The impact of water and anthropogenic objects on implicit evaluations of natural scenes: a restorative environments perspective

by

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Abstract

Research has consistently demonstrated that exposure to nature, as opposed to urban environments, can be beneficial to health and wellbeing. Among natural landscapes, aquatic (blue space) scenes are among the most preferred and psychologically restorative. Since such landscapes face an increasing range of demands, there is a need to understand how their restorative qualities arise and might be preserved, both in terms of the content of a scene and the psychological processes involved in its interpretation.

This thesis examines the cognitive impact of placing artificial (human-made) objects in natural landscapes with and without water. It reports new findings regarding the importance of specific scene content for the restorative potential of blue space. The research also explores some of the underlying psychological processes, addressing novel questions about implicit (subconscious) attitudes towards natural landscapes. It compares implicit and explicit attitudes for the first time in this context.

In four studies, methods from social and experimental psychology were used to investigate attitudes towards blue and green space with and without artificial objects. To examine the issues of both artificial objects and implicit attitudes, Study 1 used the Affect Misattribution Procedure (which measures implicit attitudes towards images) to assess whether implicit affect (subconscious positive or negative emotion) differed when the same natural scene was viewed with and without artificial objects. Results showed that introducing objects into natural scenes had a negative impact on implicit affect, particularly when the scene contained water.

In order to be able to compare implicit and explicit attitudes, Study 2 examined explicit affective reactions to the images from Study 1 using questions adapted from the Perceived Restorativeness Scale (a measure of the restorative potential of environments). Blue space scenes were rated more highly than green space scenes on all components except aesthetics. The presence of artificial objects resulted in lower ratings on all measures for both blue and green scenes.

Study 3 was motivated by an indication in the results from Study 1 that implicit attitudes towards blue and green space may differ. The Affect Misattribution Procedure was used to investigate this for natural landscapes without artificial objects. The study also examined whether implicit attitudes differ according to the type of blue or green environment. Viewing blue space scenes resulted in more positive implicit affect than green space, with sea views generating the most positive implicit affect of all.

Following the discovery that artificial objects had a more negative impact on implicit attitudes to blue space than green space, Study 4 tested the possibility that this could be due to such objects being more disruptive to the conceptual coherence of aquatic scenes. The conceptual-semantic congruence of artificial objects was assessed using a lexical decision task, in which participants reacted to object words superimposed on scenes. Results did not support the hypothesis that artificial objects are less congruent in blue space than green space.

Overall, the studies provide evidence that placing artificial objects in natural landscapes, particularly aquatic landscapes, adversely affects both implicit and explicit attitudes towards the scenes and may reduce their restorative potential. By successfully combining methods from social and experimental psychology, this research validates novel ways of formulating and addressing questions about why some environments have a more positive psychological impact than others. The new results reported here are not easily explained by current restorative theory, therefore might contribute to refining the theoretical framework within which restorative environments are studied.

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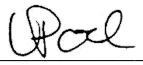
Signature of Candidate 

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Chapter 1

Introduction

1.1 Artificial objects in natural environments

In December 2013, the UK Government's Communities Minister upheld the local council's decision to reject an onshore wind farm near Frizington in West Cumbria, judging that the proposed six-turbine development would cause 'significant adverse harm to landscape character'[1]. As well as being rejected by politicians, the development had faced public opposition on the grounds of its visual impact. In contrast, a few weeks later, further down the Cumbrian coast, the first turbines started operating offshore at West Duddon Sands Wind Farm - a development that successfully passed through the planning process with more acceptance than resistance.

This situation of an offshore development proceeding relatively smoothly while an onshore development is stopped owing to opposition from both local people and politicians reflects a growing trend in the UK (Tait, 2015) to situate such developments offshore. Indeed, even though the cost of offshore wind farm development is higher, planning applications are nevertheless less likely to be rejected. This suggests that while there is clear recognition (as outlined in the Government's Visual Impact Guidelines) that developments on land can have a negative visual impact on the character of a landscape, there appears to be a corresponding assumption that developments that affect the seascape may have fewer consequences for visual character, thus less impact on people.

On one level, this may seem justifiable. That is, research (using a questionnaire with images of turbines in seascapes) has demonstrated that public opinion supports the offshore

[1] Letter from Secretary of State to Banks Renewables, 4 December 2013.

location of turbines in ways that are judged to have lower impact, such as siting them further out to sea (Bishop and Miller, 2007), while a recent study (using a questionnaire without images) found that people judged that offshore wind turbines did not 'spoil the view' (Hattam, Hooper, and Beaumont, 2015).

However, when a seascape is considered in a broader context, in particular beyond simply asking people whether they think such objects 'spoil the view', the situation may not necessarily be so straightforward. More specifically, although the current planning process for new developments may take into account aesthetics, the character of a landscape and economic considerations, the potential impact on health and wellbeing is not usually considered. Given that people have been visiting British coastal resorts for health and recuperation for at least 300 years (Brodie, 2011; Pimlott, 1947), together with more recent evidence-based recognition that environmental quality in both urban and green space affects health and wellbeing (Stokols, 1992), it is possible that important consequences of altering seascapes are being overlooked. In particular, when the environment is regarded as a visual amenity, the experience of which may have psychological impacts, different issues and questions arise. It is not known, for example, what the psychological impact of altering natural[2] landscapes is, and whether (or how) that might differ for different types of landscape. Consequently, it may be asked whether it is genuinely the case that locating developments such as wind turbines offshore has a less detrimental psychological impact than constructing them onshore.

It is this question that is the inspiration for this thesis. However, although wind turbines are used as a contemporary example here, the thesis is not specifically about wind power or wind turbines. Rather, it tackles the issue at a more general level by asking what happens to

[2] Throughout this thesis, 'natural' is used to refer to non-urban landscapes that predominantly contain elements from nature such as plants, trees, grass and water. They might be better described as 'seemingly natural', since such landscapes are often shaped by human activity.

the perception of a natural landscape, in particular an aquatic landscape, when artificial[3] objects are added, and when that landscape is considered not simply as a pleasant view but as a visual resource with the potential to impact upon human health and wellbeing. In other words, there is currently a lack of evidence regarding the salutogenic[4] impact of changing the appearance of natural landscapes by introducing artificial objects into them, yet this is potentially significant both to the people who live in coastal communities and who may find the seascape being altered, as well as those who visit aquatic environments for leisure and tourism. For the latter, an altered seascape may reduce the attraction of an area, with subsequent implications for the health of the local tourism industry and the economic prosperity of the local community.

In order to investigate how the visual quality of a landscape might be altered in a manner that could affect psychological and physiological wellbeing, the most appropriate conceptual framework is found in restorative environments research, a branch of environmental psychology that is based around evidence that natural environments are more beneficial to health, wellbeing and recovery from stress and mental fatigue than urban environments (Staats, 2012).

1.2 Green and Blue Space

In this thesis, *green* and *blue* are treated as terms referring to different types of natural scenes. Specifically, they enable natural scenes to be divided into two categories: scenes containing visible water and scenes not containing visible water. Although a stereotypical blue space scene may contain the colour blue and a stereotypical green space scene may contain the colour green, this is not necessary for the terms to apply. Thus, *green space* refers to settings including predominantly natural elements. While these natural elements

[3] 'Artificial objects' is used to refer to anthropogenic (human-made) artefacts with no particular restriction on size or function. For example, wind turbines, buildings, fences, benches, boats, etc., would all be classed as 'artificial objects' in this context. The meaningfulness of the natural/artificial distinction will be discussed in Chapter 3.

[4] Salutogenic environments are ones that can improve health (Antonovsky, 1996).

may include vegetation (and commonly do), vegetation does not necessarily need to be present. For example, a desert landscape would be considered as green space in the present context. *Blue space* refers to settings comprising predominantly natural elements, including visible aquatic elements (e.g. lakes, rivers, ponds, the sea). Such scenes need not be blue in colour; for example, a seascape with a grey sky and grey sea would be considered as blue space.

1.2.1 The restorative potential of blue space

While the branch of environmental psychology that is concerned with restorative environments is relatively new, the recognition that nature can be beneficial to health and wellbeing goes back much further and can be traced at least as far as Ancient Greece and the writings of Hippocrates (Kish, 1978). Today, there is an abundance of academic evidence that in addition to being associated with better health (Mitchell, Astell-Burt and Richardson, 2010; James *et al.*, 2016), natural landscapes are more preferred (Korpela *et al.*, 2002; Herzog and Chernick, 2000), are associated with improved self-control and reduced stress (Beute, Kort and de Kort, 2014) and can promote restoration (Kaplan, 1995; Frumkin, 2001)[5].

Restoration is defined as:

The renewal or recovery of resources or capacities that have become depleted in meeting the demands of everyday life. Hartig (2011, p.41).

A restorative environment, therefore, is one that both promotes and permits restoration. Various psychological and physiological markers for the restorative effects of natural environments have been identified. The main categories for these are cognitive function (exposure to nature improves it (Berman, Jonides and Kaplan, 2008)); physiological and

[5] Conversely, urban environments are linked with problems including higher stress (Lederbogen *et al.*, 2011), poorer mental health (van Os, Pedersen and Mortensen, 2004), cardiovascular disease (Vorster, 2002), and poorer respiratory health (Eggleston, 2007).

psychological stress (exposure to nature reduces it (Staats, Gatersleben and Hartig, 1997)) and affect[6] (exposure to nature results in more positive affect (Staats *et al.*, 1997)). In this thesis, the main focus will be on affect as an indication of restorative potential.

Within restorative natural environments, water has traditionally been a central feature. For example, sea bathing became popular in the 18th Century though, encouraged by the medical profession which promoted the supposed recuperative powers of seawater, it was initially for health reasons (Urry 1990). Soon, however, seaside resorts became socially fashionable and by the middle of the 19th Century, with improved transport links and increases in leisure time, pleasure overtook health as the driving force. People began to visit the coast in increasing numbers (Anderson, 1996; Walton, 1993) and nowadays, not only are seaside settings amongst people's favourite places (Korpela *et al.*, 2010) but also coastal resorts have become synonymous with mass tourism from its beginnings up to the present day (Segreto, Manera and Pohl, 2009). It seems that when people have the time and the resources for leisure, they are often drawn towards the sea, both day-tripping at home and holidaying abroad. This is reflected in research that reveals that hotels commonly charge around 20% more for a hotel room with a view of water (Lange and Schaeffer, 2001) and that, all other things being equal, prices for houses with views of water may be up to 12% higher than for similar houses without an aquatic view (Luttik, 2000). These phenomena are congruent with the popular idea of an enduring human fascination with and attraction to water, evident in areas including art, mythology, tradition and recreation (Berezin, 2012; Nichols, 2014).

Until recently, the role of water had not been systematically investigated in restorative environments research (Staats, 2012). Now, however, a body of evidence is accumulating that suggests that blue space[7] environments may be the most restorative of all. For example,

[6] Affect can be broadly defined as, "a momentary pleasant or unpleasant [emotional] state." (Shimmack and Crites, 2014, p. 397).
[7] 'Blue space' is used to denote scenes containing aquatic elements, including seas, rivers, lakes and canals.

White *et al.* (2010) found that natural scenes containing water were consistently rated more highly for preference, perceived restorativeness and positive affect than scenes without water. In a strand of research complementing the experimental evidence, White *et al.* (2013a; 2013b) also performed analyses of some large-scale data sets which included information about health and the environment. These revealed a positive association between self-reported mental and physical health and living near the coast (White *et al.*, 2013a). It was also discovered that amongst people who had recently visited a natural environment, feelings of restoration were highest from those who had visited a coastal location (White *et al.*, 2013b).

However, is not well understood exactly how the composition of a scene translates into restoration. That is, although recent work (e.g. White *et al.*, 2010) has shown the importance of the presence of water, the ways in which water interacts with other elements in the landscape to create its potential for restoration has not yet been comprehensively explored and remains unexplained. In particular, the impact of artificial objects on the restorative potential of blue space has received little attention, despite being of great practical significance for the large numbers of people who live in and visit blue space environments, particularly in coastal locations.

1.3 Unanswered questions about blue space and restoration

Coastal areas are often under particular pressure from development, both onshore and offshore. The coast is not only a potential site for industry, such as power generation, but it may also face demands from the leisure and tourism industry, for example. Yet, while previous work has looked at people's attitudes towards coastal development (e.g. (Bergmann, Colombo and Hanley, 2008) and potential economic benefits and costs, such as the impact on tourism (Frantál and Kunc, 2011; Westerberg, Jacobsen and Lifran, 2013) it is not currently known what impact such development might have on the health and wellbeing benefits of blue space.

Specifically, intrinsic to the visual impact of development is the addition of anthropogenic objects to the coastal landscape. However, few studies have explored the consequences for restoration of adding such objects to natural landscapes. Nevertheless, White *et al.* (2010) found that objects had a negative impact on preference and restorativeness ratings across all scene-types included in their study (some of which included natural and aquatic elements), while Motoyama and Hanyu (2014) found that the presence of public art (sculptures) reduced pleasantness ratings for natural green space scenes but not urban scenes. These results indicate that the presence of objects may have an impact and, thus, that the phenomenon (which is, as yet, unexplained) is worth investigating in more detail.

On the one hand, it is possible to introduce artificial objects into a natural landscape without negatively affecting its wellbeing benefits, something that is likely to be welcomed by those in favour of development as well as by those concerned with public health, as it would also mean that potentially conflicting priorities can co-exist in such places. It is at least conceivable that this might be the case, since when artificial objects are added to a scene the natural elements may remain, meaning that the scene may still possess restorative potential as a result of those natural elements. On the other hand, if it is the case that artificial objects decrease the restorative potential of blue space, the health implications of this for the local population (as well as the consequent impact on the quality of the location as a tourist destination) could become important for future planning and development decisions.

It is this gap in knowledge that forms the basis for this thesis. Understanding of blue space phenomena is lacking in terms of scope, constraints, and mechanisms. The question of both whether and how the presence of anthropogenic objects might alter the restorative potential of aquatic scenes remains open and, therefore, the work reported in the following

chapters represents a contribution to this relatively new area of enquiry. Thus, the broad question that this thesis addresses is:

Does the presence of artificial objects influence affective reactions to natural aquatic and non-aquatic scenes?

1.4 A cognitive psychological approach

One of the limitations of previous work that explored the affective reactions to restorative environments is that it commonly focuses on explicit attitudes - usually asking people to rate scenes. While this is an important and informative approach, this focus on self-reporting (as opposed to implicit, non-conscious responses to scenes) may not necessarily provide a full insight into blue space restorative phenomena.

In other words, given the current relevance of these issues in natural landscapes (the siting of wind farms being a good example), there are various factors (such as political and environmental views) that may have an impact on people's explicit/considered responses. So it is possible, in theory at least, that studies relying on self-reporting methods could miss some of the underlying psychological processes. For example, it could be the case that people might give a negative explicit response to a scene but have a positive implicit response (and vice versa) depending on their motivations for answering a question in a certain way, including factors such as social pressures or political views, for example. Thus, to understand the psychological (and consequential potential public health) impacts, it is necessary to be able to look beyond people's explicit reactions, where possible, in order to develop a more complete understanding of the restorative potential of a scene.

There is, at present, no comprehensive explanation for why and how restorative environments effects arise (the best-developed current explanations will be discussed in Chapter 3). In order to construct an understanding of these effects, it is important to

determine at what level of psychological processing they arise. Do they arise as a result of rapid, subconscious cognitive processes, or are they a product of considered aesthetic (or other) preferences? At present, this is an unanswered (and rarely asked) question. Cognitive psychology[8] provides the conceptual and methodological framework within which to investigate subconscious processes in this context.

The underlying processes matter because, in order to preserve and harness the health and wellbeing benefits of certain environments, we need to understand what it is about those environments that confers the benefits, and how the process works. Once this is understood, it not only provides evidence about how to retain those characteristics of natural environments, but it can also help introduce some of those benefits into urban and indoor environments. Although incorporating elements from nature is already being done to some extent in certain contexts, including architecture (Lindal and Hartig, 2013), urban design (Grahn and Stigsdotter, 2003), hospital design (Ulrich, 1991) and education (Van den Berg and Van Duijn, 2015), current methods are often based on intuition about what is likely to be beneficial or pleasant, rather than evidence of what, specifically, is most effective, in what amounts and in what respects. In short, we are still a long way from having a detailed enough understanding to be able to produce clear, evidence-based guidelines for practitioners in these disciplines.

No previous work on blue space and restoration has looked at implicit reactions, although a small number of studies have included implicit reactions to green space (Korpela, Klemettila and Hietanen, 2002; Joye *et al.*, 2013), indicating the feasibility of such a line of enquiry. The problem with the current gap in knowledge is that by focusing on considered, relatively slow reactions to blue space, the processes that occur between viewing a scene

[8] Cognitive psychology is the study of mental processes, including perception, attention, language, memory and thought (Neisser, 1967). It assumes that psychological processes can be investigated empirically and relies on experimental techniques to gain insight into their nature and operation (Anderson, 2010). Although some researchers have asserted that affect is separate from cognition (e.g. Zajonc, 1980), a more standard view (and the one that is adopted in this thesis) is that affect is a variety of cognition and as such plays a role in perceptual and psychological processes (Duncan and Barrett, 2007).

and forming an explicit opinion about it are missed. Scene recognition happens rapidly, in a single glance, without conscious effort (Oliva, 2005) and some of the rapid, unconscious processes involved may be relevant to understanding restorative effects. The research in this thesis therefore addresses the following specific questions:

Research Question 1: *Does the presence of anthropogenic objects modify implicit affective responses to natural aquatic scenes?*

Research Question 2: *Do implicit affective responses differ from explicit affective responses to natural scenes containing anthropogenic objects?*

Research Question 3*: Does the presence of water influence implicit affective responses to natural scenes?*

Research Question 4: *Can differences in implicit attitudes to natural aquatic and non-aquatic scenes containing artificial objects be attributed to differences in scene coherence?*

1.5 Limitations

When an individual observes a scene, there are many processes and factors that may have an impact upon their subjective experience of the scene as well as their affective reaction to it. For example, prior experience of the same or similar scenes (Dzebic, Perdue and Ellard, 2013), dimensions such as spirituality (Sharpley and Jepson, 2011), place attachment (Kaltenborn and Bjerke, 2002), connectedness to nature (Zhang, Howell and Iyer, 2014) and environmental attitudes (Van den Berg *et al.*, 2006) may all influence experiences and affective responses. However, although such factors will undoubtedly prove important in developing a complete understanding of people's experiences of natural scenes, they are

beyond the scope of this thesis. Specifically, the present work is concerned with the underlying psychological processes, setting aside individual social and personal differences. The question of whether restorative environments phenomena apply universally is an open one. However, since restorative phenomena have been reported so extensively and in so many contexts, it seems reasonable to make a working assumption that they may reflect a general psychological phenomenon that can be appropriately studied – and perhaps explained – in a cognitive psychological framework.

Restorative potential, as defined above, refers to the capacity for a particular scene or environment to confer health and wellbeing benefits. One of the limitations of the present work, in common with much work in the area of restorative environments research, is that it is concerned with potential, rather than actual, restoration.[9] Generation of positive affect is, however, considered to be one of the primary markers of restorative environments (e.g. Hartig and Staats, 2006), and will be the main indicator of restoration potential in the present work. Although it is usually assumed to be a reliable indicator, it should be remembered that it is indicative of restoration potential, rather than evidence of actual restoration.

1.6 Impacts and implications

Understanding how the restorative potential of blue space might be altered as a result of development is relevant for people who live in communities near water. This is not a minority concern; people choose to settle near the edges of land, with 1.9 billion people living in the 'near coast zone', within 100km of the coast (Varis, 2016) and 23 of the world's largest cities located on the coast (Wheeler *et al.*, 2012). In addition, given the importance of water to tourism and recreation, it is relevant for the many people who visit aquatic landscapes for leisure. There are over 250 million trips to the English coast each year and

[9] There are exceptions, notably research by Berto and her collaborators (e.g. Berto, 2005; Berto *et al.*, 2010).

180 million to other blue-space environments, such as rivers and lakes (Natural England, 2010).

Evidence is accumulating that indicates that blue space may be an under-appreciated public health resource (White *et al.*, 2014). In order to be able to preserve its benefits in the face of increasing pressure from development (which, almost inevitably, entails the addition of artificial objects), it is necessary to develop a more complete understanding of how experiencing blue space can lead to improvements in health and wellbeing, and what factors might decrease (or increase) these benefits. Once we have an explanation for how the elements of a scene interact to produce restorative effects, it might also be possible to design future environments to incorporate more restorative elements.

1.7 Aims, objectives and contribution to knowledge

The main aim of this research is to investigate the role of scene content in affective reactions to natural scenes, particularly implicit reactions. This will be addressed by looking at the impact of artificial objects on the restorative potential of scenes both with and without water in a series of studies where scene content is manipulated and responses to the scenes (both implicit and explicit) are measured and recorded. The level of positive affect generated by a scene is assumed to be an indicator of restorative potential.

The principal objectives of the thesis are as follows:

To increase understanding of the impact of anthropogenic objects on the restoration potential of blue space.

Explore the relationship between implicit and explicit reactions to natural landscapes with and without water.

To assess the main current theories that are used to explain restorative environments phenomena.

This thesis starts with the recognition that there seems to be something special about aquatic environments; people are attracted to blue space and experience wellbeing benefits from it. The research is, however, motivated by the lack of understanding of exactly why and how blue space has these qualities along with indications from previous work (White *et al.*, 2010; Motoyama and Hanyu, 2014) that artificial objects may have an impact. This provides a starting point for investigation. The work also fits in to the broader research agenda of aiming to understand how specific elements of a scene (in all types of scene) contribute to or detract from its restorative qualities. The impact of artificial objects on blue space has not previously been investigated in detail, beyond the initial observation that they may have a detrimental effect (White *et al*., 2010).

In addition, little work has explored implicit attitudes to natural scenes in general (examples are the studies by Hietanen et al., 2006; Joye, Pals, Steg, & Evans, 2013; Korpela, Klemettila, & Hietanen, 2002), while no work appears to have been published that relates to implicit attitudes to blue space in particular. It might be expected that implicit attitudes would follow the same pattern as explicit attitudes, but whether they actually do is an open question – and one that will be addressed in the present work. It is an important question because it could provide evidence about how restorative effects arise psychologically.

Although different types of blue space have been considered in some research (for example, Herzog (1985) found that swamps were the least preferred type of waterscapes), we do not yet have a detailed understanding of which types of blue space environments are most restorative and, if there are indeed differences in restoration potential, why this might be. This thesis also makes a contribution in this area by investigating the implicit affect generated by different types of aquatic environment.

1.8 Thesis overview

In order to contextualise the studies that follow and establish a conceptual framework, it is necessary to examine the restorative environments literature. Chapter 2, therefore, reviews the evidence for restorative environments, looking at both restorative potential from the point of view of what is in the environment (i.e. components of a scene) as well as the psychological impacts. It will consider the phenomenon of people being drawn to certain landscapes, both actively seeking restoration, such as in leisure and tourism, and when not necessarily seeking restoration but displaying a preference – such as choice of where to live or stay. After reviewing the evidence that people choose these environments over others, the remainder of this chapter considers the research that shows that these environments have benefits for health and wellbeing.

