Wilson community garden, Local Environment, 4:1, 33-46, DOI: 10.1080/13549839908725579

Sona, Brid. (2018). With all my senses: Restorative environments through holistic sensory impressions.

Stephen Kaplan, The restorative benefits of nature: Toward an integrative framework, Journal of Environmental Psychology, Volume 15, Issue 3, 1995, Pages 169-182, ISSN 0272-4944, https://doi.org/10.1016/0272-4944(95)90001-2

Stevens, Paul. (2014). Affective priming of perceived environmental restorativeness. International journal of psychology : Journal international de psychologie. 49. 51-5. 10.1002/ijop.12016.

Tennessen, C. M., & Cimprich, B. (1995). Views to nature: Effects on attention. Journal of environmental psychology, 15, 77-85.

Thomas, Felicity. "The Role of Natural Environments within Women's Everyday Health and Wellbeing in Copenhagen, Denmark." *Health & Place*, vol. 35, Sept. 2015, pp. 187–95. *ScienceDirect*, doi:10.1016/j.healthplace.2014.11.005.

Ulrich R.S. (1983) Aesthetic and Affective Response to Natural Environment. In: Altman I., Wohlwill J.F. (eds) Behavior and the Natural Environment. Human Behavior and Environment (Advances in Theory and Research), vol 6. Springer, Boston, MA. https://doi.org/10.1007/978-1-4613-3539-9_4

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*(3), 201-230. http://dx.doi.org/10.1016/S0272-4944(05)80184-7

Völker, Sebastian, and Thomas Kistemann. "The Impact of Blue Space on Human Health and Well-Being – Salutogenetic Health Effects of Inland Surface Waters: A Review." *International Journal of Hygiene and Environmental Health*, vol. 214, no. 6, Nov. 2011, pp. 449–60. *ScienceDirect*, doi:10.1016/j.ijheh.2011.05.001.

Williams, Kathryn J.h., et al. "Conceptualising Creativity Benefits of Nature Experience: Attention Restoration and Mind Wandering as Complementary Processes." *Journal of Environmental Psychology*, vol. 59, 2018, pp. 36–45., doi:10.1016/j.jenvp.2018.08.005.

Yamane, K., m. Kawashima, n. Fujishige, & m. Yoshida (2004). effects of Interior Horticultural Activities with Potted Plants on Human Physiological and emotional Status. *Acta Hortic, 639,* 37-43.

Zuckerman, M. (1977). Development of a situation-specifictrait-state test for the prediction and measurement of affective responses. Journal of Consulting and Clinicial Psychology, 45, 513-523.