Having established what characterises restorative environments, the next question to be addressed is: how do their beneficial effects arise? Chapter 3 examines the main theoretical positions that are currently used to frame explanations in restorative environments research, these being Attention Restoration Theory (Kaplan, 1995) and Stress Recovery Theory (Ulrich *et al.*, 1991). This chapter considers the extent to which each of these theories is able to account for the empirical data and where they leave gaps, then goes on to assess some recent theoretical developments that attempt to fill in some of those gaps. None of the current theories are wholly satisfactory and there is a lack of substantial explanation for many features of restorative environments. Before the theory can be advanced, however, it will be necessary to construct a more detailed understanding of the phenomena which must be accounted for.

The outputs from these two chapters are the research questions and a conceptual framework within which to investigate these questions. Chapter 4 discusses the methodology and how the research questions will be examined within the conceptual framework of the thesis. This chapter will justify taking a cognitive approach and discuss

the reasons for being interested in implicit reactions to natural scenes, as well as explaining the particular methods that will be used in the four studies reported in the chapters that follow.

Chapter 5 reports Study 1 and Study 2. Study 1 addressed the question of whether artificial objects have an impact on implicit affective reactions to natural scenes containing water. It used an experimental priming procedure and found that the presence of artificial objects did result in less positive implicit affect – a new result. It also found that the impact of artificial objects seemed to be greater for blue space than green space scenes.

After finding an impact of artificial objects on implicit affect, the most pressing question was whether a similar impact might be found for explicit affect. Study 2 addresses this question. This study used a computer-based questionnaire to record explicit affective reactions to and perceived restorativeness ratings for the same images used in Study 1. This enabled both a comparison with the implicit results from Study 1 and a comparison with previous studies that have used similar methodologies, although with different materials.

The motivation for Study 3, reported in Chapter 6, arose from an unexpected indication in the results from Study 1 that green space scenes might generate more positive implicit affect than blue space scenes. It was possible that this could be due to either some characteristic of the particular materials used, or it could be indicative of an implicit preference for green over blue space. Given the scarcity of experimental findings in this area, it was important to distinguish between these possibilities. Since Study 1 had not been designed to make a direct comparison between blue and green space, Study 3 was designed to do so. In this experiment it was found that blue space scenes generated greater positive implicit affect than green space scenes. This result was in line with the findings for explicit affect and preference in Study 2.

The next aim was to try to explain the finding from Study 1 that artificial objects had a negative impact on implicit affect – a new finding. This inspired the idea that the results might be explainable in terms of the conceptual-semantic coherence of a scene. Study 4,

reported in chapter 7, was designed to explore this possibility. It tested the novel proposal that the greater negative impact of artificial objects in blue space scenes compared with green space scenes might be explainable by the objects being more conceptually incongruent in blue space. Study 4 tested this possibility using a lexical-decision task with object-words superimposed on images of scenes. The results ruled out the semantic coherence explanation for the object effects, finding no difference between the blue space scenes and the green space scenes.

Having proposed, tested and rejected one possible explanation for the impact of artificial objects on implicit affect in chapter 7, the final chapter then provides a general discussion of the implications of the results from all the studies. It considers the theoretical implications, including what kind of theoretical framework might be needed to explain these kinds of results, and how the results from the studies reported here fit into the broader restorative environments literature. Given the explanatory shortcomings of the current main theories, this chapter will discuss whether the most recent theoretical developments within restorative environments research might be better able to account for the results. It will also discuss possibilities for future work that might help to refine the theoretical positions.

1.9 Chapter Summary

This chapter has set the scene for the thesis by rooting the research questions in a real-world context. It has introduced the idea that natural environments, particularly environments that contain water may have restorative potential for health and wellbeing. Further, it has indicated that it is not known whether introducing anthropogenic objects into such environments might affect their restorative potential. Having introduced the concept of restorative environments in this chapter, the next chapter will consider the evidence that this is a valid concept.

Chapter 2

Evidence for Restorative Environments

2.1 Introduction

Since this thesis is situated within the conceptual framework of restorative environments research, it is necessary to establish the basis for this framework as well as its validity. The aim of this chapter is, therefore, to review the evidence that experiencing certain types of environments can provide the possibility for restoration; that is, evidence that 'restorative environments' is an evidence-based concept.

The contemporary academic interest in restorative environments is predated by a long history of observational and anecdotal evidence which is discussed briefly at the beginning of this chapter in order to introduce some historical perspective. Although individual elements of the historical literature cannot be regarded as strong evidence for restorative environments phenomena owing to their lack of methodological rigour (by modern academic standards), the fact that this literature spans historical eras and cultures means that, taken as a whole, it suggests that the concept of restorative environments is meaningful and worthy of further investigation. The most striking finding to emerge from an examination of the historical literature is the consistent theme of the restorative qualities of nature and natural environments. This is interesting because although some of this literature predates the beginnings of modern-day restorative environments research by almost two millennia, the phenomena that were observed and reported are largely consistent with findings from contemporary research. It therefore seems reasonable to consider this historical literature as a precursor to the modern field.

The main body of the chapter then moves on to consider more recent work which has provided a body of evidence that is sufficiently robust and substantial to justify the existence of restorative environments as a useful concept in an academic context. It commences with an introduction to some of the seminal work that paved the way for the present day approaches to restorative environments research. The chapter then reviews more recent evidence and considers what types of environments have been shown to have restorative potential. It will cover people's preferences for different environment types, perceptions of different environments' restorative potential, and evidence for actual physiological and psychological restoration. Firstly, it assesses evidence for the restorative qualities of green space, including benefits to physical and psychological health. It then reviews the evidence for restoration in aquatic landscapes in order to assess whether the evidence supports the notion of blue space as a category in its own right, distinct from green space environments without water. Finally, it briefly considers evidence for restoration arising from other environmental types (including wholly non-natural environments and indoor environments) as well as non-visual environmental features, such as sound. Finally, the chapter concludes with a discussion of, on the basis of the literature reviewed, where the most theoretically interesting and practically useful gaps in understanding and knowledge of restorative environments lie.

2.2 History of restorative environments

It is a truism to say that we depend on the natural environment to enable our survival – the natural environment provides the resources we need for sustenance, shelter and life itself. Conversely, conditions in the environment can also take the form of threats to human survival (Wheeler *et al.*, 2014) including events such as drought, flooding, volcanic eruptions and earthquakes. It is likely that an awareness of our dependence on the environment is as old as humanity (or at least as old as the individuals who were our human ancestors). However, central to this thesis is the idea that the landscape we inhabit can

affect us in ways that go beyond meeting our immediate need for survival by having an impact on human physical and psychological health and wellbeing.

From the earliest historical records, across cultures, there are indications of a belief that the quality of the environment we inhabit has an impact on us. This is both in terms of threats, such as documented by Hippocrates (Kish, 1978) and as a positive influence on wellbeing, such as in the Hanging Gardens of Babylon, one of the seven wonders of the Ancient World, and the mythical Garden of Eden (Ward Thompson, 2011). The Ancient Greeks may have been the earliest culture for which there is evidence that ill health was recognised as being potentially caused by the influence of the environment, or simply bad luck – as opposed to supposed gods or evil spirits (Lyttkens, 2011). Furthermore, the Ancient Greeks recognised that natural settings could be conducive to mental wellbeing (Gesler, 1993) and, consequently, they took the aesthetics of the landscape into account when planning their cities (Crouch, 1993). During the time of the Roman Empire, Pliny the Elder (born 23 AD), writing in his *Natural History* on the primary importance of the natural element water, highlighted the ability of spas and springs to alleviate ill health (Jackson, 1990). The belief that the environment could also adversely affect wellbeing continued, with the eminent physician Galen of Pergamon (born 130 AD)[10] identifying a distinct category of 'environmental' causes of ill health (Porter, 1999).

Traditions of valuing the restorative potential of natural landscapes, often in the form of monastic gardens, continued throughout mediaeval Europe (Pretty, 2004; Stigsdotter and Grahn, 2002). From the 15th century onwards, the religious linkages became less important, though the spiritual significance attached to experiencing nature persisted along with the recognition of its potential to benefit both physical and mental health.

[10] Galen discovered that arteries contained blood, not air as was previously believed.

2.3 Restorative environments in more recent times

From the 18th Century onwards, the phenomenon of people seeking particular environments (or features of environments) for health and recreation began to develop, with the introduction of spas, the emergence of seaside resorts (Walton, 1981), Japanese healing gardens (Jiang, 2013) and Hydropathy (in both Germany and England) all gaining popularity on the back of the belief in the healing power of nature (Price, 2012).

The potential advantages of nature for those who were not ill were also acknowledged; even before the development of mass tourism, it was recognised that people could benefit from having access to green space. In 1724, for example, the local council bought Calton Hill in Edinburgh, making it one of Britain's first public parks (Byrom, 2005). The philosopher David Hume later lobbied for the construction of a walk there, 'for the health and amusement of the inhabitants', which was built after his death using a plan he had drawn (Douglas, 1782). The recognition that urban parks might improve public health and wellbeing continued to grow into the next century; in 1833, the Select Committee on public walks published a report acknowledging the importance of providing open spaces for 'comfort, health and content' (Conway, 1991) and recommended legislation requiring each town to provide outdoor space for its citizens. The movement for public parks grew, both in Europe and North America, where proponents such as Frederick Law Olmstead and John Muir began to argue that the benefits of green space applied to both physical and mental wellbeing (Schuyler, 1986). At the same time, the late 19th Century witnessed the emergence of policies and organisations dedicated not only to preserving the natural environment from commercial exploitation, urbanisation and industrial development, but also to promote public access, enjoyment and, implicitly, wellbeing. For example, following the designation of the world's first national park in 1872 at Yellowstone in the United States (Albright and Cahn, 1985), by the end of the century a number of other national parks had been established in the US and other countries including Canada and Australia, whilst Europe's first national park was designated 1909 in Sweden (Hoggart *et al.*, 1995). Similarly,

the National Trust was founded in the UK in 1895 with the specific purpose of saving and providing access to places of natural beauty for the benefit of the nation (Newby, 1995). Interestingly in the context of this thesis, the National trust now protects 775 mils of the UK's coastline (National Trust, 2015). As public green spaces were provided more widely, their popularity as a leisure resource grew. Then (as now), people seemed to enjoy visiting these spaces and believed in their salutogenic potential (Hartig, Mitchell, de Vries and Frumkin, 2014). At the same time, increased opportunities for travel, brought by the expansion of the railways, led to the rapid development of seaside resorts in the nineteenth century (Walton, 1981), which drew people to the coast in ever greater numbers for recreation (Brodie, 2011).

2.4 Academic interest in restorative environments

Despite the historical association between environment and health, there had been little in the way of serious scrutiny of the assumed links or systematic attempts to measure and explain them. However, a change in the conceptual background was brought about by the seminal work of Hans Selye on stress, beginning with the publication of a letter to *Nature* in 1936 (reprinted in Selye, 1998). Selye had discovered that stress, for example from factors in the environment, had predictable and measurable physiological consequences (Szabo, Tache and Somogyi, 2012). He argued that this was likely to be a general, adaptive response to environmental conditions (Selye, 1963) and coined the term 'stress' as it is currently used. Moreover, Selye provided the first scientific evidence of the general ill effects on many of the body's organ systems resulting from stressors and, as a consequence, his work represented the beginning of research in the field of stress. At that point, the focus was primarily on the negative effects the environment could have. Indeed, the idea of expanding this line of research into the potentially positive effects of the environment by asking whether environmental conditions could promote recovery of resources or functions depleted by stressors (i.e. be restorative) did not take hold until several decades after Selye's first insights. Nowadays, however, investigating whether certain features of our

environments, or certain types of environment, can improve health and wellbeing is an increasingly researched area of environmental psychology (Hartig *et al.*, 2014).

2.5 Green space benefits to physical health

Although there has been a long history of anecdote and subjective belief that contact with nature could be restorative, the notion had not been tested experimentally until Ulrich (1979), acknowledging the lack of research on this topic, conducted an experiment to test the impact on levels of anxiety of nature views compare with urban views. He found that views of nature led to lower feelings of stress (in stressed participants) than views of urban scenes, and that this difference could be attributed to an increase in positive affect[11] after viewing the nature scenes. In symmetry with Selye's findings on the negative impact of environmental stressors, Ulrich observed that natural environments, or elements of nature, reduce stress and may have beneficial physiological consequences.

Subsequently, Ulrich (1984) published a ground breaking study on the impact of the view from their hospital windows on patients recovering from gallbladder surgery. Ulrich looked at two groups of male patients, matched for age, weight, smoking habits and previous surgery. Patients in one group had a view of a brick wall from their windows whilst patients in the other group (in identical rooms on the same ward) had a view of trees. Ulrich found that the patients with the view of trees recovered more quickly (spent less time in hospital after their surgery), required fewer doses of moderate and strong analgesia, received fewer negative evaluations from the nursing staff and had experienced slightly lower rates of postoperative complications. Ulrich's work marked the beginning of restorative environments research as an academic enterprise and was significant in that he demonstrated quantifiable, beneficial effects of the environment on physical health.

[11] Affect (as a noun) is used throughout this thesis as a technical term meaning a state that represents how an object or situation impacts a person in terms of emotional valence (Duncan and Barrett, 2007).

Since Ulrich's study, evidence of benefits to physical health from experiencing nature has continued to accumulate. As well as experimental evidence, there is also evidence from various types of observational study (e.g. cross-sectional surveys, ecological studies and cohort studies). The evidence for the positive impacts of exposure to green space are reviewed in the following sub-sections for the main areas/indicators of health that have been studied to date.

2.5.1 Cardiovascular health

According to the World Health Organisation, cardiovascular disease (which includes both coronary heart disease and stroke) is the most common cause of death worldwide, with more people dying from this cause than any other (31% of all global deaths in 2012).[12] Although some of the preventable and modifiable risk factors are well-known (such as smoking and diet) others, including contact with green space, are less thoroughly understood though have been investigated in a number of studies. For example, Markevych *et al.* (2014) conducted an observational study looking at whether green space in residential areas in Germany was associated with blood pressure levels in 10 year-old children. The authors found that lower quantities of residential green space were associated with higher blood pressure levels in the children. This effect was not influenced by other potential environmental stressors, including air pollution, noise and level of urbanisation. In an experimental study, Pretty *et al.* (2005) looked at blood pressure levels in adults during exercise. Participants were asked to run on a treadmill while viewing pleasant or unpleasant rural or urban scenes projected onto the wall in front of them (a control group ran on the treadmill without seeing any images). Blood pressure was measured before and after exposure to the scenes. Pretty *et al.* (2005) found that although exercise alone reduced blood pressure, viewing pleasant scenes (both urban and rural) reduced it further, with the greatest reduction coming from viewing pleasant rural scenes. The scenes that were classified as pleasant rural in this study appear to correspond with what would typically be

[12] *Cardiovascular Diseases: Fact sheet 317*. http://www.who.int/mediacentre/factsheets/fs317/en/

described as 'green space' in the literature. It is also worth noting that, as the authors themselves point out, many of the scenes in their pleasant urban category contained green space features, such as parks and gardens.

Duncan *et al.* (2014) also conducted an experimental study that looked at the effect on blood pressure of exercising with a green view. The participants were 14 primary school children (7 girls and 7 boys) who all completed two 15-minute cycling sessions on a stationary bike. During one of their sessions the children viewed a forest scene; in the other there was no visual stimulus (order of presentation of the different scenes was counterbalanced). Results showed that systolic blood pressure was significantly lower following exposure to the forest scene compared with the control condition (no visual stimulus). There was no difference in diastolic blood pressure between the two conditions.[13] Although these results are suggestive of a benefit from viewing the forest scene, since the control condition consisted of no scene it is not possible to conclude that the benefit arose from green space as such – it could have been a benefit from simply having an image to look at (or a detriment in the case of having no image to look at in the control condition). Nonetheless, the results have interesting potential implications for places where people participate in indoor exercise and might benefit from having images of nature to look at during their activities.

In another study, Hu *et al.* (2008) discovered from analysis of census data in Florida that high levels of stroke mortality were associated with low levels of green space. In similar analyses of UK census data, studies by Mitchell and Popham (2008) and Richardson and Mitchell (2010) also found that (controlling for other potential risk factors), deaths from cardiovascular disease were more likely among populations living in areas with less green space. This is consistent with results from a large-scale study of 249, 405 Medicare beneficiaries aged over 65 in Florida (Brown *et al.*, 2016), which found that higher levels of

[13] Diastolic blood pressure is the pressure in between beats (i.e. the lowest pressure). Systolic pressure is the amount of pressure exerted on the arteries when the heart is pumping out blood (Pal and Pal, 2005).

residential greenness were associated with lower rates of cardiometabolic conditions. It was also found that the relationship between health and green space was stronger and more reliably positive in lower and middle income neighbourhoods than higher income neighbourhoods.

Maas *et al.* (2009), in a cross-sectional study of morbidity data in the Netherlands, similarly found that greater levels of residential green space were associated with a lower risk of coronary heart disease, whilst Pereira *et al.* (2012) investigated whether a relationship exists between neighbourhood green space and risk of coronary heart disease and stroke, looking at both self-reports and hospital admission data. This study was unusual in that it not only assessed the quantity of green space in a neighbourhood but also looked at the variability of green space, dividing areas into 'highly variable greenness', 'predominantly green' and 'predominantly non-green' (the latter two both being classed as low variability of greenness). They found that adults who lived in neighbourhoods with highly variable greenness were 37% less likely to be hospitalized for heart disease or stroke than adults living in the low variability neighbourhoods, independent of the absolute level of green space. The authors speculate that this may be explained by the fact that the neighbourhoods with highly variable greenness may be more conducive to physical activity, such as neighbourhood walking. However, the study did not directly measure levels of physical activity. This factor is discussed further in Section 2.5.2 below.

2.5.2 Physical activity

A growing body of evidence supports the idea that the composition of the local environment can influence activity levels (Lee, Jordan and Horsley, 2015). One of the benefits of nearby, accessible green space is that it may encourage people to be more physically active (Coombes, Jones and Hillsdon, 2010). This can arise because of the ease of access to and opportunity for activities such as walking or cycling, particularly in areas such as urban parks (Macintyre, Macdonald and Ellaway, 2008). Although there is an abundance of

research that reinforces this positive association between green space and physical activity (e.g. Richardson *et al.*, 2013; Mytton *et al.*, 2012; Gong *et al.*, 2014; Cochrane *et al.*, 2009; Coutts *et al.*, 2013), several studies have not found an association (e.g. Ord *et al.*, 2013; Hillsdon *et al.*, 2006). Furthermore, Maas *et al.* (2008) not only failed to find an association between green space in residential environments and self-reported physical activity, but also found that people who lived in proximity to more green space walked and cycled less (in both frequency and duration) than people with less green space in their living environment. It is possible, however, that these results can be explained by the characteristics of the areas studied; as the authors point out, it is likely that the areas characterised by more green space were likely to be further away from shops and other urban facilities, making it more likely that people would use cars than travel by bike or on foot.

Several studies have combined measures of greenness[14] in the environment with data from GPS and accelerometer units worn by participants during the course of their normal activities to look at the association between green space and physical activity. The advantage of this approach is that it allows the levels of actual activity when in the presence of green space to be measured, as opposed to the measurement of general activity levels reliant on self-reports. For example, Almanza *et al.* (2012) used wearable GPS and accelerometer units to examine the relationships between exposure to greenness and activity in children. They found that when the children were in greener areas, the likelihood of contemporaneous physical activity was greater. There are further studies that have used GPS and accelerometer data from children that have found similar results (Lachowycz *et al.*, 2012; Wheeler *et al.*, 2010).

[14] The measure used is often the Normalized Difference Vegetation Index (NDVI), calculated from reflectance picked up by satellite images of the Earth's surface. It is possible to distinguish green, as produced by chlorophyll and calculate vegetation cover from the satellite images (Gao, 1996).

In other investigations of activity levels in children, Grigsby-Toussaint *et al.* (2011) found an association between neighbourhood greenness and physical activity in preschoolers, although the authors concluded that, for this age group, parental involvement was the most critical factor.

Although physical activity is beneficial to health in itself (Warburton *et al.*, 2006), positive effects that have been found on wellbeing in this context do not come from the exercise alone; several studies have found that physical activity conducted in natural environments provides health benefits over and above the same activities conducted in synthetic environments (e.g., Bodin and Hartig, 2003; Bowler, Buyung-Ali, Knight and Pullin, 2010). So it seems that green space has a double benefit in this respect – firstly, it increases the likelihood that people will be physically active more often (Rosso *et al.*, 2011); and secondly, physical activity in green space, as opposed to other settings, is particularly beneficial to health and wellbeing (Yeh *et al.*, 2015).

2.5.3 Obesity

Levels of obesity are rising at an increasing rate; according to most recent data, approximately one quarter of adults in the UK are classified as obese compared with around 16% in the period 1993-1995[15]. Although this is a public health issue which is usually considered to be within the remit of doctors and dieticians, there is mounting evidence suggesting that the urban environment, in particular urban green space, could play a role in tackling the issue (Barton and Grant, 2013; Nielsen and Hansen, 2007).

Specifically, Liu, Wilson, Qi, and Ling (2007) investigated the relationship between being overweight amongst children and the amount of vegetation surrounding their residence in areas of differing population density. They found that for those children living in high

[15] *Public Health England, Adult weight data factsheet*, published October 2015: http://www.noo.org.uk/securefiles/151118_0648//Adult_weight_factsheet_October_2015.pdf

density areas, increased vegetation was correlated with lower weight. In a subsequent study, Bell, Wilson, and Liu (2008) looked at changes in body mass index (BMI) in children and young people over a two-year period. They found that higher levels of green space were associated with less weight gain over the two-year period. Similarly, Dadvand *et al.* (2014) also evaluated the relationship between obesity and different types of green space in children (9-12 years old) in Spain. They also found that an increase in green space surrounding residential areas and residential proximity to forests were strongly associated with a lower incidence of obesity. However, residential proximity to parks only showed a weak negative association with overweight/obesity. The authors were unable to conclude whether this was due to some particular feature of their respondents, such as a self-selection bias, or the environments themselves (e.g. the quality of the parks), for which they had no detailed data.

However, the relationship between green space and obesity is not always clear cut in the literature. For example, Coombes *et al.* (2010) combined data from a survey of 6821 adults in Bristol with a database of neighbourhood and green space characteristics. They assessed the relationship between access to green space, frequency of use of green space, weight and physical activity and found that although respondents living closest to green space were less likely to be overweight, once the results were adjusted to take account of respondent characteristics, area deprivation and other neighbourhood environment characteristics, the association with weight did not hold. Similarly, Mowafi *et al.* (2012) found no association between BMI and neighbourhood green space in their study based on the 2007 Cairo Urban Equality Study. The authors conclude that relationships between green space and obesity that have been observed in other studies in western urban contexts might not apply in developing countries. However, given that other studies have also failed to find an association (Cummins and Fagg, 2011), have found only a weak association (Oreskovic, Winickoff, Kuhlthau, Romm and Perrin, 2009; Tilt, Unfried and Roca, 2007) or an association only for certain environment types (Witten, Hiscock, Pearce and Blakely, 2008) or different

subgroups (Astell-Burt, Feng and Kolt, 2014; Prince *et al.*, 2011), the Mowafi study is not necessarily unusual in its results. In a review of the literature, Lachowycz and Jones (2011) point out that although most research in this area has found evidence of some relationship between BMI and green space, there has also been some variation, primarily due to subgroups and different measures being used. Cross-sectional surveys have commonly been used, and bias in the results obtained in this way due to non-responses is an acknowledged potential problem with this methodology (James, Banay, Hart and Laden, 2015). However, further research is undoubtedly needed to examine whether the links between green space and obesity – as well as other links between green space and health – hold in a range of different countries and cultures.

2.5.4 Mortality

There is evidence from a range of mainly observational studies that higher levels of green space are associated with lower mortality. In one of the earliest studies that looked at mortality in relation to green space, Takano, Nakamura and Watanabe (2002) correlated residential proximity to urban parks with mortality in senior citizens. They found that the five-year survival rate of participants in the cohort study (3144 Tokyo citizens) increased with proximity of their residence to parks and tree-lined streets.

Hu *et al.* (2008) examined the association between air pollution, greenness and mortality from stroke in Florida. They found that the greatest rate of death from strokes was found in areas with low quantities of green space, whilst stroke deaths were also associated with higher levels of air pollution and lower levels of income. The authors suggest that increasing green space in areas of low income and high air pollution may modify the detrimental effects of those factors to some extent. (Wilker *et al.*, 2014) investigated the impact of residential proximity to green space on post-stroke survival and found that green space was associated with lower mortality and Villeneuve *et al.* (2012) conducted a cohort study of 575,000 adults aged over 35 in Canada. They matched place of residence to surrounding urban green

space, controlling for air pollution, and discovered that higher levels of green space were associated with lower non-accidental mortality. They found that this was attributable to cardiovascular health outcomes.

Similarly, in a UK-wide study, Richardson and Mitchell (2010) found that mortality from cardiovascular and respiratory causes was lower with increased residential proximity to green space for men (the same association was not found for women). However, after adjusting for potential confounding variables, Richardson *et al.* (2010) did not find an association between the availability of green space and mortality from cardiovascular ill health. This was not in line with their predictions and the authors speculate that it may demonstrate that the health benefits usually associated with exposure to green space may vary depending on factors such as geographic location – this study was carried out in New Zealand where, as Richardson *et al.* (2010) point out, the overall levels of green space relative to urban environments may be greater than in the locations of other similar studies. In an attempt to uncover some of the potential mediating factors between green space and health outcomes, Lachowycz and Jones (2014) evaluated the relationship between self-reported walking, access to green space and mortality to see whether any association between green space and mortality might be mediated by walking. Although they found that greater access to green space was associated with more (self-reported) walking in all areas included in the study, there was only an association between green space and reduced mortality rates in the most deprived areas. Furthermore, it was not possible to explain this association between green space and mortality by quantity of recreational walking.

It is not currently clear whether there are general mechanisms underlying the associations between green space and mortality, or whether mortality outcomes may be secondary to other health impacts, as some of the studies discussed above imply. It is certainly the case that many of the health outcomes that have been studied in this context are linked (for example, lack of physical exercise is associated with increased risk of obesity, which is

associated with increased risk of heart disease, and so on), both to each other and to mortality. However, because most of the research in this area has relied on ecological data (as opposed to controlled experiments, for example), despite the correlational evidence it is not possible to draw firm conclusions about causal effects of green space on mortality.

2.5.5 Physical health summary

In general, many measures of health have been found to be better when people live in close proximity to green space. Furthermore, larger green spaces often confer larger benefits (Mitchell *et al.*, 2011; Ward Thompson *et al.*, 2012). However, researchers have also found that these benefits are not always equal across different sections of society (James *et al.*, 2015); in particular, stronger associations between green space and health have been found in groups of lower socio-economic status (Dadvand *et al.*, 2012; Maas *et al.*, 2009; Mitchell and Popham, 2008). There is also evidence that the quality of green space may be important (Mitchell and Popham, 2007). Because so many of the studies in this field are large-scale observational studies, it is often difficult to disentangle the various factors that may contribute to the health effects and reveal the underlying mechanisms and it is not usually possible on the basis of such studies to infer a direct causal link between green space and good health. However, Hystad *et al.* (2014) concluded that it was likely the association between health outcomes and green space in their study could be explained by underlying psychological and psychosocial mechanisms related to experiencing green space.

2.6 Green space and psychological health

According to the United Nations, more than half the world's population lives in urban areas, an increase from a third of the population in 1950. By 2050, two-thirds of the global population is projected to be urban[16]. With this rise in urbanisation comes an increase in associated ill health, not only the physical disorders that are disproportionately linked with

[16] United Nations, Department of Economic and Social Affairs, Population Division (2014). *World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).*

cities (e.g. cardiovascular disease, as discussed above) but also mental health (Peen, Schoevers, Beekman and Dekker, 2010; van Os, Pedersen and Mortensen, 2004). However, it appears to be the case that green space in urban areas may be able to mitigate this to at least some degree (Herzog, Maguire and Nebel, 2003). This section will consider the restorative impact of greenness on mental health, stress and happiness.

2.6.1 Mental health

Green space may improve mental health by indirect means, such as encouraging physical activity (Humpel, Marshall, Leslie, Bauman and Owen, 2004) or fostering social cohesion (Fan, Das and Chen, 2011), or by having a direct impact on mental functioning (Grinde and Patil, 2009). These effects are found independent of degree of urbanization (Triguero-Mas *et al.*, 2015). It is worth pointing out that many of the studies in this area are cross-sectional surveys, in which non-responses can limit generalisability (James *et al.*, 2015). These types of studies also do not enable conclusions to be drawn about causality; rather, they can only note correlations. There is also the potential weakness of using self-reported measures with similar answering formats for various factors together, creating a possibility for associations to arise due to the method and process of responding and a possibility of overestimating the strength of associative relationships (de Vries, van Dillen, Groenewegen and Spreeuwenberg, 2013).

Nutsford, Pearson and Kingham (2013) looked at whether urban green space is associated with mental health. In a cross-sectional study in Auckland, New Zealand, they assessed total green space and usable green space in 3149 small areas against numbers of anxiety/mood disorder treatments amongst residents in those areas. They found that higher amounts of total green space and usable green space within 3km of residence were significantly associated with a lower number of treatments for anxiety/mood disorders. Several studies have investigated the importance of quality versus quantity of neighbourhood green space. For example, Pope *et al.* (2015) looked into the relationship between mental health and

quality of and access to green space in a deprived urban community in the UK. They found that quantity of green space, accessibility to green space and having the ability to use green space for recreation were significantly associated with reduced mental ill health. Furthermore, the authors note that there appeared to be a dose-response relationship between the quality of the green space (in terms of the number of positive green space attributes) and the reduced reporting of mental ill-health.

Conversely, Francis, Wood, Knuiman and Giles-Corti (2012) found that in an urban area, the quality of public open space was linked with mental health whereas the quantity was not – residents of neighbourhoods with high quality open space (quality being defined according to features such as trees, water, birdlife, paths) were less likely to suffer from poor mental health. However, the quantity of open space was not associated with mental health status. In a similar study, de Vries *et al.* (2013) found that quality of streetscape greenness was significantly associated with better mental health. Although there was an association with quantity of greenness and mental health, the quality and quantity of greenness were related and quality was the most important factor in predicting mental health. As the authors point out, however, streets in which the quality of greenness was high may have been likely to be visually attractive on other dimensions (other aspects of design and layout), meaning that it could have been the overall attractiveness of the neighbourhood that was having an impact on general wellbeing and residential satisfaction, rather than just the quality of the green space. This would be consistent with results from an experimental study by Karmanov and Hamel (2008), who found that the overall attractiveness of an environment, not specifically greenness or urbanicity, was the most important factor for mental restoration. Sugiyama, Leslie, Giles-Corti and Owen (2008) looked at both perceived greenness and actual green space. They found that people who perceived there to be a high level of greenness in their surrounding neighbourhood were more likely to have better mental health than people who perceived there to be less greenness. Thus, although it is not possible to infer the direction of any causality (for example, it could be the case that better

mental health creates a predisposition to perceive higher levels of greenness), the fact that people's perceptions of greenness may differ could be an important consideration for future work.

Some research has investigated potential mediators between green space and mental health outcomes. Maas, van Dillen, Verheij and Groenewegen (2009), for example, looked at whether social contacts might be an underlying mechanism behind green space benefits on health. They found that lower amounts of green space were associated with more feelings of loneliness and a perceived lack of social support. Annerstedt *et al.* (2012) did not find a direct association between access to green space and mental health in their analysis of data from a longitudinal population survey in Sweden. After follow-up, however, it was found not only that the additive effect of access to green space combined with exercise did reduce the risk of poor mental health, but also that the effect was stronger for women than for men. It is worth noting, however, that Annerstedt *et al.* (2012) used data only from rural and suburban areas in their study, discounting data from urban areas because it was not possible to assess levels of greenness in the urban areas from the survey data they used. This makes it difficult to make a direct comparison with results from other studies that have included data from urban areas. De Vries *et al.* (2013) found that physical activity was not a mediating factor between green space and mental health, but social cohesion and stress were the most important mediators, whilst Maas *et al.* (2008) further reported that exercise did not mediate the effect of green space on perceived health. Rather, after adjusting for socio-economic and demographic characteristics, Maas *et al.* (2009) discovered that perceived social support and loneliness were the most important mediators of the association between low amounts of green space in the residential environment and lower self-perceived physical and mental health.

In addition to the study by Annerstedt *et al.* (2012), a small number of other studies have been conducted that have looked at the longer term impact of green space on mental health.

These include a study by Astell-Burt, Mitchell and Hartig (2014), who used longitudinal survey data to investigate how the association between green space and mental health varies across the life course for individuals living in urban neighbourhoods. They found that, before taking age into account, green space was associated with better mental health for men but not women. When age was included in the analysis, the association between green space and mental health was found to vary across the life course, and also to differ for men and women. For men, green space had the most beneficial impact on mental health in early to mid-adulthood. For women, moderate green space availability was associated with better mental health among older women. It is not obvious why the effects should differ across the life course or why there should be gender-specific trajectories, and there is currently a lack of research that addresses these questions.

Similarly, White, Alcock, Wheeler and Depledge (2013) also used data from a longitudinal survey (over 18 years of data from more than 10,000 participants) which enabled them to look at the relationship between urban green space and mental distress for the same individuals over time. This methodology allowed the authors to control for individual and regional covariates. They found that living in areas with more green space was associated with both lower levels of mental distress and higher levels of psychological wellbeing. Alcock, White, Wheeler, Fleming and Depledge (2014) assessed the longitudinal effect on mental health of people moving to urban areas with differing levels of green space. They used data from the British Household Panel Survey for participants with mental health data for five consecutive years and who had moved to a different residential area between the second and third years. Controlling for variables in both the areas (such as employment deprivation and crime index) and the individuals (such as marital status, household income and employment status), they found that people who moved to areas with more green space had significantly better mental health compared to before their move, and this persisted for the three years that were monitored after the move. In contrast It was found that people who moved to areas with less green space had slightly worse mental health scores in the

year before the move, though returned to baseline scores in the years after the move. The explanation for this dip is not clear from the data although, as the authors speculate, this could be due to anticipation of a move to a less green area. These panel data-based studies are particularly strong in that they were able to control for variables that are often not possible to take account of in cross-sectional studies, thus making it much more likely that apparent effects of green space are actually due to green space and not one of the many potentially related variables.

2.6.2 Stress

Stress can be defined as the psycho-physiological state that occurs when an individual perceives that environmental conditions or demands exceed or are likely to exceed that individual's ability to cope with those demands (Evans and Cohen, 1987). Just as environmental conditions can cause stress, there is a growing body of evidence that environmental conditions, in particular the presence of nature and green space, have the potential to reduce stress. There are various ways in which green space might be beneficial. As well as the possible direct link of people visiting the green space for the purpose of stress reduction (Home, Hunziker and Bauer, 2012), there are indirect routes, such as the presence of green space often resulting in relative absence of potential urban stressors (Hartig *et al.*, 2014), for example hiding unattractive constructions (Smardon, 1988) and providing screening and privacy for homes (Day, 2000).

Stigsdotter *et al.* (2010) analysed data from a Danish Health Survey of randomly selected adults which included over 11,000 returned questionnaires. The authors found that people living more than 1km away from the nearest green space self-reported poorer health and health-related quality of life and they were also more likely to experience stress than people living under 300m from the nearest green space. At the same time, there was an evident association between self-reported stress and visiting green space; that is, people who did not visit green space were more likely to report stress. It was not possible, though, to infer

the direction of causality as to whether people were less likely to visit green space because they were suffering stress or whether they were suffering stress because they were visiting green space less often. However, there was a perception among respondents that green space might contribute to the reduction of stress and certainly, for those individuals who were suffering stress and did visit green space, alleviation of stress was given as a reason for making those visits.

Using data from a population health survey of Wisconsin, Beyer *et al.* (2014) found that higher levels of green space were associated with lower levels of stress, as well as less anxiety and fewer symptoms of depression, when taking into account a range of potentially confounding factors. They controlled for a range of individual-level potential confounders, such as socio-economic status, level of education and employment status, as well as potential neighbourhood-level confounders such as level of urbanicity and population density. Similar results have been found when looking at perceived availability of green space in neighbourhoods. For example, in a cross-sectional survey, Gidlöf-Gunnarsson and Öhrström (2007) found that among the residents who perceived they had better access to green space, fewer exhibited stress-related symptoms than among those who perceived they had less access to green space.

Because short-term stress can be induced in volunteers for the purposes of studying its effects in a restorative environments context, it is possible to carry out experimental manipulations that could not be done with most other indicators of psychological ill-health. It is also possible to make use of known stressful situations in order to study social ecological effects. In addition, instead of relying only on self-reports, as is common when it comes to some other psychological health measures, stress has physiological consequences that can be measured and studied objectively, such as impacts on blood pressure, heart rate and cortisol levels (De Vente, Olff, Van Amsterdam, Kamphuis and Emmelkamp, 2003). Ulrich, Simons and Miles (2003) conducted a study in a clinic waiting room for blood donors.

Participants (872; 68% males) were presented with videos of different environmental conditions to view on a television monitor, including nature settings, urban settings, daytime television or a blank monitor. Blood pressure and pulse rate were measured to record the effect on donor stress. Ulrich *et al.* (2003) found that stress was lower during the no television condition and the nature condition, and higher during the urban condition. Pulse rates were significantly lower during the nature condition. These results are consistent with earlier work by Ulrich and his collaborators which has found that physical indicators of stress, such as heart rate and muscle tension, can be reduced by exposure to nature as opposed to urban scenes (Parsons, Tassinary, Ulrich, Hebl and Grossman-Alexander, 1998; Ulrich *et al.*, 1991). An interesting implication of the results from this study is that the common practice of playing daytime television in healthcare settings could increase stress levels in outpatients (who may already be feeling stressed).

Hartig, Evans, Jamner and Davis (2003) compared stress recovery in natural and urban settings amongst young adults. They found that sitting in a room with a view of trees led to a faster decline in diastolic blood pressure than sitting in a room with no view, and subsequent walking in a forest setting had a greater effect on reducing symptoms of stress than walking in an urban setting. Van Den Berg and Custers (2011) experimentally investigated the impact on stress of outdoor gardening versus indoor reading. Participants performed a stressful visual attention test then were either allocated 30 minutes of outdoor gardening or 30 minutes of indoor reading on their own allotments. Salivary cortisol and mood (assessed by self-report) were measured throughout. It was found that there was a decrease in cortisol levels for both activities during the recovery period, although the decrease in the group who did outdoor gardening was significantly greater. For the gardening group, positive mood was fully restored after the recovery period (to pre-task levels) whereas in the reading group, mood continued to deteriorate. These findings are in line with other studies that have found that outdoor gardening can decrease self-reported stress more than indoor activities (e.g. Hawkins, Thirlaway, Backx and Clayton, 2011).

Ward Thompson *et al.* (2012) conducted the first observational study in which cortisol levels were measured in non-experimental, ecologically valid settings in order to study the impact of green space on biomarkers for stress (in this case, cortisol levels), as well as self-reported stress, in the course of everyday lives in a deprived urban population. They found significant relationships between self-reported stress, patterns of cortisol secretion and the amount of green space in the residential environment. Further analysis of the results showed that the amount of green space in the residential environment was a significant and independent predictor of the pattern of cortisol secretion. Larger quantities of green space in the residential environment were associated with healthier patterns of cortisol secretion.

The findings of this study by Ward Thompson *et al.* (2012) were replicated and extended by Roe, Thompson, Aspinall and Brewer (2013) who recruited 106 participants (aged 35-55, not in work) from the same urban area in Scotland as the previous study. Salivary cortisol was measured three times per day over the course of two days, along with self-perceived stress levels. There was a significant negative relationship between stress levels and green space (i.e. higher amounts of green space were associated with lower stress levels). Furthermore, it was found that the results differed according to gender, with women in areas of low green space showing higher levels of stress than men.

One factor that may provide a partial explanation for some of the findings on the relationship between green space and stress was suggested by Woo, Tang, Suen, Leung and Wong, (2009) who examined telomere length in 976 males in Hong Kong in a study of their health status. Telomere[17] length is inversely associated with psychological stress, as well as mortality and chronic diseases. They found that telomere length was greater in people living in the district that contained parks and green spaces. Although this is not evidence of a

[17] Telomeres are proteins that 'cap' the ends of chromosomes and protect them from degradation (Der *et al.*, 2012). Age-related diseases have been found to be characterised by shortened telomeres (Blasco, 2007).

causal relationship, the work does indicate a possible mechanism for the association between green space and health which is worthy of further research.

2.6.3 Subjective wellbeing and happiness

Although happiness is an end in itself, and was recently recognized by the UN as a measure of the progress of nations, when it invited countries to measure the happiness of their citizens and use this as a guide for policy-making (Layard and Sachs, 2013), it is also associated with better general health (Steptoe and Wardle, 2005) and longevity in healthy populations (Veenhoven, 2008).

It seems, however, that the relationship between happiness and green space may not hold for all sections of the population. Huynh, Craig, Janssen and Pickett (2013), for example, looked at the relationship between positive emotional wellbeing and public green space amongst young people in Canada. In a cross-sectional study including over 17,000 students, only weak and inconsistent associations were found between measures of green space and positive emotional wellbeing, leading the authors to conclude that there is not a strong relationship between public green space and emotional wellbeing in young people. It was not possible, on the basis of the results, to explain why the impact of green space might be different on younger people, though the authors point out that by focusing on only public green space, potentially significant quantities of green space that the participants were exposed to might have been missed out, for example in private gardens and agricultural land. However, bearing in mind that the majority of the participants in the Huynh *et al.* (2013) study were under 16, their results are not inconsistent with other work such as the study by Astell-Burt *et al.* (2014) discussed above, based on longitudinal data, which revealed that effects of green space emerged in early to mid-adulthood in men and later in life for women. Further investigation of how greenness may have different impacts across the life course is clearly needed.

A further study that similarly did not identify an association between green space and happiness in younger people was conducted by Saw, Lim and Carrasco (2015). The authors investigated the relationship between psychological wellbeing and access to/use of different green spaces among young adults (18-25 years old) in Singapore by means of a survey of students at the National University of Singapore (*n*=426). The results showed no significant relationship between wellbeing and either use of or proximity to green space. The authors suggest that characteristics specific to Singapore may explain the lack of a relationship – that is, it being a temperate, non-European city with relatively high levels of urban greenery, which makes it different in character to many (Western) urban environments used in similar research. While this may be the explanation, it is also possible that the age of the participants may have contributed to the (lack of) findings in this case.

In a study looking at individual happiness in relation to different types of environment, MacKerron and Mourato (2013) devised a smartphone app that was able to match momentary subjective happiness ratings with an individual's geographical location using their mobile phone's GPS. Once downloaded on to a participant's phone, the app alerted them at random moments, presenting a brief questionnaire as well as recording location data. After releasing the app, Mackerron and Mourato collected over one million responses from more than 20,000 UK-based participants. They were able to control for factors including weather, daylight, activity, companionship, time and response trends; they found that when outdoors, participants were significantly happier in green space (all types) than in urban environments. Comparisons were made within individuals. This study is noteworthy, both for the originality of its method and the scale and scope of the data collected. However, despite the large sample size, the authors point out that the demographic profile of their participants was not representative of the UK as a whole, since the app was only available on iPhone. This resulted in a relatively wealthy (median household income was twice the UK average) and young (66% aged under 35) sample, 78% of whom were in employment and 13% in full-time education. Although this means the

results cannot necessarily be generalised to the population at large, the relationships found were highly statistically significant and reliable within the sample. However, the strong associations do not provide information about any possible direction of causality – for example, it could be the case that the participants were more likely to visit green space as a result of being happy, rather than becoming happy as a result of visiting the green space. This is a clear and important avenue for future research.

2.7 Restorative benefits of blue space

Despite its importance for human survival, settlement and landscape aesthetics, as well as its frequent presence as a natural element in environments classed as 'green', blue space had not until recently been considered as a separate category in restorative environments research (White *et al.*, 2010). Motivation for considering that landscapes containing water might form a distinct category in this context comes both from the ubiquity of aquatic elements in historical restorative landscapes (e.g. Jackson, 1990; Price, 2012) as well as the popularity of water in modern environments for leisure and wellbeing (Gustavo, 2010; Verouden and Meijman, 2010).

Studies looking at the restorative qualities of natural environments/green space have sometimes included areas containing aquatic features as a separate category (e.g., Hansen-Ketchum, Marck, Reutter, and Halpenny, 2011; Richardson *et al.*, 2013). On occasion, water has deliberately been excluded from stimuli depicting natural environments (e.g. Herzog *et al.* 2003) whereas at other times, aquatic features have not been treated systematically, thus running the risk of water becoming a confounding factor in the results (e.g. Berman, Jonides, and Kaplan 2008; Pretty *et al.* 2005; Karmanov and Hamel, 2008; Korpela, Ylén, Tyrväinen, and Silvennoinen 2010).

Nevertheless, despite the inconsistency in the way water has been treated in some of the research, other work has been done that has addressed some of the questions about the

restorative potential of aquatic environments. As a feature of the landscape, water has particular aesthetic appeal and people are arguably drawn to it more than to other landscape features (Burmil, Daniel and Hetherington, 1999). Moreover, the presence of water is a strong predictor of how attractive people will find a landscape (Ulrich, 1983; Zube, Sell and Taylor, 1982) whilst there is also evidence that people treat landscapes containing water as a separate typological category (Amedeo, Pitt and Zube, 1989), further supporting the idea that blue space could be considered as a classification in its own right.

Purcell *et al.* (2001) included lakes as a category in their study of preference for and restorativeness of different types of outdoor scene. They found that of their scene-types, which included natural and urban scenes, lakes were the most preferred and were rated as being the most restorative. However, there is some indication from previous research that not all water is equal when it comes to restorativeness and preference. Herzog (1985), for example, looked at different types of water in his study of preferences for waterscapes. 249 students from the University of North Carolina rated a series of 70 colour slides depicting aquatic scenes on 7 variables, including how much they liked the scene. Herzog found that mountain waterscapes were the most preferred, with swampy areas the least preferred (the other categories were large bodies of water and rivers, lakes and ponds). Of the other variables that were measured, coherence of the scene and spaciousness were significant predictors of preference. Herzog did not include scenes without water in the study, so it is not possible to tell how the preference for aquatic scenes might fit into overall preferences for natural scene types. However, it is perhaps not surprising that swampy areas were the least preferred, given the increased likelihood of stagnant water in these areas (and associated factors, such as possible bad smell and biting insects). More recent research has found that people are sensitive to water quality and are more attracted to water that appears to be higher in quality (Lee and Lee, 2015; Smith, Cragg and Croker, 1991; Wilson, Robertson, Daly and Walton, 1995). Herzog and Bosley (1992) found a difference between types of water in their study which looked specifically at tranquillity of and preference for

different scenes. Large bodies of water were rated higher for tranquillity than preference (as were 'misty mountains' and 'field-forest'), while preference was rated higher than tranquillity in the category 'rushing water'.

(White *et al.*, 2010) found that natural scenes containing water were consistently rated more highly for preference, perceived restorativeness and positive affect than scenes without water. More surprisingly, given previous findings that urban scenes are the least restorative although in line with earlier work by Karmanov and Hamel (2008), White *et al.* (2010) found that urban scenes containing water also received high restorativeness ratings, suggesting that the aquatic/non-aquatic distinction may be just as important as the natural/urban distinction made by most previous studies. White *et al*. point out, however, that studies making such a distinction have often unintentionally used natural scenes containing water and urban scenes without water, potentially confounding their results. Wilkie and Stavridou (2013) compared pleasant and unpleasant water in both urban and rural scenes in a study of scene preference and perceived restoration. They found that water quality had an impact on perceived restoration, with pleasant waterscapes receiving the highest ratings and unpleasant waterscapes receiving lower ratings than scenes containing no water.

In a large-scale epidemiological study of adolescents (aged 11-16 years) in Canada, Huynh et al., (2013) investigated the relationship between exposure to urban green space and positive emotional wellbeing. Although only a weak positive association was found between green space and emotional wellbeing overall, the results showed that the neighbourhoods that were associated with more positive emotional wellbeing contained more blue space, leading the authors to suggest that the association might be explainable by exposure to water. Other work reporting that urban spaces containing water can also provide restoration and increase happiness includes studies by Völker and Kistemann (2011, 2015) and Pradhan (2012).

Indoor water has also been studied (though not in comparison to outdoor aquatic environments). Cracknell, White, Pahl, Nichols and Depledge (2015) explored the impact on restorative experiences for visitors of different levels of animal and plant life in a large aquarium. They found that increased levels of animal and plant life corresponded with reductions in heart rate and improved self-reported mood amongst viewers of the exhibit.

The idea that aquatic environments can be beneficial to health has developed from early beginnings in spas and healing water places (Foley, 2011) to modern, evidence-based research programmes such as Blue Gym at the University of Exeter (Cresswell, 2010; Depledge and Bird, 2009; Wheeler, White, Stahl-Timmins and Depledge, 2012) which is investigating how natural water environments can be used to promote public health and wellbeing (Ashbullby, Pahl, Webley and White, 2013). It has been found that improvements to self-esteem and mood from exercise are increased during exercise in green space and increased further when water is present in the exercising environment (Barton and Pretty, 2010). However, compared with the attention that green space has received, the potential of blue space in this context is still relatively unexplored (White, Pahl, Ashbullby, Herbert and Depledge, 2013), despite its potential relevance to public health policy in social and public spaces (Foley and Kistemann, 2015).

More specifically, the extent of the constraints on the potential for blue space to be restorative has received little attention beyond the effects of water quality (Lee and Lee, 2015) and the possibility that quantity of water may be important (Shafer and Brush, 1977). White, Cracknell, Corcoran, Jenkinson and Depledge (2013) considered the impact of inclement weather conditions on preferences for waterscapes, noting that previous work had often used images of aquatic scenes only in pleasant-looking conditions with sunny blue skies (e.g. Han, 2010; Ulrich, 1983). When weather conditions in their scene categories (waterscapes, green/rural and urban) were varied, White *et al.* (2013) found that although the order of preference was maintained between the scenes (waterscapes the most

preferred, followed by green space then urban scenes) preference for waterscapes was significantly higher during clement weather conditions, whereas preference for urban scenes was unaffected by the weather. These results seem congruent with findings reported by Hipp and Ogunseitan (2011) who discovered that visits to the coast are perceived as being more restorative when the weather is sunny. Other factors that might undermine the restorative potential of blue space scenes include litter and objects that are not naturally part of the landscape. Wyles, Pahl, Thomas and Thompson (2015), for example, investigated the impact of marine litter on preference for and perceived restorative quality of coastal scenes. They found that the presence of litter could reduce the potential psychological benefits of the scenes, with different types of litter having different impacts – litter left by the public (as opposed to drift seaweed and fishing litter) had the most negative impact.

A number of early studies found no beneficial effect of water over and above that of green space (Ulrich *et al.*, 1991; van den Berg *et al.*, 2003) However, it is difficult to generalise on the basis of these studies. In the study by Ulrich *et al.*, (1991), for example, no effect of water was found in the pilot for the study (no data are presented) resulting in the water category being abandoned for the main study. Conversely, Van den Berg *et al.* (2003) compared the restorative qualities of a walk in an urban or rural setting with and without water, and found no effect of water on restorativeness. However, the water that was used in their materials was a brown, small stream or canal – while technically water, it was perhaps not representative enough of water in general to be able to draw firm conclusions. The authors themselves point out that it is possible that their manipulation may have been too weak to have a detectable effect, and conclude that more work is needed to elucidate the role of water.

In a more recent study, Triguero-Mas *et al.* (2015) looked at relationships between natural outdoor environments and physical and mental health. They used data from a cross-sectional survey of adults living in Spain. While the authors found that green spaces were

associated with better mental and physical health, the results for blue space (which was included as a separate category) were inconclusive. However, only 6% of their respondents lived near water, so it may be that they did not have a large enough sample to be able to detect any effects. Another recent study of adults in New Zealand indicates that visibility of blue and green space may be a more relevant measure than simple proximity (Nutsford, Pearson, Kingham, and Reitsma, 2016). This study was designed to investigate possible relationships between the visibility of blue space in urban neighbourhoods and self-reported psychological distress. Nutsford et al. accessed pre-existing national data from the New Zealand Health Survey and used geospatial techniques to map the Vertical Visibility Index[18] of the study area. Controlling for factors including age, sex, income, population density, housing quality, crime and deprivation, they found that higher levels of visible blue space were associated with lower levels of self-reported psychological distress. However, no significant association was found between visible green space and self-reported psychological distress. The authors highlight some possible shortcomings in their methodology, including the fact that they used scores averaged across blocks of residences rather than for individual addresses, and did not distinguish between different types of green space. They also did not include private green space, such as back gardens, in the analysis, so it is possible that their method may not have been sensitive enough to detect any green space effect. However, the association between blue space and psychological distress scores was clear. It is interesting to note that over 99% of the blue space in this study was oceanic. Whether views of bodies of fresh water might be similarly associated with mental well-being is not yet known.

[18] The Vertical Visibility Index is a measure of the visibility of green and blue space, both vertically and rotationally. It provides an indication not just of whether green or blue space is visible, but also the visual significance of that space from a human perspective (Nutsford, Reitsma, Pearson, and Kingham, 2015).

2.7.1 Blue space summary

Overall, although the evidence points towards water being a feature that can increase the restorative potential of a landscape, much less work has been done looking at blue space specifically than has been generated studying green space. It is therefore not yet possible to break down the effects of blue space on different aspects of restoration in the same way as has been done for green space. In order to begin to understand what makes blue space particularly restorative – if, indeed, it is confirmed that it is, further investigation of restorative phenomena in blue space is needed.

2.8 Scene content

A limited amount of work has looked at specific scene content, though this is an area of research still in its infancy, particularly in terms of what specific components are necessary for restoration and in what quantities and configuration. It is necessary to investigate these issues in order to be able to understand and explain what it is about certain scenes that makes them restorative at all, as well as what features make certain scenes more restorative than others.

2.8.1 Biodiversity

Many studies of the restorative impact of different types of scene have deliberately excluded animals as they are a potential confounding factor (e.g. Felsten, 2009; Han, 2010; Herzog *et al.*, 2003). However, since animal and plant biodiversity is a naturally occurring variation between scenes, a complete explanation of restorative environments will need to address the matter. Fuller, Irvine and Devine-Wright (2007) looked at the impact of plant, bird and butterfly species richness on the wellbeing of visitors to urban green space areas in Sheffield, finding that there was a positive association between the species richness of plants (and, to a lesser extent, birds) and visitor wellbeing. Although it cannot be assumed that increased biodiversity necessarily caused the higher levels of wellbeing among the visitors (for example, it could have been the case that individuals who were already

experiencing higher levels of wellbeing were more likely to select the more biodiverse greenspace areas to visit), the results from this study do suggest that the restorative impact of the quality and content of green space requires further investigation. Although the issue has been addressed in more recent research (Clark *et al.*, 2014; Sandifer, Sutton-Grier and Ward, 2015) it has not yet been explored systematically. In a review of the limited literature on the relationship between biodiversity and restoration, Lovell, Wheeler, Higgins, Irvine and Depledge (2014) found that although there was some evidence that biodiverse natural environments are associated with increased wellbeing, overall there is not yet any conclusive evidence that biodiversity increases the restorativeness of an environment.

2.8.2 People

To date, researchers have tended to avoid the inclusion of people in scenes used in restorative environment studies. However, work based on the experience of actual environments has not usually attempted to control for the presence of other people in those environments beyond the immediate companions of the participants (e.g. Doughty, 2013; Johansson, Hartig and Staats, 2011). In addition, some studies have included people within scenes in a way that could confound results, such as using images of urban scenes containing people and images of natural scenes without people in the same study (e.g., Hartig and Staats, 2006; Staats and Hartig, 2004; Ulrich, Simons, Losito, Fiorito *et al.*, 1991). Other research has treated the presence of people as an experimental variable and investigated their impact on potential restorativeness. For example, White *et al.* (2010) included categories of scenes containing people in urban, green and blue space settings and found that scenes containing people tended to be rated more positively than those without people. This is another area that has the potential for more research to elucidate the underlying mechanisms. The results reported by White *et al.* are consistent with findings that the presence of other people may in itself be restorative (Staats and Hartig, 2004). However, Nordh *et al.* (2009), in a study of the restorative components of urban parks, found that while the presence of a few people improved preference ratings compared with no people,

the presence of many people resulted in lower preference ratings. As these authors point out, this could be due to the presence of a few people resulting in feelings of increased safety, as found in other work (Staats and Hartig, 2004), while the presence of many people might be interpreted as crowding, which has been associated with increased stress.

In common with other aspects of restorative environments research, a causal link has been difficult to establish with regard to crowding and stress (Vine, 1981). Indeed, findings from other studies that have looked at the presence of crowds in relation to restoration in natural environments have, so far, proved inconclusive. For example, in a study of restoration in wilderness environments, Cole and Hall (2010) found no effect of 'congestion' on perceived restorativeness whilst Arnberger and Haider (2005) looked at the impact of crowding on visitors to an urban forest in Vienna and found that the reactions of their respondents to crowding depended on individual personality factors. Similarly, Kalisch (2012) found that visitors to a coastal park in Germany differed substantially in their perceptions of crowding.

2.8.3 Urban environments

It appears that almost all the studies that have been undertaken in urban environments have compared built scenes with scenes incorporating natural elements. Although urban scenes can be restorative, this seems to depend upon the presence of nature (e.g. Abkar, Kamal and Maulan 2011; Van den Berg, Jorgensen and Wilson, 2014). There are a few pieces of research that have looked specifically at the restorative potential of scenes that might be regarded as wholly urban (containing few or no natural or green elements) including studies such as that by Karmanov and Hamel (2008) which looked at 'attractive' urban landscapes and found that these could be restorative. However, their urban landscapes included significant water – a natural element, thus restricting the scope of the conclusions that can be drawn from this work. There appears to be a paucity of research examining how the built aspects of environments could be made to be more restorative, beyond adding plants or other natural features.

Architects have taken inspiration from nature since at least the beginnings of the biomorphism movement in art and architecture in the early 20th century (Grigson, 1935), in which naturally occurring patterns, shapes and forms of nature are either directly copied or used as inspiration (Feuerstein, 2002). Despite this and the resurgence of interest in biophilic design (Beatley, 2009) which involves the incorporation of natural elements, such as greenery, into built spaces, little empirical work appears to have been carried out investigating the restorative properties of biomorphic architecture. Therefore, the extent to which such structures, or other styles/elements of architectural design, might have restorative potential is an open question. A recent review (Gillis and Gatersleben, 2015) concludes that although there is evidence for the benefits of certain aspects of biophilic design (mainly the inclusion of natural elements), empirical evidence for other aspects of nature-inspired design is currently lacking.

In a 2006 study, Hidalgo, Berto, Galindo and Getrevi compared attractiveness and restorativeness of different urban spaces, defined by function rather than visual or architectural form. They found that historical-cultural places and recreational places were judged as being the most attractive and restorative (housing and administrative areas were least attractive and restorative) when people were asked to list the most attractive and unattractive places in the city of Malaga. Participants were then asked to rate these places for aesthetics and restorative qualities. Hidalgo *et al.* (2006) found that it was the restorativeness of the places that affected whether they were judged to be attractive or unattractive. A similar direction of causation was reported by Van den Berg *et al.* (2003), when they examined the mediating role of restoration in environmental preferences. Stress was induced in volunteers by showing them a frightening film. Participants were then shown a video of either a natural or a built environment, after which they were given a test of concentration and asked to rate the beauty of the environment. Mood was also measured before and after viewing the videos. The researchers found that affective restoration

(measured by improvement in mood) accounted for much of the preference for the natural over the built environments.

Several studies have looked at the impact of lighting on restoration in urban environments after dark. Nikunen and Korpela (2009) found that in urban night time scenes with the focus of illumination on different aspects of the scene, focusing light on roads and parking areas resulted in images of the same scenes being judged as less restorative than when the light was focused on vegetation. Although further work would be required to discover the reasons for this as little is known about restorative effects of nightscapes, this study does suggest a relatively straightforward way in which urban areas could be improved for residents (for example, by illuminating the trees after dark).

In a study investigating the attractiveness of city skylines, Nasar and Terzano (2010) found that city skylines after dark were rated similarly for attractiveness to natural scenes - both were rated more highly than city skylines during daylight. This finding suggests that the visual appearance of a scene may be as important as its content and meaning (which remain the same for a city view, whether in daylight or at night) including the urban-natural distinction. Taken together with the findings of Hidalgo *et al.* (2006), discussed above, it seems both meaning and appearance may be significant. Further research is needed to elucidate the relative importance of form and content of a scene with regard to its restorative potential; separating these characteristics may provide important evidence about how restorative effects arise.

2.8.4 Dramatic nature features

Although people are commonly drawn to dramatic nature (such as impressive waterfalls and spectacular mountain views) for recreation, most of the restorative environments research has ignored images and experiences that might be considered awe-inspiring, concentrating instead on more mundane images of nature. However, in a recent exploratory

study, Joye and Bolderdijk (2015) found that awe-evoking nature scenes produced greater restorative effects than viewing more ordinary nature scenes. This is an area that may prove fruitful in future research, particularly when it comes to assessing theories of and explanations for restorative environments. These will need to be able to account for differences in restoration potential between types of natural environment as well as between urban and natural scenes (the main theories that attempt to explain restoration are reviewed in Chapter 3).

2.8.5 Soundscapes

Although most of the evidence is based around restoration arising from visual experiences, there is a small body of research that has considered how other aspects of the environment, mainly focusing on sounds (Payne, 2011)[19] may affect restorative potential. In a recent study, Jahncke, Eriksson and Naula (2015) investigated sound as a component of restorative experiences. They asked participants to imagine themselves as cognitively fatigued then rate scenes for perceived restorativeness (urban green space and an indoor office scene) when presented in combination with four different sounds (office noise, broadband noise such as traffic or air conditioning, nature noises and silence). Jahncke *et al.* (2015) found that nature sounds and silence enhanced the perceived restorative qualities of natural scenes, whereas office and traffic noise did not.

In an experimental study, Alvarsson, Wiens and Nilsson (2010) found that participants who had been asked to complete a stressful arithmetic task recovered to an unstressed state faster when exposed to natural sounds (such as running water and birdsong) than when exposed to urban noise (such as road traffic) or ambient sounds (such as a quiet backyard). Other work has also found a restorative effect of sounds associated with natural scenes. For example, Ratcliffe, Gatersleben and Sowden (2013) used semi-structured interviews to

[19] Some work has considered the impact of smells, for example in the context of reducing anxiety (Lehrner *et al.*, 2000), but is beyond the scope of the present work.

investigate the impact of different sounds on perceived restoration and found that birdsong was the type of natural sound most associated with stress reduction and restoration.[20] However, they found that not all birdsong was judged to be equally restorative, with bird sounds that were perceived as harsh and loud being less restorative than sounds with more melodic acoustic properties.

Rather than isolating individual sounds or sound elements, Payne (2013) assessed whole soundscapes. She found that urban soundscapes were rated as being less restorative than urban park soundscapes, which were in turn rated as less restorative than rural soundscapes. As part of this work, Payne developed a scale for assessing perceived restorativeness of soundscapes. This proved sensitive to differences in perceived restorativeness between different environment types (urban, urban green and rural) as well as to differences between environments within the same category. The existence of a standard scale may help future work to clarify the relationship between visual and auditory components of restorative experiences.

Although this work on environmental sounds helps to provide a more complete picture of restoration in different environments, the importance of the soundscape for restoration – whether it is a central component or of tangential importance - has not yet been established. Much of the research into restorative environments assumes that the phenomenon is primarily visual. So far, on the basis that strong restorative effects have been found from visual stimuli alone in a great number of studies, it seems reasonable to proceed on the basis that this is the case, until stronger evidence to the contrary emerges.

[20] Of potential relevance for blue space research, the sound of water was the second most restorative sound in this study.

2.8.6 Indoor environments

The majority of studies investigating restorative environments have focused on outdoor settings. However, there is some evidence that indoor environments can also be restorative, particularly if they contain plants (e.g. Fjeld, 2000; Park and Mattson, 2009; Dijkstra, Pieterse and Pruyn, 2008), although as Bringslimark, Hartig and Patil (2009) point out, research so far suggests that benefits of indoor plants depend upon both the indoor context and the characteristics of the individuals involved. Other indoor environments that have been shown to have restorative potential include museums (Packer and Bond, 2010; Kaplan, Bardwell and Slakter, 1993), churches (Herzog, Ouellette, Rolens, and Koenigs, 2010), monasteries (Ouellette, Kaplan and Kaplan, 2005), casinos (Rosenbaum *et al.*, 2015) and art galleries (Clow and Fredhoi, 2006). Currently, it is not clear whether the restorative benefits such indoor environments can provide arise from the same mechanisms that enable restoration in outdoor contexts, or whether there might be other processes in operation.

2.9 Conclusion

A belief that nature can be beneficial to health and wellbeing can be traced back to the earliest human history, and this idea has been explored and supported by contemporary academic research. The literature reviewed in this chapter has shown that experiencing green space can have a positive impact on both physiological and psychological health. There is converging evidence from a large number of studies that natural environments have restorative potential over and above urban environments. While only a small proportion of this research has specifically studied aquatic environments, those studies that have done so indicate that blue space can be particularly restorative. It also appears there may be enough of a difference to distinguish blue from green space in general, thus justifying its consideration as a category in its own right. However, it is a category that is under-researched at present and the scope of and constraints upon the restorative potential of blue space are not well understood.

A key area for future research is the relationship between blue and green space – the finding that blue space may be more restorative needs further corroboration. Another important area where knowledge is lacking in order to be able to understand how restorative effects arise is specific scene content. This is a question of practical importance, since landscapes that might have restorative potential yet are not protected from development may face change from the construction of buildings and other objects – the current literature has not addressed the question of how the imposition of anthropogenic objects might affect the restorative potential of a landscape.

As well as having real-world relevance, the question of how restorative effects arise from experiencing certain environments has theoretical significance, since it is not yet understood how certain environments or environmental characteristics give rise to wellbeing benefits. This chapter has reviewed evidence that restoration arising from exposure to environmental contexts is a meaningful concept. It has discussed what restorative environments are, as well as their effects on health. On the basis of gaps in current understanding it has provided a basis for the aims of the present research. However, before embarking upon an investigation of the research questions, the next chapter is devoted to assessing current explanations for restorative environments so as to establish a theoretical framework for the practical studies that follow.

Chapter 3

Theory of Restorative Environments

3.1 Introduction

The previous chapter discussed the question of *what* constitutes a restorative environment. The question that naturally follows, and the subject of this chapter, is *why* do certain (predominantly natural) environments have restorative potential?

While there is plentiful evidence, from a variety of different types of study, that environments containing natural elements can be beneficial to various aspects of health and wellbeing, collecting evidence that such benefits exist is only part of what is required in order to understand the phenomenon. A theoretical framework within which to interpret and explain the findings is also needed. It is necessary to understand the basis for and underlying mechanisms of restoration for a number of reasons: Firstly, in order to be able to conserve elements of existing environments, both urban and rural, that may be beneficial to health and wellbeing. Secondly, to be able to make evidence-based decisions about development in landscapes that are largely natural in character. Thirdly, to be able to incorporate evidence-based features into design of new buildings and urban plans to increase their potential wellbeing benefits (or decrease their potential detrimental effects). This chapter will review the dominant theories in the field of restorative environments research, assess their strengths and weaknesses, then go on to consider some recently emerging alternatives.

The intellectual roots of the currently most prominent restorative environment theories can be seen in many of the earlier works on nature and health, which supposed that humans have a seemingly instinctive affinity with nature (e.g. Olmstead, 1886; Simmel, 1903). A bolder reinterpretation of these ideas was published in E.O. Wilson's (1984) book *Biophilia,*

in which Wilson argued that this affinity with nature has a genetic basis, and is innate, evolved and confers a survival (and reproductive) advantage. Wilson's biophilia (literally, *love of life*) concept is hypothesized to encompass all forms of life, including animals[21]. Further, it predicts that people's aesthetic responses to nature are one of the most basic embodiments of biophilia and may be a human universal (Kellert, 1993). Biophilia has been used as the theoretical basis for work in areas including design and architecture (Freeman, 2011) and research into pro-environmental behaviour and attitudes (Born *et al.*, 2001; Raudsepp, 2005). It is rarely adopted as a theoretical framework in its own right in restorative environments research, though it is often mentioned in conjunction with other generally compatible theories in the field.

Around the same time as Wilson put forward his Biophilia theory, two theoretical frameworks emerged along with the (then) new academic enterprise of restorative environments research; these frameworks have dominated the field ever since. They are Stress Recovery Theory (Ulrich, 1983) and Attention Restoration Theory (Kaplan and Kaplan, 1984). Both theories fit within and are compatible with the overarching concept of biophilia, but differ in their explanations of the driving force behind humans' putative biophilic tendencies. These theories are discussed in Sections 2 and 3 below.

It is notable that the focus of the research in the field has been largely directed towards exploring the effects of restorative environments. This has included, for example, investigating the restorative impact of different types of nature (Velarde, Fry and Tveit, 2007), its impact on different sections of the population (Nieuwenhuijsen *et al.*, 2014), as well as the various potential restorative benefits (Groenewegen, Van den Berg, de Vries, and Verheij, 2006; Hartig, Mitchell, de Vries, and Frumkin, 2014). Another, related, avenue of enquiry has focussed on practical applications of restorative phenomena, for example in

[21] It is common in restorative environments research to exclude animals from experimental stimuli, although work that has included (non-threatening) animals has found positive impacts (e.g. White *et al.*, 2010). There is a body of research that has found benefits to health and wellbeing from pet ownership (e.g. O'Haire, 2010) and could be seen as being broadly compatible with biophilia. However, this area of study is beyond the scope of the current work.

architecture (Lindal and Hartig, 2013), interior design (Bringslimark, Hartig and Patil, 2009) and urban planning (Grahn and Stigsdotter, 2003). However, there has been little critique of the conceptual structure underpinning most research in the field, and there have been few theoretical advances since Stress Recovery Theory and Attention Restoration Theory were proposed. In recent years however, several researchers have begun to question the dominance of these theories and suggest alternatives that rely less on notions of biophilia and more on specific characteristics of scenes, such as low-level visual structure (e.g. Joye, Steg, Ünal, and Pals, 2015; Kardan *et al*., 2015). These theoretical developments are still in their early stages and will be discussed in Section 4 below.

3.2. Stress Recovery Theory

3.2.1 Overview

Ulrich (1983) proposed Stress Recovery Theory[22] (SRT) as a psycho-evolutionary framework to explain why people have a preference for natural environments (e.g. Purcell, Peron, and Berto, 2001) and how such environments may have physiological and psychological benefits (e.g. Haluza, Schönbauer, and Cervinka, 2014). SRT is based on the assumption that humans are psychologically adapted to the types of environments that would have conferred survival benefits during the course of human evolution. These, according to proponents of the theory, can be characterised as, 'unthreatening natural environments' (Ulrich *et al*., 1991, p.209) which are likely to be dominated by vegetation and indicative of food and shelter (e.g. including shade, water, fruits, etc.).

The theory has much in common with the Savanna Hypothesis (Orians, 1986) which proposes that landscape preferences in humans are innate and a result of hominin[23]

[22] This framework is also sometimes referred to as Stress Reduction Theory. Henceforth, it will be referred to as SRT.

[23] There is some, historically based, inconsistency in the usage of *hominin* and *hominid.* The currently accepted definitions are assumed throughout this work; i.e. that *hominid* refers to all modern and extinct great apes and their immediate ancestors, whereas *hominin* refers to modern humans, extinct human species and all our immediate ancestors (Jurmain *et al*., 2008).

evolution in the Pleistocene (Orians and Heerwagen, 1992) on the African savanna. According to this hypothesis, environments that today contain features typical of the African savanna should be preferred. Unthreatening natural landscapes, according to SRT, promote recovery from stress[24] due to the reduced level of information processing required when experiencing such scenes. This enables arousal/stress levels to diminish and restoration to occur (Ulrich, 1979). In contrast, built urban environments hinder recovery from stress due to the increased demands they place on cognitive resources (Velarde, Fry and Tveit, 2007). Natural environments, according to SRT, are optimal for stress reduction because of their unthreatening nature.

Within this framework, it is argued that attraction to these environments, motivated by a rapid positive affective response upon encountering them, was a trait that would have conferred a survival advantage and was thus selected for in the course of human evolution. The restoration that then occurs in response to experiencing unthreatening nature is hypothesized to result from a reduction in stress and the consequent impact on cardiovascular and endocrine systems (Ulrich, 1983; Ulrich *et al*., 1991).

Since humans' evolutionary development took place in landscapes that more closely resemble what we today regard as natural environments (as opposed to urban settings), SRT proposes that experiencing nature still evokes the same evolved responses in today's humans, and might still be considered to be positively adaptive (Ulrich *et al*., 1991). Urban environments, it is argued, are likely to incorporate high levels of visual complexity as well as highly stimulating (and potentially threatening) sounds, sights and events, thus causing high levels of stress and psychological fatigue. Modern natural environments, according to this position, are likely to be less intense and less visually complex, thus promoting positive affect and allowing stress recovery to take place (Ulrich and Parsons, 1992; Ulrich, 1979).

[24] Within this framework, stress is regarded as a complex of physiological responses to a situation which might threaten wellbeing (Baum, Fleming and Singer, 1985). These responses can result in negative emotions, physiological indicators such as increased heart rate and increased arousal of the autonomic nervous system leading to symptoms such as anxiety (Ulrich, 1983).

SRT proposes that positive affective responses to natural environments, as well as restoration phenomena, are rapid, automatic processes. Ulrich (1983) argues that when people are exposed to an environment, there is an immediate affective response (e.g. a general liking or disliking) which occurs at an unconscious level, before the scene has been fully processed or recognised. This affective response may be triggered by particular elements that are associated with nature, such as vegetation, as well as structural features of the scene and the absence of threats (Ulrich, 1983; Ulrich and Parsons, 1992).

3.2.2 Relevant research

While not designed as a direct test of SRT, a study conducted by Balling and Falk (1982), looking at the preference for different landscape types among people of different ages, is often cited as support for the savanna hypothesis. Balling and Falk showed images of five different landscapes (savanna, desert, tropical rainforest, temperate deciduous forest, coniferous forest; none of which contained animals or water) to six age groups (8, 11, 15, 18, 35, 70+) and asked participants to rate the landscapes according to how much they would like to live in and visit them. Results showed that no age group preferred the rainforest or desert, and the 8 and 11-year olds preferred the savanna. Balling and Falk argue that if the preference for savanna landscapes is innate, in line with the savanna hypothesis, this preference should be strongest in childhood, since social and cultural factors will have had less impact on preferences at this age. However, while it could be argued that these results are consistent with the savanna hypothesis, other possible explanations were not ruled out: for example, since participants were asked to make a decision about visiting or living in the environments, the responses that were collected were not necessarily indicative of the immediate affective response evoked by those environments. The fact that responses differed for the questions about living versus visiting suggest that other factors were relevant in deciding how to respond. Participants were not asked to explain their responses, so it is not possible to assess whether these additional

factors may have explained the differences found between the age groups. Although children under the age of 12 have been influenced by social and cultural factors for less time than adults, they are not uninfluenced by these factors and it is not necessarily the case that any innate tendencies should be more apparent in this age group[25]. On the contrary, it is not clear how an innate preference for savanna only present in childhood might have conferred an evolutionary advantage, since it is unlikely that selection of habitats would have been driven by the pre-pubescent members of early hominin groups.

A subsequent study (Falk and Balling, 2010) in which a preference for savanna over other environments was found in both children and young adults is open to similar criticisms. In particular, in this study participants were only asked to judge the environments on one dimension (how much they would like to live there). Subsequent studies including children have not replicated Balling and Falk's results (e.g. Lyons, 1983) and studies looking at environment type preferences in adults have shown preferences for other environment types over savanna (e.g. Han, 2007; Hartmann and Apaolaza-Ibáñez, 2010). Future work might investigate whether infants display a preference for particular types of natural environment, since if this were found to be the case it would constitute stronger support for a genetic component to landscape preferences. However, if these preferences do not persist into adulthood, their existence would not support the evolutionary claims of the savanna hypothesis in its current form.

As far as the relationship between environment type and stress is concerned, most of the research has been conducted with adult participants. Various studies have found that environments which people find aesthetically pleasant (typically environments that include natural elements) as well as moderately interesting and calming, can promote recovery from stress (e.g. van den Berg, Maas, Verheij, and Groenewegen, 2010; Ulrich, 1983; Ulrich *et al.*, 1991; Ulrich and Addoms, 1981). In a cross-sectional study of 80 neighbourhoods in

[25] Studies in areas where both innate tendencies and socio-cultural factors have an impact on behaviour, such as food preferences in children, show that while innate tendencies may be detectable from the earliest age, environmental factors also have a significant impact on behaviour, even before 5 years of age (Wardle and Cooke, 2008).

four Dutch cities, de Vries, van Dillen, Groenewegen, and Spreeuwenberg (2013) collected information on quality and quantity of streetscape greenery. They also collected questionnaire data from 1641 adults in those neighbourhoods on self-reported health and possible mediating factors (stress, social cohesion and physical activity). In line with previous research (reviewed in Chapter 2), the authors found an association between quantity and quality of green space and perceived health as well as actual health conditions. As far as SRT is concerned, the most relevant finding from this study was that stress was the strongest mediator of the association. Social cohesion was also found to be a mediating factor, while total physical activity was not a mediator. Although it is not possible to infer causality from this study, the association found between green space and health, mediated by stress is broadly consistent with an SRT framework.

Hawkins, Thirlaway, Backx, and Clayton (2011) conducted a study on the impact of outdoor versus indoor leisure activities on stress and found lower self-reported stress levels in a group of older (aged 50-88 years) people doing allotment gardening, compared to a control group doing an indoor leisure activity. The groups did not differ with respect to social support or physical activity, leading the authors to argue that the differences in perceived stress levels could be attributed to engagement with nature and the consequent psychological restoration.

In a survey of 953 randomly selected adults from nine cities across Sweden, Grahn and Stigsdotter (2003) found an association between the use of urban green spaces and self-reported stress. This relationship between green space usage and stress was not affected by the variables of age, gender or socio-economic status. Both frequency of visits to green space and total time spent in green space were associated with lower levels of stress.

Saw, Lim, and Carrasco (2015), conversely, did not find a relationship between perceived stress and either access to or usage of green space in a survey of 426 students (aged between 18 and 25 years) at the University of Singapore. Instead, they found that lower perceived stress levels were associated with greater extraversion and emotional stability. The absence

of an association between perceived stress and green space usage is unusual in studies of this type, and appears to be inconsistent with SRT, which would predict that the stress reducing properties of nature are a human universal. Saw *et al*. point out that one point of difference between their work and similar urban research is that the majority of previous work has been conducted in temperate regions, such as Europe, whereas their study was conducted in a tropical climate. While SRT would not necessarily predict a difference according to the type of climate, one potentially relevant characteristic of Singapore is that, for an urban area, it has an unusually high proportion of green space. Saw *et al*. point out that it has one of the highest percentages of urban green space in the world, at 47% (for comparison, New York has 14%; London has 38%), as well as a high level of biodiversity in proportion to its size (thus allowing residents to come into contact with nature even when not physically situated in green space). Therefore, it could be the case that there is enough green space surrounding people in their everyday activities that the impacts of deliberately visiting urban green space might be too subtle to be detectable by the survey method used. Another factor that the authors do not consider is that not only are residents of Singapore likely to be exposed to blue space often, due to it being a small island, but the University of Singapore is itself situated in close proximity to the sea. Blue space was not included as a variable in their study, and it is at least plausible that these high levels of ambient exposure to natural elements, including water, may explain the lack of detectable association between visiting urban green space and perceived stress levels.

A further potential weakness of the studies described above is that they rely on survey methods and record self-reported stress, which introduces a level of subjectivity that is difficult to control or assess the impact of. Although studies using such methods are prevalent, there is also a body of research based on more objective measurements of stress, such as salivary cortisol levels[26], in relation to green space exposure. In a series of studies

[26] A number of studies have found a link between stressful experiences and increased salivary cortisol levels (e.g. Smyth *et al*., 1998; Van Eck, Berkhof, Nicolson, and Sulon, 1996). However, despite the appeal of having a factor that can be measured objectively and with relative ease, it is important to bear in mind that cortisol should only be considered an indirect biomarker of stress, the relationship is not necessarily linear

looking at the impact of *shinrin-yoku*[27] in Japan, cortisol levels were measured at set points throughout the day, including before and after participants (n = 280) took a walk in either a forest or an urban area (Park, Tsunetsugu, Kasetani, Kagawa, and Miyazaki, 2010; Park *et al*., 2007). It was found that the forest environments were associated with lower levels of salivary cortisol, as well as lower blood pressure and heart rate than urban environments.

Much of the research into the stress-reducing potential of nature investigates experiences of nature without considering the potential impact of different sensory modalities. However, Alvarsson, Wiens, and Nilsson (2010) studied the auditory impact of different environment types to discover whether sounds typical of urban or natural environments could facilitate recovery from stress. The authors asked participants to complete a stressful mental arithmetic task, then exposed them to various environmental sounds whilst recording heart rate variability and skin conductance levels as measures of activation of the sympathetic nervous system (responsible for 'fight or flight' stress responses (McEwen, 2007)). Alvarsson *et al*. found that exposure to nature sounds (such as fountains and birdsong) speeded up recovery from the psychological stress induced by the task, compared with quiet ambient urban noise and loud urban (traffic) noise.

In another experimental study, Van den Berg and Custers, (2011) investigated the impact of gardening on stress by subjecting participants to a stressful task before randomly assigning them to either 30 minutes of gardening or 30 minutes of indoor reading on their own allotment. Cortisol levels were repeatedly measured throughout the process. It was found that salivary cortisol moved closer to optimal levels (indicating reduced stress) in both groups during the recovery period, but the improvement was greater in the group assigned to gardening.

(Hellhammer, Wüst and Kudielka, 2009), and there may be other biomarkers that provide a better index of stress, such as salivary amylase (Takai *et al.*, 2004).

[27] *Shinrin-yoku* (also known as 'taking in the atmosphere of the forest' or 'forest bathing') is an activity consisting of walking in forests, popular in Japan (Morita *et al.*, 2007). The term was coined by the Japanese Ministry of Agriculture, Forests and Fisheries in 1982 and it is a recognized form of stress-management in Japan (Park *et al*., 2007).

Building upon these experimental findings, Thompson *et al*. (2012) conducted a study looking at whether the amount of green space in urban residential settings was associated with stress levels measured both objectively by cortisol levels and subjectively via self-reports. Repeated salivary cortisol measurements were taken from 25 participants in their everyday residential settings, along with self-reports of perceived stress, general wellbeing and exposure to green space over a two-day period. Results showed a positive relationship between lower cortisol secretion and higher levels of green space, as well as an inverse relationship between quantity of green space and self-reported stress levels; That is, as the percentage of neighbourhood green space increased, self-reported stress levels decreased. Both of these findings were unaffected by demographic and socio-economic variables, though since this was a cross-sectional study, not a controlled experiment, the possibility that there may have been other, uncontrolled, environmental factors playing a part cannot be ruled out. However, these results are consistent with the other studies that have found a relationship between nature exposure and cortisol levels. Further studies looking at the relationship between cortisol and stress levels have found a similar pattern of results (e.g. Beil and Hanes, 2013; Gidlow, Randall, Gillman, Smith, and Jones, 2016; Roe, Thompson, Aspinall, and Brewer, 2013).

In terms of the mechanisms by which the hypothesized stress reducing properties of natural environments may occur[28], there is some support for the proposal that the affective states experienced in response to such environments may play a part, in line with SRT, bearing in mind that there is substantial evidence that natural environments tend to evoke positive affect (e.g. Hartig, Evans, Jamner, and Davis, 2003; Martínez-Soto, Gonzales-Santos, Barrios, and Lena, 2014; McMahan and Estes, 2015). For example, in a study looking at the cardiovascular impacts of viewing short film clips designed to elicit various affective states,

[28] There are other potential processes that could play a part in the whole experience of being in a natural environment that may contribute to its stress-reducing potential. For example, physical exercise such as walking, which can reduce stress and improve mood (Penedo and Dahn, 2005) and the fact that green space can foster social contact, which also has the potential to reduce stress (Fan, Das, and Chen, 2011). However, since experiencing nature has an impact that can be separated from these factors (Mackay and Neill, 2010), they are neither sufficient nor necessary to explain green space effects on stress.

Fredrickson, Mancuso, Branigan, and Tugade (2000) found that films eliciting positive affect produced faster cardiovascular recovery than neutral or sad films. Further, it was found that positive emotions were able to 'undo' the cardiovascular repercussions of experiencing negative emotions.

Although there is long-standing evidence that negative emotions are reliably associated with poorer health (Kiecolt-Glaser *et al.*, 2002; Padgett and Glaser, 2003), as well as recognition of the significance of positive emotion to physical health (Fredrickson, 2000; Tugade, Fredrickson, and Barrett, 2004), recent work has begun to look at some possible biological pathways via which positive emotions may benefit health. For example, Stellar, Anderson, Gordon, Mcneil, and Keltner (2015) found that positive emotions generated by experience of nature, art and spirituality were associated with lower levels of pro-inflammatory cytokines[29]; this is a marker of good health.

Although the majority of published studies in this area have found a relationship between greater exposure to nature and decreased stress and could be considered to be broadly supportive of SRT, it is important to remember that the evidence only shows that exposure to nature is associated with, and may perhaps cause, a reduction in stress. It does not follow that this relationship must necessarily be the result of a trait that was selected for in the course of hominin evolution, as hypothesized by SRT. The next section will discuss this issue in more detail.

3.2.3 Theoretical adequacy of SRT

The previous section showed there is a body of research that provides support for the theoretical framework underpinning SRT, and some of its predictions are also substantiated. Despite this apparent support for the idea that we are attracted to, and

[29] Cytokines are proteins that affect interaction and communication between cells. High levels prompt the immune system to work harder (Zhang and An, 2007) and are associated with inflammation, autoimmune disease and depression (Dantzer *et al.*, 2008).

benefit from, environments that may have been important in our evolutionary history, when some of the assumptions underlying the framework are scrutinised, a number of problems become evident. The current section critically evaluates the strengths and weaknesses of SRT, firstly by assessing the overall theoretical framework then by considering SRT itself in more detail.

3.2.3.1 Assessment of the overall framework

The overall framework within which SRT is situated can be broadly characterized as a version of the savanna hypothesis (Orians, 1980; 1986) which assumes that human landscape preferences are innately determined and evolved in response to the landscapes that existed in East Africa during the Pleistocene[30]. This section will consider three potential problems with this framework: Firstly its assumptions about environmental and landscape conditions at that point in hominin evolution. Secondly, the absence of a strong argument for why human landscape preferences today should necessarily reflect the landscapes of the Pleistocene. Thirdly, these previous issues highlight a problem common to many evolutionary theories of psychology and behaviour – the extent to which they may be based upon plausible-sounding speculation that, when scrutinized, lacks specificity and testability.

(i) The evolutionary environment and landscape

The savanna hypothesis relies on an assumption that the type of landscape that predominated during the Pleistocene in East Africa comprised large, flat, open grassy spaces with scattered trees or groups of trees (Ulrich, 1993). However, this has not been established, leaving the question of what types of environments our hominin ancestors lived

[30] The Pleistocene epoch spanned the period of time from 2.6 million years ago until 11,700 years ago (dates from International Commission on Stratigraphy's International Stratigraphic Chart, 2016).

in still open. In contrast to the traditional assumption (underlying the savanna hypothesis) that early *Homo* evolved in a stable environment resembling the grasslands of East Africa today, more recent research has uncovered evidence of variability in both climate and landscape (Potts, 2013; Shultz and Maslin, 2013). As well as indications that both climate and environment varied during this period, there is evidence that the landscapes of our African ancestors may have been quite different from the present day savanna (Reed, 1997). For example, paleoarchaeological reconstructions of portions of the Pleistocene landscape in East Africa, together with carbon dating of stone tools and bones, suggests that hominins from this era may have had a preference for relatively closed woodland habitats, potentially offering food, shade and refuge from predators (Sikes, 1994). Recent research analysing geochemical fossils from the Olduvai Gorge in Tanzania (Magill *et al.*, 2016) suggests that our early ancestors frequented landscapes that included patches of woodland and spring-fed wetlands surrounded by open grassland.

Given the growing body of research that is pointing towards wooded environments and forests as early hominin habitats (Domínguez-Rodrigo, 2014), it cannot be assumed that the ideas about the environment embodied by the traditional savanna hypothesis are accurate. Whilst it is possible that the general principles underlying the hypothesis could still be sound, if it relies on a mistaken conception of the relevant landscapes, its predictions and explanations will not be correct.

Regarding the existence of a preference for certain landscape types in humans today, the evidence is mixed. While the studies of Balling and Falk (Balling and Falk, 1982; Falk and Balling, 2010) discussed above appear to support a preference for savanna, other studies have not replicated these findings. For example, Hartmann and Apaolaza-Ibáñez (2010) compared emotional responses to images of different environment types, including urban scenes, in 750 participants. They did not find a preference for savanna; instead they found a preference for verdant landscapes with water, especially when those landscapes were more familiar to the participants (e.g. European as opposed to Australian or tropical

landscapes). In a study investigating responses to the six major terrestrial biomes (i.e. grasslands, tundra, deserts, tropical forest, deciduous forest and coniferous forest) in 274 college students, Han (2007) found that coniferous forests and tundra were the most preferred landscapes, whereas grasslands and deserts were least preferred. However, even if evidence of consistent landscape preferences across modern humans were to be found, the question of whether such preferences might have an evolutionary basis would remain. The next section will discuss this issue.

(ii) Evolution and landscape preferences

A central tenet of the savanna hypothesis in the context of SRT is that landscape preferences in modern humans are a direct reflection of landscapes during the period in which the species evolved (Lohr and Pearson-Mims, 2006). Whether or not the savanna hypothesis is correct about the composition of the landscapes in which hominins evolved, it does not necessarily follow that our ancestors had a genetically determined preference for those landscapes, or that such a preference has persisted up to the present. It is therefore necessary to examine the argument that landscape preferences observed in humans today are an innately determined adaptation in response to Pleistocene landscapes.

This idea relies on the concept of the Environment of Evolutionary Adaptedness (EEA), which can be defined as the combined selection pressures leading to an evolutionary adaptation (Tooby and Cosmides, 1990). It is not in itself a specific place (or time), but may reflect conditions present at particular points in space and time – in this case, the East African savannas of the Pleistocene, where modern humans evolved (Marean, 2015), together with the problems faced by early hunter-gatherers in those environments. The EEA in this context assumes that psychological characteristics of modern humans reflect adaptations selected for in our ancestors at a certain point in our evolutionary history (Tooby and Cosmides, 2005). In particular, the savanna hypothesis requires that a preference for savanna-type landscapes is an adaptive trait that would have conferred

survival and reproductive advantages to early hominins. There is no consensus on the specific mechanism involved, with some authors arguing that simply due to spending almost 2 million years on the East African savanna humans have a general tendency to prefer that type of landscape (Wilson, 1984; Orians and Heerwagen, 1992). There is no specific evolutionary process invoked in this type of explanation and no clear account of why familiarity with a landscape over the course of evolutionary history would necessarily lead to modern preferences. In addition, this position assumes an unchanging landscape over the past 2 million years, which is not in line with current evidence (e.g. Shultz and Maslin, 2013). It can therefore be discounted, at least in its current form.

The variability in climate and landscape also poses a problem for explanations that invoke evolutionary processes in the context of an unchanging environment, arguing for the survival value of preferring certain environment types and features (e.g. Kahn, 1997; Appleton, 1975, 1990). These arguments founder on two counts. Firstly, on logical grounds: If hominins evolved and lived in a single, relatively invariant, environment over a long period, it is not clear what the survival value of preferring that environment over others (which were not available) would be (Joye and De Block, 2011). Secondly, as pointed out above, the evidence indicates that the environment was changeable and unpredictable (Anton, Potts and Aiello, 2014), suggesting that specific environmental preferences would not necessarily have provided a survival advantage. Indeed, it appears to be a special characteristic of *Homo* that while the environment was undergoing marked fluctuations, diet remained variable, broad and flexible (Uno *et al.*, 2016). In other hominin species, there is evidence that diet was much more closely tied to the environmental conditions (Uno *et al.*, 2016). It has been argued that the evolutionary success of *Homo* is due, in part, to dietary flexibility, which was facilitated by not being tied to a particular environment type (Anton, Potts and Aiello, 2014).

Another distinctive characteristic of *Homo Sapiens* is the ability to thrive in different environments, as opposed to being tied to a particular landscape (Richerson and Boyd,

2005). Based on the migration of *Homo Sapiens* around the world in a geographical dispersion unmatched by any other hominin (Liu *et al.*, 2006), there would, if anything, appear to be a stronger case to be made for a lack of specific landscape preferences in humans. Being tied to a particular environment type could have conferred a survival disadvantage in the face of changing environmental conditions.

It has been argued that this environmental variation itself may have been a factor in human evolution; perhaps the source of our adaptability and ability to live almost everywhere on Earth, and potentially even beyond the planet itself (Henn, Cavalli-Sforza, and Feldman, 2012). Other *Homo* species that did seem to have favoured habitats – such as *Homo Neanderthalis* whose fossils show evidence of adaptation to colder environments (Del Tredici, 2001) are now extinct. It is at least plausible that adaptations to particular climatic conditions and environment types could have made Neanderthals more vulnerable in the face of variations. Unlike other species of *Homo* who dispersed over smaller geographical areas (Finlayson, 2005), a willingness (perhaps driven by need) to seek, inhabit and thrive in new environments could contribute to explaining why we are the only surviving *Homo* species (Uno *et al.*, 2016); this flexibility and lack of a tie to a particular environment may have provided an evolutionary advantage (Mesoudi, 2016) and is difficult to reconcile with the savanna hypothesis.

(iii) Evolutionary theories of psychology and behaviour

The conceptual framework underlying both the savanna hypothesis and SRT comes from the field of evolutionary psychology. This field has attracted criticism for producing theories which may sound plausible, but do not always stand up to scientific scrutiny (Richardson, 2007). Several of the problems for the savanna hypothesis are representative of this general class of problems for evolutionary psychological theories. For example the theoretical basis for selecting the relevant point in our evolutionary history is not clear. It could be argued according to the savanna hypothesis that the critical point in evolutionary history is the

emergence of *Homo Sapiens*, 195,000 years ago; or it could be the time of *Homo Erectus*, our first hunter-gatherer ancestor, 1.8 million years ago. The problem is that the choice is arbitrary, depending on the construction of the evolutionary 'story' that the theory is based upon (Gould and Lewontin, 1979). It is also not necessarily the case that because humans evolved during the Pleistocene this is the appropriate place to look for the emergence of psychological adaptations – for example, it has been argued that some human emotional systems have origins further back in the evolutionary history of primates, and others even further back in pre-mammalian ancestors (Panksepp and Panksepp, 2000).

Another problem common to both the savanna framework and many evolutionary psychology theories is the assumption that the minds (and brains) of today's humans are essentially unchanged from those of our Stone Age ancestors. Since there is evidence that the effects of natural selection can appear over as few as 18 generations (Bell, 2008), it would be surprising if no human evolutionary change had taken place since the Pleistocene, even if environmental conditions had remained stable. On the contrary, there is clear evidence of genetic change since the end of the last Ice Age, 10,000 years ago, such as the capacity for lactose tolerance in adults (Holden and Mace, 1997). Given the major environmental and socio-cultural shifts that have taken place since the evolution of *Homo Sapiens* – including the advent of agriculture, the transition from the Stone Age to the Bronze Age, the first civilization in Mesopotamia, and even the Industrial Revolution, together with the potential speed of evolutionary change, there is no reason to assume that we remain psychologically adapted to the Pleistocene landscapes of our hunter-gatherer predecessors (Richerson and Boyd, 2005; Buller, 2009).

A further problem for the evolutionary framework underpinning both the savanna hypothesis and SRT is the question of whether it makes sense, in the light of evolution, to argue that humans have created, built and chosen environments to which we are not well adapted and that are not congruent with our psychological biases. There is research that shows evidence for the co-evolution of genes and culture in humans (e.g. Chiao and

Blizinsky, 2010; Gintis, 2011) and even in other species, such as killer whales (Foote *et al.*, 2016), suggesting that genome, culture and environment are not necessarily separable in a simple manner. From this perspective, arguments based on the idea that modern humans house a Stone Age brain which is at odds with the modern world (e.g. Cary, 2000; Maurer, 2008) may not be well-founded. It has been argued that gene-culture coevolution could be the most important form of evolution in humans (O'Brien and Laland, 2012) with the development of agriculture and, more recently, urbanisation being examples of the type of niche creation that is both driven by and a driver of evolution (Downey, 2016). Urbanisation is a product of the interaction between brain and environment, neither of which is static or unchanging. Indeed, the impact of humans on the planet has been so great, it is contended to have created a new geological epoch, the Anthropocene (Crutzen, 2006; Lewis and Maslin, 2015).

In summary, there are problems with the savanna-hypothesis framework underlying SRT originating from its assumptions that neither the African savanna nor the human mind have changed much since the Pleistocene. The paleoanthropological and paleoclimatic evidence does not support these assumptions.

3.2.3.2 Issues specific to SRT

While there are weaknesses in the broad framework underlying SRT, as discussed above, there are also some potential problems with SRT itself: Firstly, assumptions it makes about the environment – not only in terms of its physical composition, but also the relationship between the physical characteristics and its hominin inhabitants. Secondly, assumptions about the adaptive value of stress reduction and the role of positive affect in response to natural landscapes. These issues will be discussed in turn below.

(i) Assumptions about the environment

Beyond the general assumptions about the environmental conditions during the Pleistocene made by the savanna hypothesis, there are further environmental assumptions specific to SRT that do not necessarily stand up to closer scrutiny. These concern the idea of unthreatening environments and highlight the problem of deciding what should be classified as nature.

Assumption1: Threat

The concept of unthreateningness is important in SRT (Ulrich, 1993), which predicts that specifically unthreatening natural environments promote restoration and stress reduction more than urban environments via the positive affective responses they induce (Ulrich, *et al*., 1991). There is evidence that natural scenes are judged to be less potentially restorative when they contain perceived danger such as 'an ominous stalker' (Herzog and Rector, 2008) and the difference in ratings of potential restorativeness between urban and natural scenes is eliminated by the presence of this threat. However, as Joye and Van den Berg (2011) neatly point out, "*demonstrating that threatening nature is not restorative is not the same as demonstrating that nature is restorative because it is unthreatening*." (p. 263).

If the absence of threat is central to restorative potential, it might be expected that both unthreatening urban and built environments would be restorative – and even that a benign built environment (such as a brick wall) might be more restorative than an unfamiliar vegetated environment, due to the lack of threat from the wall and the potential for threat from the vegetation (which could conceal some kind of danger). Ulrich's own work shows that this is not the case. In his seminal hospital study, discussed above, the window view of a brick wall was less restorative than a view of trees (Ulrich, 1983). Therefore the difference in restorative potential between benign built and natural environments is unlikely to be due to the absence of threats. Further, there is no definition in SRT of 'threat' or how to classify scenes on the basis of whether or not they are unthreatening. This is not necessarily a straightforward matter. For example, a natural scene that might look unthreatening today

(to observers in Western countries, where predators and venomous insects are not a concern, for example), may have concealed many different threats to our ancestors (snakes and insects in grass, big cats in trees, crocodiles in water, etc.). It might not be the case that early humans saw what we see when we look at what we regard as a natural scene, either in terms of the psychological processes involved in scene perception (which cannot be assumed to be identical in early and modern humans; though could have been) or due to the impact of socio-cultural factors (which can almost certainly be assumed to have differed). Even within the past few hundred years, the popular view of certain landscape types has changed dramatically: until the 18th Century, coastal landscapes were seen not as places of health and recreation but as places of danger (Corbin, 1994). In contrast to the later Romantic view of landscapes full of beauty and views worthy of being painted and contemplated, they were seen as functional places where food was brought ashore and journeys began and ended (Gillis, 2012). When there is evidence that even our very recent ancestors did not necessarily look upon landscapes in the same way as we do, assumptions about how our earliest *Homo* ancestors may have viewed their environment should perhaps be made more cautiously.

SRT does argue that in addition to the lack of threat, restorative environments contain elements that could have contributed to survival and reproduction in the past, for example by providing food and shelter (Frumkin, 2001). The problem with this is again how to delimit these elements in a meaningful way, when we do not know how our ancestors perceived their environment, or what types of food and shelter they may have been drawn to. If absence of threats was a crucial factor, it could be argued that for humans living in a wholly natural (i.e. unbuilt) environment amongst the dangers associated with wild nature, a built landscape would represent a safer, less threatening option, so might be preferred and be potentially more restorative due to the absence of threats and the opportunity to recover from stress in safety. In addition, in terms of adaptive value, it is at least possible to argue that human ancestors who had a preference for built environments over nature might have enjoyed advantages. For example, when sharing a habitat with large carnivores, living

in a house in a village is probably beneficial to survival. The same line of argument could even be extended to predict an evolutionary advantage for humans who had a preference for built over unbuilt environments. The logical extension of this would predict the opposite pattern to the preference for natural over built scenes typically found in the large and growing body of restorative environments research.

This highlights a problem with making *post hoc* assumptions in evolutionary arguments when explaining current phenomena: there may be many apparently plausible accounts that can be constructed, but unless there is a way of distinguishing between them empirically, they are of little theoretical value (Gould and Lewontin, 1979; Buller, 2005; Fodor, 2007). Being able to use the same evolutionary arguments advanced by SRT to make the case for the opposite outcome (i.e. preference for built environments over nature) demonstrates the problem with making such arguments in support of the theory.

Assumption 2: Nature

The difficulties involved in defining what should be classed as 'threatening' in a theoretically sound and prehistorically meaningful manner, apply in a similar way when it comes to what is classed as 'nature' or natural environments in the context of SRT. There are both general issues and specific problems with such classification, which will be discussed below.

Firstly, there is the overarching issue of deciding what counts as 'nature'. As with 'threat', this is not straightforward in a theory with evolutionary psychological underpinnings, since it is defined relative to ourselves and is thus bound to time, place and context. Today, in an urbanised world, 'natural' and 'artificial' are dichotomous terms, with artificial referring to human constructions and natural referring to landscapes largely unaffected by human activity[31]. However, there are both practical and conceptual problems with this dichotomy. From a practical perspective there are, arguably, no areas on Earth that have not been altered by the presence of humans. It has been estimated that in order to find the last

[31] Interestingly, *natural* has overwhelmingly positive connotations whereas *artificial* has overwhelmingly negative connotations across Western countries that have been studied in this context (Rozin, 2005).

landscapes unaffected by human activity, it would be necessary to travel back more than 10,000 years (Boivin *et al.*, 2016). Even if any small areas had previously survived beyond the spread of agriculture, farming, prehistoric cultures and urbanisation, today the whole planet is affected by human-generated carbon in the atmosphere and chemicals such as nitrogen (from industrial fertilisers) deposited on the Earth's surface (Waters *et al.*, 2016). There is evidence that even deep-sea ecosystems have been and are still being affected by human activity (Ramirez-Llodra, *et al*., 2011), leaving no corner of the planet free from human influence.

Another pertinent question is whether it is conceptually coherent to categorise human interactions with and impacts upon the environment as artificial while non-human processes are regarded as natural. A visiting alien ecologist with a rational, non-anthropocentric approach might classify termite mounds and tower blocks in the same category: as constructions in which certain species live. Similarly, the differences between a beaver dam and the Hoover Dam concern size, scale and materials more than type. Ever since Darwin's (1859, 1871) publications on natural selection, there have been no grounds for supposing that humans are anything other than part of nature[32]. By definition then, everything we create is also part of nature. It is difficult to argue logically that there is a difference in kind between a house built by a human from stones and a nest built by a bird from twigs. From this perspective, a city is as much a part of nature as is a rabbit warren or a wildflower meadow (Schuyler, 1999). This issue of defining nature does not only pertain to SRT, but to the whole area of restorative environments research. However, it is particularly relevant to the evolutionary component of SRT because it highlights the awkwardness of the idea of early humans in the Pleistocene being attracted to natural landscapes. If separating modern humans from the rest of nature is conceptually problematic, it is even harder to see the distinction as meaningful before the advent of

[32] Darwin did not mention human evolution in *Origin of Species* (1859) despite laying out his theory of evolution in this work. However, he had discussed the issue in correspondence with Alfred Russel Wallace in 1857 (Beer, 2000), saying that although he regarded humans in the same way as other life with respect to evolution, he planned to avoid the subject in his book. However, in *The Descent of Man* (1871) Darwin did write about human evolution and a possible common ancestor for primates.

civilisations and agriculture, when all landscapes would be classified (according to the natural-artificial dichotomy) as natural. In this case, it would make no sense, from an evolutionary point of view, to develop a preference for natural landscapes – nature was the only option.

Accordingly, SRT argues that it is not nature *per se*, but certain types of nature that are preferred and that these preferences arose at a certain point in our evolutionary history because of their adaptive value (Ulrich, 1986) and have not changed since. The consensus seems to be that the crucial characteristic is vegetation (e.g. Grinde and Patil, 2009; Lohr, 2007), given the supposed role of vegetation in providing food and shelter for early humans (Frumkin, 2001). However, this too is problematic in its vagueness: since not all vegetation is necessarily suitable for either food or shelter, it is not clear what adaptive purpose an attraction to vegetation in general would serve in an evolutionary sense (Joye and Van den Berg, 2011). One way of avoiding this criticism would be to propose more specific attractors, such as trees bearing fruit (Orians and Heerwagen, 1992; Ulrich, 1993) or non-vegetative features, such as water (Ulrich, 1983). Few studies have looked specifically at responses to features based on their adaptive significance. Although the body of research finding a preference for scenes containing water was reviewed in Chapter 2, these studies have neither been conducted on the basis of evolutionary hypotheses (e.g. comparing responses to different water bodies according to their potential survival advantages), nor explained in those terms. Like all animals, hominins during the Pleistocene would have been motivated by thirst; it is not necessary to posit an additional adaptive mechanism in order to explain attraction to water in the context of human evolution.

Regarding differences in responses to vegetation types, particularly on the basis of potential food provision, again little work has been done. Some research has found evidence of positive affective responses to flowers compared with other vegetation (e.g. Haviland-Jones *et al*., 2005); another study (Lohr and Pearson-Mims, 2006) found a preference for trees with spreading crowns (typical of trees found in present day savanna environments) over

trees with rounded or conical crowns. However, since such trees are not likely to be a source of food for humans, there is no clear argument for this preference on the basis of attraction to food sources. Further, since these trees (and other shrubs typical of savanna) may harbour big cats, such as leopards (Bothma, *et al*., 1994), it is not necessarily the case that an attraction to these trees would have conferred a survival advantage to our ancestors. Lohr and Pearson-Mims opt for a more general explanation of their results, arguing that these preferences exist as a consequence of human evolution taking place in savanna environments where trees with spreading crowns would (they assume; no evidence is provided) have been typical.

As mentioned in Section 2.3.1 above, there are inherent problems with explanations that rely on the idea that we are predisposed towards certain types of nature, not because of their adaptive value, but because those features or environment types happened to be present at a particular point during evolution. There is no basis for assuming that a species will necessarily prefer a particular environment type because that was the environment in which it evolved. When studying other species, the working assumption amongst ecologists is that habitat preference reflects and is shaped by habitat quality and resources in relation to fitness[33] (Beerens *et al.*, 2015). Habitats and resources vary over time, and evolution does not stop. The idea that humans have a preference for the environment in which the species first evolved does not take account of this dynamic variance and implies that human evolution was something that happened in the past, then stopped. This is not borne out by the evidence, which shows that humans are still undergoing evolutionary changes today (e.g. Mekel-Bobrov *et al*., 2005).

In addition, if the idea of being tied to a long gone ancestral environment lacks general ecological plausibility, when applied to humans in particular it seems particularly dubious, since it is humans' adaptive flexibility that has allowed the species to colonise the planet (Laland and Brown, 2011). The argument from SRT that savanna epitomises our species'

[33] Within a population fitness is defined in terms of the individuals who pass on their genes with the greatest frequency (Dawkins, 1989).

natural habitat (and that our psychology today reflects that in terms of stress reduction and preferences) does not sit comfortably with the successful global dispersal of *Homo Sapiens*[34]. Further, it is the drive to modify the environment to make it more habitable that has resulted in urbanisation and, in this context, buildings and cities are themselves a product of human evolution. Hence there is no *a priori* reason to suppose they should necessarily be incompatible with our psychology.

Even for other species, which did not create cities, there is evidence of adaptation to urban environments without negative consequences. For example, in a study comparing cognition in urban versus rural birds (Audet *et al*., 2016) it was found that bullfinches from urban areas had better innovative problem-solving skills and greater immunity than rural bullfinches. It appears that urban life results in changes to cognition and physiology that are advantageous to these birds. While there are no grounds for proposing any parallel between bullfinches and humans, this study serves as a reminder that the assumption that species will necessarily thrive in a more 'natural' environment, or the environment their ancestors evolved in, is flawed.

Of course, this is not to say that cities are ideal habitats for humans. There are health benefits for urban dwellers, including better medical care, sanitation and nutrition (Dye, 2008). However, there is a large body of evidence (much of it discussed in Chapter 2) that reduced physical and mental wellbeing is associated with certain urban environments (e.g. Beil and Hanes, 2013; Mitchell and Popham, 2008; Vorster, 2002). It is undoubtedly the case that our modern living environments differ greatly from those inhabited by our hominin ancestors for a large portion of evolutionary history. However, this does not necessarily mean that the explanation for the negative impacts of built environments must be an evolutionary one; there are many other factors associated with urban living, such as pollution, toxins and crowding that could be relevant (Dye, 2008).

[34] There is still debate about whether there was a single migration out of Africa or multiple dispersal events (Dennell and Petraglia, 2012), but both options are at odds with SRT.

This highlights a critical problem with SRT – although there is evidence that stress may play an important role in the detriments to wellbeing suffered by those who live in urban areas (Lederbogen *et al.*, 2011), there is no reliable evidence that this can be traced back to early humans inhabiting savanna-type landscapes. The preceding section has shown that the evolutionary reasoning underpinning SRT does not stand up to scrutiny, and many of its assumptions are flawed.

(ii) Assumptions about the adaptive value of affective responses

In principle, some of the weaknesses of SRT discussed above could be bolstered, for example by proposing a theoretically justifiable point in evolutionary history and an evidence-based conception of the landscape inhabited by hominins at that point. However, even in the event of improvements to these details, there is another substantial theoretical concern – the question of what the adaptive value is, or might be, of a preference for nature. This section will consider the role of the affective response in stress reduction proposed by SRT.

The positive affective response to natural environments is a foundation of SRT, and a main point of difference between this theory and the other main theoretical framework used in restorative environments research, Attention Restoration Theory (which will be discussed in Section 3 below). Ulrich (1983) argues that from an evolutionary perspective, rapid affective responses motivate appropriate (therefore adaptive) behaviour in a given context. For example, a positive affective response to an area of vegetation might lead to approaching or exploring that vegetation, whereas a negative affective response to a different environmental stimulus (threat) might result in avoidance or flight (Ulrich, 1983). Importantly for SRT, Ulrich argues that affective responses can, "motivate behaviors that are not necessarily expressed as observable actions, but which nonetheless qualify as adaptive functioning." (1983, p.94). For example, for someone who is stressed, a view containing natural elements could elicit a positive affective response, thus reducing stress

and promoting psychophysiological restoration (Ulrich, 1979). In this scenario, simply viewing the scene could be classed as an adaptive behaviour.

The problem with this is its generality. As much as stress reduction might be beneficial, an evolved, generally positive, response to vegetation lacks plausibility. Since the savannas envisaged by proponents of SRT were vegetated landscapes, it makes little sense to propose that a positive affective response to vegetation in general would have been adaptive. Even if being in such a landscape conferred psychological benefits, since this was the only landscape, any individuals who were genetically predisposed to an automatic affective response would not have an advantage over individuals who were not. Therefore, there would be no selection pressure driving the evolution of a positive affective response (Joye and Van den Berg, 2011).

It would, then, be possible to argue that it might not the vegetation *per se* that is important, but the affective response to it. This would require the positive affect, rather than the vegetation, to be responsible for stress reduction. There is evidence that positive affective states can be beneficial to health (Steptoe, Wardle and Marmot, 2005), so this is at least plausible as a pathway by which natural environments could reduce stress. However, it does not help the evolutionary line of argument advanced by SRT. Furthermore, if positive affect is the important factor, natural features or vegetation might become just one class of many potential types of trigger. This seems unlikely to suffice as an explanation for restorative environments phenomena, since it would still be necessary to account for why and how natural elements generate positive affect in the first place. In addition, it cannot be assumed that the type of evolved affective response proposed by SRT would have been useful in terms of finding food or avoiding threats. Ulrich argues that preferences driven by these responses would have directed early hominins to food and protection in vegetated landscapes. The difficulty is that these preferences are general and do not distinguish between types of plants or natural features (which would not all have been equal in terms of survival value). Since what counts as 'food' or 'threat' differs according to temporal,

geographical and cultural context (and must, therefore, be learned[35]), it is not clear how a rapid positive affective response to vegetation in general would have been beneficial.

What can be concluded from this section is that SRT does not satisfactorily account for the positive affective response and does not explain how natural elements reduce stress. Although there is considerable evidence that exposure to nature is associated with reduced stress levels and positive affective responses, the evolutionary arguments advanced by SRT do not explain what it is about natural environments that makes them restorative.

3.3. Attention Restoration Theory

This section will provide an outline of Attention Restoration Theory (ART) before reviewing the most relevant research pertaining to the theory. Following that, it will discuss the theoretical adequacy of ART, both in terms of its underlying logic and the question of whether placing attention at the centre of the theory is empirically justifiable.

3.3.1 Overview

ART was formulated by Kaplan and Kaplan (1989), based on the ideas of William James (James, 1890, 1892) who proposed the concept of *voluntary attention* to refer to a process of consciously attending to phenomena which may not themselves capture attention, but are important to pay attention to. Kaplan and Kaplan term this *directed attention* and argue that it requires effort, is under voluntary control (i.e. an individual can choose what to attend to), can only be sustained for a finite period, and controls distraction via inhibition (Kaplan, 1995).

[35] Although biophobia (in the sense of an innate fear of certain natural elements) is sometimes mentioned as a counterpart (and implied support) for the notion of biophilia (e.g. Ulrich, 1993) a detailed critique of this concept is beyond the scope of the present work. Studies that have looked for phenomena such as fear of snakes in children (e.g. DeLoache and LoBue, 2009) have not been conclusive, while studies that have investigated other primates (e.g. Cook and Mineka, 1990; Mineka, Davidson, Cook, and Keir, 1984) have found evidence that the fear of snakes is learned (albeit rapidly, on minimal exposure to social cues).

According to ART, urban environments provide an excess of dramatic stimulation which captures attention in an effortful manner, such as the noise of car horns and the movement of traffic. Voluntary attention is conceived of as a top-down cognitive process that is effortful because it requires conscious attention in order to focus on and avoid the potential hazards or annoyances (Berman, Jonides and Kaplan, 2008). This effort eventually leads to attentional fatigue.

Natural environments, on the other hand, engage James' concept of *involuntary attention*, which does not require mental effort or cause fatigue. In ART, the term *fascination* is used in place of involuntary attention. Kaplan (1995) distinguishes between *hard fascination*, which is intense and requires total commitment of attentional resources – the example he gives is, "watching auto racing" (p.172) – and *soft fascination*, in which attention is captured in an automatic and effortless manner by natural features such as, "clouds, sunsets and snow patterns," (Kaplan, 1995, p.174) which elicit pleasure, allow space for reflection and enable restoration of cognitive resources (Kaplan, 1995, 2001).

Fascination is regarded as a bottom-up process in which attention is automatically captured, without deliberate effort, by stimuli which are inherently engrossing (Kaplan, 1995). This type of attention is, according to ART, not subject to fatigue since it is not effortful. While *fascination* is the key theoretical construct of ART in that it provides the mechanism for restoration of attention, it should be regarded as a necessary quality of an environment, but not on its own sufficient for restoration to take place (Kaplan, 1995; Kaplan and Talbot, 1983).

The other qualities an environment must possess in order to have restorative potential, in ART, are defined as follows:

- Being Away – i.e. being away from 'tired' cognitive processes that have become fatigued through overuse; a separation from the everyday background environment. Kaplan (1995) states that this does not necessarily need to be a

different physical environment, it could be a difference in perspective (either conceptually or visually) towards an existing environment.

- Compatibility – i.e. there should be a fit between an individual's inclinations and purposes, meaning that less mental effort is required.
- Extent – i.e. the scope to sustain mental interaction for a period of time (of unspecified length) without boredom. "It must … be rich enough and coherent enough so that it constitutes a whole other world." (Kaplan,1995, p.173).

Natural settings and landscapes may often possess these qualities, according to ART, explaining why such environments are associated with restoration. However, there is no reason in principle, within this framework, why restorative environments must contain natural elements. Unlike SRT, in which natural elements are central, in ART it is not the naturalness that matters, but whether the four qualities of *fascination*, *being away*, *compatibility* and *extent* are present.

3.3.1.1 Differences between ART and SRT

SRT is a psycho-evolutionary theory, since it explains psychological phenomena in terms of their evolutionary origins and development, whereas ART could be described as a psycho-functionalist theory (Berto, 2014), since it is concerned with an explanation in terms of current psychological functioning. The functionalist framework of ART does sometimes veer into evolutionary territory, for example arguing that the disposition to respond positively and attend to natural features is based on settings that were beneficial to survival in our evolutionary past (Kaplan and Kaplan, 1989). The problems with this type of evolutionary reasoning explored in Section 2 above apply equally in this context, however since an evolutionary basis is not an essential element of ART, it will not be considered further here.

Although it is possible that both types of theory could be relevant and they are sometimes characterised as being complementary (Berto, 2014), SRT and ART propose different

underlying mechanisms, thus provide different explanations for restorative effects. While SRT is based on psychophysiological stress and its reduction, ART is based on mental (specifically attentional) fatigue and its reduction. SRT predicts quick, automatic effects, whereas ART is more reliant on the role of slower, reflective cognitive processes in restoration phenomena.

3.3.1.2 Initial assessment of ART

Before considering the evidence relevant to ART, it is worth pointing out some potential problems with the theory. Firstly, the issue of defining the terms. In order to predict whether any given environment is likely to be restorative (or explain its restorative potential), according to ART, it should be possible to assess it according to the four qualities it must possess for restoration. However, this is not straightforward. While *fascination* (i.e. involuntary attention) may be measurable, therefore susceptible to definition, there are problems with categorising environments on the basis of their fascinating qualities. Kaplan (1995) argues that certain features are inherently fascinating, though it is not clear how to elucidate or explain this in a manner that is not circular. For example, fascination is defined as being stimulated by, "inherently fascinating stimuli" (Berman *et al*., 2008). When it comes to defining what is inherently fascinating, it is common for authors to list examples of natural features (Berto, Baroni, Zainaghi, and Bettella, 2010; Hartmann, Apaolaza, and Alija, 2013; Joye, Berg, and Steg, 2011; McMahan and Estes, 2015; Roe and Aspinall, 2011), but uncommon for such authors to explain what is inherent to such features that makes them fascinating.

If the property of being fascinating is difficult to characterize objectively, the other qualities an environment must possess, according to ART, in order for it to be restorative seem even less tangible. It is not clear when it comes to *extent*, for example, how to decide whether a given setting is coherent enough to constitute another world, whether it is sufficiently rich, how richness and coherence should be defined and how they interact in the context of

extent. It is also unclear how to assess *compatibility* objectively, i.e. how to define the relevant kinds of inclinations and purposes (for any particular individual and in general), and how to measure these. This dimension of ART implies that the restorative qualities of a given environment will differ according to the individual experiencing it. Whether this is the case (and if so, to what degree) is currently an open question. However, one of the notable outcomes of the body of research into restorative environments (reviewed in Chapter 2) is that restorative effects are apparent in populations in general – the restorative benefits of nature seem to apply over and above individual differences[36], so a successful theory of restoration will need to account for this consistency. As far as *being away* is concerned, the definition seems too loose to be useful. Since it can refer to simply redirecting one's gaze or reframing one's perspective, it is hard to envisage how this could either distinguish different environments or be measured objectively, since any scene or experience could be subjectively reframed in this way, with potentially indefinite (and unmeasurable) variation.

A further problem is the matter of defining the roles of *being away*, *compatibility* and *extent*. If soft fascination is necessary but not sufficient, there needs to be an account of firstly why these other three dimensions are needed (i.e. if the central process is the restoration of directed attention, why is it necessary to invoke concepts that are not obviously connected to attentional mechanisms?). Secondly, there is the (unanswered) question of how the dimensions interact to produce restorative effects. These dimensions (other than *fascination*) do not seem to be theoretically motivated, and because they are imprecisely defined, they are difficult to evaluate empirically. However, some relevant research has been done and will be reviewed below.

[36] This generality is why it makes sense to consider restorative environments as a distinct category and research area.

3.3.2 Relevant research

While there are many studies of restorative phenomena that cite ART as the theoretical framework for their research[37], the number of studies that have looked specifically at attention restoration or attempt to test the predictions of ART directly is much smaller. Based on the four dimensions of *fascination*, *being away*, *extent* and *compatibility*, the Perceived Restorativeness Scale (Hartig, Korpela, Evans, and Gärling, 1997) is often used as a measure of perceived restoration in the context of ART. Although studies have found associations between the four dimensions and favourite places (Korpela and Hartig, 1996), reactions to green space (Herzog, Maguire, and Nebel, 2003) and environmental preferences (Purcell, Peron and Berto, 2001), such research does not directly support ART over any other framework.

Participants are typically asked to rate images of different environments using a Likert-type scale to indicate how much they agree or disagree with statements such as: My attention is drawn to many interesting things (*fascination*); To get away from things that usually demand my attention I like to go to places like this (*being away*); There is much to explore and discover here (*extent*); The environment gives me the opportunity to do activities that I like (*compatibility*) (Hartig *et al*., 1997). Items may differ slightly according to the details of each study, but are essentially similar across the literature (Ojobo *et al*., 2014; Pasini, *et al*., 2015). Although these measures of perceived restoration have proved useful in identifying environments that may be generally restorative (Han, 2003), they do not provide direct support for ART, since they do not assess depletion or restoration of attentional (or other cognitive) resources. Also, although they purport to assess the four dimensions of ART, their generality and necessarily subjective interpretation mean that such measures cannot be regarded as evidence for ART over other general explanations. For

[37] It is common that such studies are framed within the context of ART, yet do not investigate attention restoration either directly or indirectly (e.g. Calogiuri, Nordtug, and Weydahl, 2015; Hawkins, Thirlaway, Backx, and Clayton, 2011; Ivarsson and Hagerhall, 2008; Korpela and Ylén, 2007; Nikunen, Puolakka, Rantakallio, Korpela, and Halonen, 2014; Scopelliti and Vittoria Giuliani, 2004). The discussion in this section will be restricted to work that is germane to evaluating ART.

example, it could be argued that items on a typical Perceived Restorativeness Scale are a reflection of a generally positive attitude towards certain environments; there is no necessary link between these subjective ratings and the actual restoration of attention predicted by ART. Further, not only is there no necessary link between the Perceived Restorativeness Scale and attention restoration, the links between the four dimensions themselves and the manner in which they are assessed by the scale are questionable. For example, since *fascination* (involuntary attention) is hypothesized to be an automatic process, individuals may not be aware of it (Lamme, 2004; Koch and Tsuchiya, 2007). Therefore, asking participants to report upon their own unconscious cognitive processes is not necessarily a reliable method for gaining insight into these processes.

When it comes to empirical findings, the most relevant body of research consists of the studies that test cognitive performance in the context of ART, usually comparing the impact of exposure to nature with exposure to urban scenes. In early work in this area, Tennessen and Cimprich (1995) conducted a study with university students to explore whether the view from their dormitory windows was associated with scores on tests of directed attention. Views were categorised into types ranging from entirely natural to entirely built. Tennessen and Cimprich found that window views of nature were associated with better performance on measures of attention. Although this study showed an association between nature views and attentional performance, suggesting a possible relationship, it did not demonstrate a causal link.

Hartig, Evans, Jamner and Davis (2003) performed an experimental study including measures relevant to both stress reduction and attention restoration. The authors designed a procedure that included an environmental exposure condition (natural or urban) and a pre-exposure cognitive task condition (task or no task). They assessed the cognitive impact of their manipulations by recording performance on the Necker Cube Pattern Control Test[38].

[38] The NCPT is a psychological test that is commonly used as a measure of attentional capacity (Inui *et al*., 2000; Toppino, 2003). The procedure involves viewing a line drawing of a three-dimensional Necker cube (Necker, 1832) which can be perceived as either protruding from or intruding into the screen, but not both. Although perception of the shape will flip spontaneously between the two possibilities, it is also possible to

Results showed that exposure to nature resulted in a decrease in pattern reversals on the NCPT (indicating decreased attentional fatigue), whereas exposure to the urban environment resulted in an increase in pattern reversals (indicating increased attentional fatigue). These findings are consistent with the prediction from ART that natural environments should be associated with increased attentional capacity and urban environments with decreased attentional capacity. Hartig *et al.* also assessed stress (via blood pressure measurements) and affect (via self-reports) and found that although nature exposure was associated with lower stress, the change in Necker Cube task performance did not correlate with the pattern of blood pressure changes, suggesting that the stress reduction and attention restoration were not driven by the same underlying process. There was, however, a significant association between improvement in task performance and increase in positive affect. This raises the theoretically important question of whether valence of affect might mediate attentional capacity, or *vice versa*.

In a study of attentional capacity, Berto (2005) induced attentional fatigue in her participants (using a demanding cognitive task) before presenting them with scenes depicting either nature or built environments. The participants who were shown images of nature then performed better on a second cognitive task than did those who had viewed the built scenes. Berto argues that these results support ART, since they suggest that viewing natural scenes allowed better recovery of attentional capacity than viewing urban scenes. In a further study, Berto, Massaccesi, and Pasini (2008) looked for further evidence in support of ART by attempting to measure *fascination* in urban and natural scenes. Using eye-tracking apparatus, Berto *et al.* recorded saccades and fixations of the eye in participants viewing photographs of natural and urban scenes chosen to represent high fascination (i.e. soft fascinating, in ART terms) and low fascination respectively. The results showed that although the amount of movement (saccades) did not differ between scenes,

control the reversal of perspective with conscious effort (Kornmeier and Bach, 2005). The number of reversals during a 30-second period is taken as a measure of attentional fatigue, with fewer reversals indicating lower fatigue (Cimprich, 1993).

low fascination (built) images resulted in more fixations than the high fascination (nature) images, suggesting that less effort was required to view the images of nature. The authors interpret these results as supporting the predictions of ART that high fascination images will engage effortless, involuntary (bottom-up) attention and will therefore stimulate a different pattern of eye movements than low fascination images which will, in turn, be more likely to recruit effortful, top-down attention.

Despite the logical conclusion that the nature images may have stimulated less visual effort than the urban scenes, it is not possible to conclude from this that there was any difference in the type of attention employed in each case, since it is not possible to distinguish top-down and bottom-up attention on the basis of fixations (i.e. there is no theoretical reason why bottom-up attention would necessarily result in fewer fixations). Further, although fixation duration has been shown to be associated with attentional control in some circumstances (Papageorgiou *et al.*, 2014) the number of fixations is not necessarily an indicator of attention[39]. It cannot even be assumed that a single fixation indicates directed attention, as demonstrated by the existence of so-called *inattentional blindness* (Simons and Chabris, 1999) where an object that is fixated upon is not consciously noticed because attention is focused elsewhere. Based on eye movements alone, it is not possible to determine whether the fixated-upon object has been consciously attended to, as objects that are not noticed may be fixated upon (or 'looked at') in the same manner and for the same duration (Memmert, 2006).

Chang, Hammitt, Chen, and Machnik (2008) conducted a study to investigate physiological responses to scenes selected to represent each of the four components of ART. They selected photographs to represent each component, then recorded participants' ratings of these on a version of the Perceived Restorativeness Scale and also took measurements using electromyography (EMG), electroencephalography (EEG) and blood volume pulse (BVP).

[39] An association has been found between saccades and attention (Hoffman and Subramaniam, 1995), but in Berto's study, the saccades did not differ between scenes, further diminishing the claims that this study found differences relating to attention in apparent support of ART.

Viewing the natural scenes resulted in beneficial changes in all the physiological responses (compared with viewing a solid blue rectangle) except BVP. Some differences were found between the scene-types; most notably, increased activity measured by EEG for the *being away* scenes. Despite these significant findings, it is difficult to relate these results straightforwardly to ART for a number of reasons. Firstly, the selection of images to represent each dimension was based only on *ad hoc* examples given in a book by Kaplan *et al.* (1998), rather than any formal definitions. Consequently, the images were not controlled in any way, including no control of the other three factors in the images for each dimension. This means it could have been the case that the images selected to represent *being away* might also have been high on one or all of the other dimensions (or some other factor). In addition, there were no urban scenes for comparison, only a non-viewing condition. In such a design, it might be expected that differences in brain activity would be seen in response to images versus a solid block of colour. As the authors point out, although they believe that their findings relate to restorative responses, the results do not allow that conclusion because (apart from the methodological criticisms made above) there is no clear link between the physiological responses they observed and actual restoration, either in terms of mechanisms or interpretation of the meaning of the brain activity patterns.

Lin, Tsai, Sullivan, Chang, and Chang, (2014) investigated the relationship between urban trees and restoration of attention. Four groups of participants were shown images of urban streetscapes: either streetscapes with no trees, streetscapes with brief flashes of trees (participants had minimal awareness of the scene content), streetscapes with trees, or streetscapes with trees which participants were instructed to pay attention to. It was found that the presence of trees improved performance on an attentional test, irrespective of participants' awareness of the trees, thus appearing to supporting ART. A further finding, however, was that participants who had greater awareness of the trees performed better in the attentional test than those who had experienced the trees but not had their conscious attention directed towards them. These participants also rated the streetscapes with trees as being more restorative. This is not predicted by ART, which argues that the restorative

effects of nature come from its engaging of involuntary attention, in a bottom-up process. This study does, though, highlight the issue that the role of implicit and explicit psychological processes in restoration phenomena is currently not well understood.

In an intervention-based strand of research in healthcare settings, Cimprich and her collaborators (Cimprich, 1992, 1993; Cimprich and Ronis, 2003; Tennessen and Cimprich, 1995) attempted to facilitate attention restoration in patients undergoing surgery for breast cancer. The assumption underlying this research is that such patients are likely to be suffering from attention fatigue (this assumption was substantiated in the studies cited above), that exposure to nature could restore attentional capacity (evidence for this was demonstrated by Cimprich and Ronis, 2003) and that restoration of attention would be helpful for recovery (the evidence for this is less apparent). While the benefits of exposure to nature in healthcare settings have been observed previously (e.g. Ulrich, 1984, Vincent, Battisto, Grimes, and McCubbin, 2010) there is no clear causal link between attention restoration and recovery from illness. While the participants in Cimprich and Ronis' (2003) study appeared to benefit from their nature intervention, it is worth noting that the comparison was between the group of patients who received the nature intervention and those who did not receive an intervention, leaving open the possibility that it was not necessarily the nature, but the presence of an intervention that was beneficial. This explanation could have been ruled out by including a third group who received a non-nature intervention. It is also possible that the observed attention restoration may have been a secondary consequence of other effects of exposure to nature (such as stress reduction or increase in positive affect). These factors were not controlled for or ruled out. Therefore, despite providing evidence in support of the potential health benefits of nature exposure, this work does not provide direct support for ART.

Other experimental studies have discussed their findings' lack of support for the predictions of ART. For example, Emfield and Neider (2014) investigated the impact of both images and

sounds of nature on cognitive restoration, using three cognitive tasks[40]. The authors did not find an improvement in performance on any of the tasks. They did, however, find that the nature images and sounds were more relaxing than the urban stimuli. This study is not alone in failing to replicate the findings of improvements in cognitive tasks after exposure to nature, discussed above. For example, Hartig, Evans, Jamner, and Davis (2003) did not find an improvement in search and memory tests when participants were exposed to natural settings. However, Emfield and Neider's study is unusual in that the images of nature they used were exclusively ocean scenes. It is therefore not clear whether the explanation for their results may be due to some characteristic of those scenes, or some other methodological factor (for example, as suggested by the authors, their tasks not being sufficiently fatiguing to produce an effect).

3.3.3 Theoretical adequacy of ART

Although the studies discussed above provide some evidence that viewing or experiencing natural scenes can restore attentional capacity, the relative scarcity of such studies, together with the methodological concerns highlighted above, indicate that their support for ART should be regarded as tentative. At this stage, it has not been established whether cognitive benefits from exposure to nature are due to direct effects on attentional processes or whether they may be due to mediating factors. This issue will be discussed further below, after considering whether the conceptual framework underpinning ART is well-founded.

[40] The three tasks they used were typical of studies investigating attention restoration: The backward digit span task, a commonly used measure of working memory (Richardson, 2007) which assesses digit span capacity by presenting participants with sequences of digits of increasing length (through headphones), then requiring them to enter the digits in reverse order using a keyboard; the attention network task, which assesses the attentional functions of alerting, orienting and executive control (Fan *et al.*, 2002) by measuring reaction times to spatial cues; and the functional field of view task (variations of which are known as the useful field of view task, often used to assess driver safety in older adults (Wood and Owsley, 2014), which measures visual attentional capacity, including peripheral vision (Edwards *et al.*, 2006).

3.3.3.1 Underlying logic

Setting aside the paucity of empirical work that unambiguously supports ART, the theory faces further problems when its underlying logic is examined. ART relies on the notion that the capacity for directed attention is susceptible to fatigue and can be restored when involuntary attention (fascination) is engaged. However, the distinction between hard and soft fascination required by ART creates a logical problem. If it is the switch to involuntary attention which permits the capacity for directed attention to be restored, then any involuntary attention should be effective in this respect, whether it is characterised as 'hard' or 'soft'. However, only soft fascination is restorative according to ART. This is argued to be because soft fascination allows the opportunity for reflection (Kaplan, 1995). If it is the opportunity for reflection that is the crucial factor, the role of fascination becomes less clear, suggesting that the basis for restoration might then be 'reflection potential' rather than fascination itself. In this case it might be expected that a completely non-fascinating view, such as a blank wall, would be the most restorative type of view since it would not place demands on directed attention and would provide the greatest opportunity for reflection, free of distractions. However, research findings do not support this shift of emphasis, with evidence that such non-views are the least restorative of all (Ulrich, 1984; Verderber, 1986). So although ART maintains that soft fascination is the cornerstone of restoration, the mechanisms by which this works to replenish depleted cognitive resources are not satisfactorily specified.

In relation to urban environments, there is an additional problem with the claims about directed attention made by ART. It is argued that, in contrast to natural environments, urban settings engage hard fascination, with bottom-up stimuli (such as car horns) that capture attention dramatically, and may then recruit directed attention in order to overcome potential hazards (Berman, Jonides and Kaplan, 2008). While this could be argued to apply in real settings, such hard fascination and the need for directed attention is not present in experimental settings where participants view images of natural and urban scenes. It is

difficult, therefore, to explain the restorative effects that are seen in experimental situations involving looking at photographs within this framework. Further, ART argues that the bottom-up attention engaged by natural scenes results in soft fascination, allowing restoration of directed attention. However, it is not clear why tranquil urban scenes or urban images in general should not also engage soft fascination, and so be equally restorative. In addition, since top down and bottom up attention have been shown to be independent (Pinto *et al.*, 2013), it could be argued that any activity that does not recruit directed attention should allow its restoration. There is no satisfactory way of accounting for these issues in ART as it stands.

3.3.3.2 The role of attention restoration

The concept of attention upon which ART is based was proposed in the 19th Century (James, 1892). There is now evidence that James' concepts of voluntary and involuntary attention have some relevance in terms of neuropsychological processing (Larson and Merritt, 1991; Morecraft, Geula, and Mesulam, 1993) and this appears to support the notion of directed attention that is central to ART (Kaplan and Berman, 2010).

Modern attentional theory has developed beyond this simple distinction, however. In the context of current research, attention can be defined as a set of processes which enable "the maintenance of goal-directed behaviour in the face of multiple, competing distractions" (Parasuraman, 1998). As such, it is characterised as having three main aspects: executive attention, selectivity and intensity (Raz and Buhle, 2006). These are based in separate neural systems (McAvinue *et al.*, 2012) and serve the distinct functions of alerting, orienting and executive control (Fan *et al*., 2009; Posner and Fan, 2008). It is thus important to remember that when ART refers to 'attention' this should be considered not as a unitary phenomenon, but as a set of separable processes. It is also worth noting that the operation and interaction of these processes, both amongst themselves and with other cognitive processes, is not fully understood (Haladjian and Montemayor, 2012).

One of the problems for ART is that even if studies show that performance on attentionally demanding tasks can be improved as a result of exposure to natural environments, it cannot be concluded on that basis that the reason for the improvements to performance are necessarily due to restoration of attention, as opposed to some other factor. For example, it could be the case that attention is not the primary mechanism but is affected by some other phenomenon, such as mental fatigue. Boksem, Meijman, and Lorist (2005) showed that the capacity to direct attention declined with mental fatigue, suggesting that the apparent depletion and restoration of attention might be a result of mental fatigue. These conclusions are supported by findings that mental fatigue has an impact on both attention, and working memory and executive control processes, indicating that mental fatigue could impair the ability to attend to and process information (Cook, O'Connor, Lange, and Steffener, 2007). Kaplan (1995) proposes that directed attention fatigue results in mental fatigue, which is consistent with the theory of Baumeister, Bratslavsky, Muraven, and Tice (1998), who argue that effortful control of behaviour results in depletion of the capacity for self-control. However, Boksem *et al*.'s research suggests the opposite direction of causality, i.e. that it is mental fatigue that diminishes attentional capacity.

Further work on mental fatigue supports and extends this interpretation. Using a combination of EEG, eye-tracking and performance measures, Hopstaken, van der Linden, Bakker, Kompier, and Leung (2016) investigated the influence of mental fatigue on a cognitively demanding task that required directed attention. They found that rather than performance being explainable by a depletion of finite attentional resources (as required by ART), the important factor was motivation. Hopstaken *et al*. found that when they increased the rewards, mentally fatigued participants were able to re-engage with the task and exceed their performance at the beginning of the procedure (at a point when they were not fatigued), despite still reporting high subjective levels of fatigue. Their results lead the authors to conclude that,

"Mental fatigue is a mostly motivationally driven protection mechanism in order to restrain individuals from spending cognitive resources on tasks that are not worth the effort. This directly contradicts the view that fatigue effects are explained by an inability to engage in the task (or explore the alternative stimuli) caused by depleted resources." (2016, p.10)

This work contradicts the predictions of ART and challenges the conception of attention being the primary mechanism. From this perspective, rather than depletion of limited resources explaining variation in attentional performance, it may instead be due to cost/benefit trade-offs; that is, when the cost of engaging with the task outweighs the benefit of staying engaged, performance will decline. This is an issue common to much of the empirical work cited in support of ART. Since attention is the only process that is assessed, the results do not require attention (restoration or depletion) to be the primary mechanism. Interpretation of such results rarely considers the possibility that variation in attentional capacity may be a consequence of variation in other processes, as suggested by the evidence above.

A further problem for ART is that even if the notion of attention restoration could be justified, either theoretically or empirically, the role of the four dimensions (*fascination, compatibility, extent, being away*) would need to be accounted for within the framework of attentional theory. This has not yet been done, with the result that they may appear somewhat arbitrary and lack theoretical coherence. A broader weakness of ART is that it can only purport to explain the beneficial effects of nature on cognitive functions that depend on attention. It does not have the explanatory capacity to account for the wider health and wellbeing benefits associated with exposure to natural environments, which have no clear connection to restoration of attention. While it could be the case that there is a separate, unrelated explanation for every restorative phenomenon, one overarching framework which accounts for all the phenomena is theoretically preferable[41].

[41] Applying the principle of Occam's Razor, which states that entities should not be multiplied beyond necessity – in a scientific context, the simplest theory that accounts for the data should be preferred (Myung and Pitt, 1997).

3.3.4 Summary

It was Kaplan and Kaplan (1989) who coined the term *restorative environments* and their theory of attention restoration has framed much of the research in the field. While many of the studies which cite ART as their theoretical basis have provided support for the validity of the concept of restorative environments, so far there is little evidence that restoration of attention is the primary mechanism in restorative effects. Although ART and SRT make different theoretical assumptions and propose alternative explanations, together these theories underpin the strong empirical evidence base that natural environments have greater potential for restoration than urban environments (e.g. Berto, 2005; Hartig, Korpela, Evans, and Gärling, 1997; Herzog, Black, Fountaine, Knotts, and Herzog, 1997) and that scene preference is influenced by the need for restoration (e.g. Purcell, Peron, and Berto, 2001; Staats, Kieviet, and Hartig, 2003; Van den Berg *et al*., 2003; van der Wal *et al*., 2013). A problem common to both theories, however, is that neither can account for all the data. SRT is beset by theoretical weakness, whereas the narrow focus of ART, together with its lack of objective definitions, means its explanatory power is limited. The next section will consider some of the more recently proposed, and still developing, theories.

3.4 New theoretical directions

The large number of studies showing that restorative effects can arise from simply viewing images of nature (e.g. Chang *et al*., 2008; Hartig and Staats, 2006; Herzog *et al*., 2003) suggests it is possible that the effects may be a result of visual characteristics[42] of those images, as opposed to whether they depict natural or built scenes. The legitimacy of this idea is supported by work which shows that objective, low-level visual features of images, including contrast changes, density of straight lines and colour saturation can predict the

[42] There are strands of research investigating other modalities that may influence restoration, such as sound (e.g. Abbott, Abbott, Newman, and Benfield, 2015; Alvarsson, Wiens, and Nilsson, 2010; Payne, 2013; Ratcliffe, Gatersleben, and Sowden, 2013) and smell (Lehrner *et al.*, 2000). However, since restorative effects can be induced through visual stimuli alone, the working assumption that such effects are primarily visual seems justifiable (Grinde and Patil, 2009).

degree to which an image is perceived as natural (Berman *et al.*, 2014). Recent attempts to extend the theoretical framework within which to interpret restorative phenomena have focused on this aspect by proposing that restorative effects may be connected with ease of visual processing of statistical features. This could be due either to internal repetition of structure (Joye, Steg, Ünal, and Pals, 2015) or processing of visual spatial frequencies (Valtchanov and Ellard, 2015). These newly emerging theories will be discussed below.

3.4.1 Low-level visual features - fractal geometry

It is well established that ease of processing can have an impact on perception, i.e. some stimuli are easier to process than others (Alter and Oppenheimer, 2009). This phenomenon is known as perceptual fluency (Johnston, Dark and Jacoby, 1985). In terms of visual perception, factors that have been shown to have an impact on perceptual fluency include symmetry (Locher and Nodine, 1989), visual clarity (Oppenheimer and Frank, 2008) and figure-ground contrast (Reber and Schwarz, 1999). Further, some research has demonstrated that perceptual fluency is associated with positive affective responses (Winkielman and Cacioppo, 2001; Winkielman *et al.*, 2003). Consequently, it has been argued that aesthetic pleasure is related to perceptual fluency, indicating that stimuli that are easier to process will be judged to be more attractive (Reber, Schwarz and Winkielman, 2004).

This perspective had not been applied to cognitive restoration until Yannick Joye's work based on the observation that perceptual fluency need not necessarily be restricted to simple forms, but that apparent complexity might also be easy to process when that complexity arises from the operation of simple rules (Joye *et al.*, 2015; Joye, 2006; Joye, 2007a, 2007b). Since the fractal geometry of structures found in nature (Mandelbrot, 1983, 1990) is characterised by the continuous internal repetition of simple structures, Joye hypothesized that such structures would be easier to process than apparently complex structures that were not fractal. Despite their visual complexity, fractal structures can be

described by the operation of the same simple rule at different hierarchical levels (Martins *et al.*, 2014), which may result in lower perceptual and processing demands (Joye and Van den Berg, 2011).

Joye *et al*. (2015) tested this hypothesis in a series of studies in which participants were exposed to high-fractal and low-fractal stimuli while completing tasks designed to reflect both objective processing fluency (measures were reaction times and error rates) and objective fluency (perceived effort in completing the tasks). The stimuli did not include images of real objects, but comprised three-dimensional block structures, as shown in Figure 3.1 below. It was found that when the complexity in an image resulted from internal repetition of structure, processing was easier (more fluent and less effortful) than for apparently less complex images. It is widely recognized that nature abounds with fractal patterns (Barnsley, 1993; Gouyet, 1996) in structures including trees, coastlines and clouds (Taylor *et al*., 2011) and previous research has linked fractal characteristics with positive affective responses, in both landscape silhouettes (Hagerhall, Purcell and Taylor, 2004) and art, such as the drip paintings of Jackson Pollock, which have been found to have fractal structures (Taylor *et al*., 2005). The indication from Joye's studies that cognitive processing might also benefit from exposure to such patterns suggests that further research is warranted into a possible role for fractal characteristics in restorative environments phenomena.

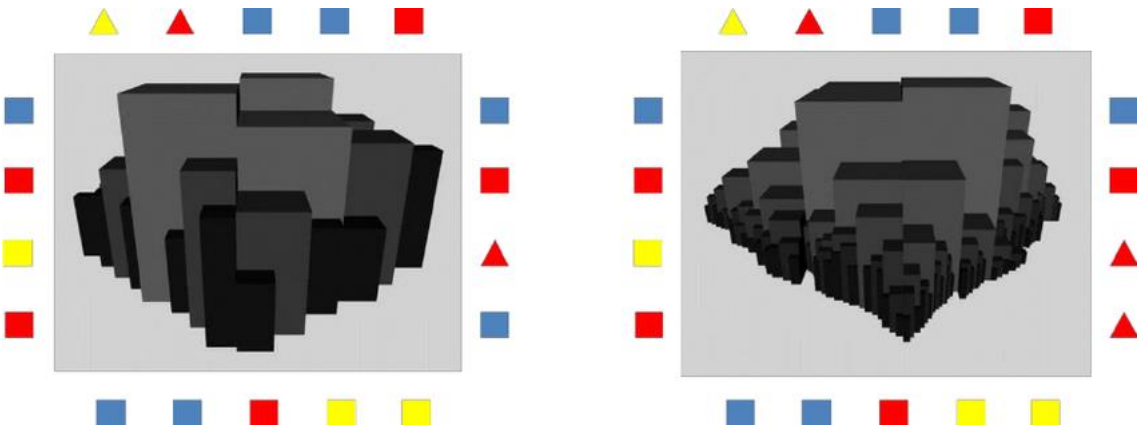

Figure 3.1. *Sample pictures of low-fractal (left) and high-fractal (right) experimental stimuli from Joye et al. (2015).*

Since Joye's studies used only abstract block structures, it cannot be assumed that these findings will necessarily be transferable to natural scenes. Despite the fractal structure of many natural features, not all fractals are equivalent in terms of characteristics such as spatial structure, with random fractals often lacking the spatial structure and contrast (variation of luminance) found in natural images (Baker and Mareschal, 2001). It is also worth remembering that fractality is not absent from urban and built scenes (Cooper and Oskrochi, 2008). Joye *et al*. (2015) point out that their theory is potentially compatible with ART, since ease of processing could be viewed as defining *fascination*. However, it is not clear what is gained by integrating this new perspective into the existing framework as opposed to letting it stand alone. The advantage of Joye's theory over ART and SRT is that it makes predictions that are testable, since fractality can be quantified and measured. One interesting prediction is that a built scene containing a high degree of fractality should result in greater perceptual fluency (therefore improved cognitive processing and more positive affect) than a natural scene containing low levels of fractality. This has yet to be tested and would complement a new strand of research looking at how aspects of urban environments such as building height and architectural variation might promote restoration (Lindal and Hartig, 2013).

3.4.2 Low-level visual features – visual spatial frequencies

Taking a different approach to relating restoration effects to low-level visual processing, Valtchanov and Ellard (2015) have proposed a new theory which may go some way to explaining why some scenes are more restorative than others. In a similar manner to the fractal-processing theory, this framework is based on the idea that restoration phenomena can be traced back to the ease of processing of low level visual features. This work is not necessarily incompatible with Joye's theory, though the emphasis is different. Valtchanov and Ellard argue that it is also compatible with both ART and SRT, in that it predicts (and

explains) an initial positive affective response to mid-to-high spatial frequencies of scenes, as well as their less effortful visual processing.

Valtchanov and Ellard's theory is underpinned by the notion of visual reward mechanisms, based on functional neuroimaging (fMRI) studies of scene preference. This research has found that viewing preferred scenes is associated with greater activation in two areas of the brain: the ventral striatum (which is active in reward systems) and the parahippocampal cortex (which is involved in scene processing) in the ventral visual pathway (Yue, Vessel and Biederman, 2007). Valtchanov and Ellard point out the similarity between these processes, which are active when viewing preferred scenes, and the neural activity observed when other pleasant stimuli (such as food) activate opioid reward systems (Gosnell and Levine, 2009). Studies that demonstrate the pain-relieving potential of viewing natural scenes add support to the justifiability of this link. For example, Lechtzin *et al*. (2010) performed a randomized, controlled trial with patients undergoing the painful procedure of bone marrow aspiration and biopsy. A control group of patients received standard care, another group viewed an urban image, and a third group viewed a nature image. Although the differences between results in the three conditions were not large, there was an indication that viewing an image of a natural scene may reduce pain more than standard care (involving no nature scene). There was no difference in pain between the patients assigned to the urban image group and the standard care group.

Valtchanov and Ellard propose that the ventral visual pathway may be activated when natural scenes are viewed, thus triggering opioid reward systems which may be the source of restorative effects. The basis for this proposal is their observation that the ventral visual pathway is sensitive to spatial frequencies, and that such frequencies may differ in natural and urban scenes (Valtchanov and Elllard, 2015). Spatial frequency indicates the amount of detail in an image or scene per degree of visual angle. A scene with many small details and edges has a higher spatial frequency than a scene with just one large, smooth blob, for example (Price, 1997). This is illustrated in Figure 3.2, below.

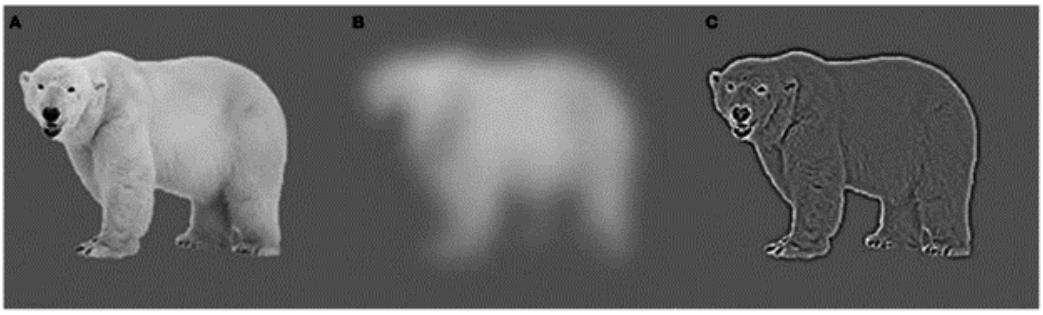

Figure 3.2. *Image including both high and low spatial frequencies (A), low spatial frequencies (B) and high spatial frequencies (C). From Panichello et al. (2013).*

Visual perception research has shown that humans are most receptive to images containing mid-to-high spatial frequencies (Fintzi and Mahon, 2014). Therefore, Valtchanov and Ellard predicted that the positive effects of viewing natural scenes would be associated with the mid-to-high spatial frequencies of natural scenes.

To test their hypothesis, Valtchanov and Ellard conducted a study in which participants viewed photographs of nature and urban scenes, some of which were altered to include only low or mid-high level visual spatial frequencies. The authors investigated the impacts of viewing the altered and unaltered scenes on preference ratings and cognitive load (measured by blink rate[43]). Results showed, in line with previous research, that the unaltered nature scenes were rated as being more pleasant than urban scenes. However, when the images were altered to remove certain spatial frequencies, responses to the urban and natural scenes differed. For the high-spatial frequency variants, natural scenes were still rated as more visually pleasant. However, for the low-spatial frequency variants there was no difference in pleasantness between urban and natural scenes. Further, removing the mid-to-high spatial frequencies resulted in a greater reduction in pleasantness ratings than

[43] There is evidence that blink rate increases with cognitive load (Siegle, Ichikawa and Steinhauer, 2008). However, other factors such as fatigue and task demands can also influence blink rate (Stern, Boyer and Schroeder, 1994), so it cannot be regarded as a definitive measure.

removing the low spatial frequencies. These results suggest that it is the mid-high spatial frequencies that have the greatest impact on positive affective responses.

The results for blink rate displayed a different pattern. Blink rate was greater when viewing unaltered urban scenes compared with unaltered nature scenes, suggesting that less cognitive effort was involved in viewing the nature scenes. This finding was congruent with the pleasantness ratings. However, for the altered images, when low spatial frequencies were removed there was no difference in blink rate (cognitive load) between the nature and urban images. When the mid-to-high spatial frequencies were removed, the difference in blink rate between urban and nature images remained. This difference in the blink rate patterns and pleasantness ratings suggests that preference for and positive affective responses to nature may be dissociable from the benefits to cognitive processing from viewing nature; hence two different mechanisms may be involved in affective and cognitive aspects of restoration (Valtchanov and Ellard, 2015). This marks a point of difference between this framework and the fractal processing theory of Joye *et al*., which explains both the positive affective reaction and the cognitive benefit as resulting from easier processing. However, it is important to note that blink rate was an indirect measure of cognitive load rather than an actual measure of cognitive performance. Therefore, more work is needed to elucidate the nature of the relationship between cognitive restoration and positive affect.

These two frameworks, which attempt to account for restoration phenomena in terms of low-level visual processes are still at an early stage of development. However, their initial findings indicate that the unconscious psychological processes involved in visual perception may provide a basis for explaining why some scenes may be more restorative than others.

3.5. Theoretical perspectives on blue space

Explanations of the restorative potential of natural scenes have been framed overwhelmingly in terms of green space (scenes consisting of mostly vegetated features)

both in terms of the theories themselves and the empirical work that has attempted to test their predictions. However, as discussed in Chapter 2, there is growing evidence that blue space scenes (those containing water) are particularly restorative. Although both SRT and ART mention water, it is in general terms, without making specific predictions about the impact of water or its restorative potential in relation to other natural elements.

For example, Ulrich (1999) argues that, "… modern humans, as a partly genetic remnant of evolution, have a biologically prepared capacity for acquiring and retaining restorative responses to certain nature settings and content (vegetation, flowers, water), but have no such disposition for most built environments and their materials." (p.52). However, despite water being mentioned, it is not distinguished from other natural features in SRT.

In the context of ART, Kaplan (1995) also adopts a vague approach, citing the seaside, lakes and streams as examples (amongst other, non-aquatic natural environments) of locations for restorative opportunities. Similarly, Kaplan, Kaplan and Ryan (1998) acknowledge the potential of water as one among many restorative features: "*Nature is well endowed with objects of fascination in flora, fauna, water and the endless play of light*." (p. 20). Much research into restorative environments phenomena mentions water similarly, in passing, as a potentially restorative natural feature, though without distinguishing it theoretically from other features. Amongst the work that has considered the role of water specifically, the focus has been on observing its restorative effects more than explaining how these effects arise. A number of studies hint at an evolutionary explanation, arguing that a preference for aquatic environments may have been beneficial in our evolutionary past (e.g. White *et al*., 2010). As with the evolutionary arguments discussed above, this is more speculation than theory and cannot be regarded seriously in the absence of supporting evidence[44]. In a series of studies adopting an explicit evolutionary framework, Meert, Pandelaere and Patrick (2014) found a preference for glossy items amongst both adults and children. They also

[44] The first evidence for innate recognition of a habitat cue in a mammal was published only recently (Greif and Siemers, 2010). Interestingly, it was evidence for recognition of water bodies by echolocating bats. While this research demonstrates that the concept of genetically determined responses to environmental features is credible, there is currently no evidence of such responses in humans.

found that aquatic landscapes were rated as significantly more glossy than desert landscapes, a result which the authors interpret as supporting their hypothesis that people's preference for glossy items is related to an innate preference for fresh water. There is, however, no necessary causal connection between the two findings. Further, in a final study, Meert *et al*. manipulated thirst levels in their participants (by feeding them salty crackers) before asking them to rate glossy or matte pictures of planets on the basis of attractiveness. The glossy pictures were rated most highly in the control condition, suggesting that thirst did not increase preference for glossy images, contrary to the predictions of their hypothesis. Other work has found a preference for reflective water (Nasar and Li, 2004) but related it to the characteristics of the reflective surface, rather than the water itself. While Nasar and Li consider their results to be congruent with both ART and SRT, the emphasis on visual qualities also makes this research potentially compatible with the theories of visual feature processing discussed in Section 4 above.

In summary, the prominent theoretical frameworks do not satisfactorily explain the mechanisms by which blue space is restorative. They also do not make easily testable predictions about the restorative effects that may arise from exposure to blue space. Since blue space appears to have greater restorative potential than any other environment type (White *et al*., 2010) it is under-researched compared with many scene categories. The investigation of blue space may provide important insights to inform the theoretical development that is needed in restorative environments research.

3.6 Conclusion

The dominant theories, ART and SRT, ignited and have defined the field of restorative environments research. Despite the progress that has been made in understanding which broad types of environments are restorative, as well as gathering evidence of their benefits to health and wellbeing, there has been little theoretical development since these frameworks were proposed. Although this is now beginning to change, neither the old nor

the new theories can satisfactorily explain restorative effects. It is not yet understood exactly what it is that makes a scene restorative, which scene elements or factors are responsible for which elements of restoration, and how the underlying psychological processes work (particularly regarding the relationship between implicit and explicit processes). In addition, the observation that water may be the most restorative environmental feature has not been explained. The potential health benefits of blue space coupled with the pressure on many aquatic landscapes from urban and industrial development mean that understanding the basis for their restorative potential is not only of theoretical interest, it has immediate practical implications.

The original studies conducted for and reported in this thesis will investigate some of the constraints on blue space effects by exploring the question of whether the presence of artificial objects can affect the restorative potential of natural environments with and without water. Due to the theoretical weaknesses of ART and SRT, the present studies will not assume either of these as a main framework. These theories may, however, be referred to in order to situate the present work within the context of restorative environments research in general. In line with the recently emerging (and initially promising) theories based on psychological processes underlying visual perception, the present studies will adopt an experimental psychological approach to address the research questions, focusing on implicit responses to natural scenes. The next chapter will discuss this methodological approach in detail.

Chapter 4

Addressing the research questions

4.1 Introduction

This chapter links the research questions motivated by the research reviewed in Chapter 2 with a methodological framework based on the theoretical positions outlined in Chapter 3. The methods used in this thesis constitute part of the originality of the work. Therefore their suitability for addressing the research questions will be discussed and justified in terms of the general aims of the research, the particular approach taken, and the strategy and research design of the studies.

4.2 Research questions

Chapter 2 showed that although there is abundant evidence of the existence of the restorative effects of natural environments (and natural elements of built environments) in general, evidence about the role of specific environmental features is lacking. Some natural features – in particular water – seem to be particularly restorative, but their impact has not been investigated systematically. Other features – such as artificial objects in natural scenes – have rarely been investigated in a controlled manner and their impact on restoration is not known. Chapter 3 then highlighted the lack of a satisfactory explanation for the mechanisms underlying restorative effects. Together, these chapters indicate that current understanding of restorative effects needs to be developed in terms of: the underlying mechanisms (hence the cognitive psychological approach adopted here); scope (the need to focus on the effects of blue space); and constraints (the need to understand the impact of artificial objects). The research questions are derived from these considerations.

The overarching question driving the research is:

Does the presence of artificial objects influence affective reactions to natural aquatic and non-aquatic scenes?

In order to address this question, four more specific research questions were formulated. Each question formed the basis for a separate study:

Research Question 1: *Does the presence of anthropogenic objects modify implicit affective responses to natural aquatic scenes?*

Research Question 2: *Do implicit affective responses differ from explicit affective responses to natural scenes containing anthropogenic objects?*

Research Question 3*: Does the presence of water influence implicit affective responses to natural scenes?*

Research Question 4: *Can differences in implicit attitudes to natural aquatic and non-aquatic scenes containing artificial objects be attributed to differences in scene coherence?*

The theoretical considerations arising from chapter 3 suggest the need for methods that allow thinking to move beyond the original theories which are not able to satisfactorily account for restorative phenomena. The newer theoretical directions that are based upon underlying cognitive processes seem promising and indicate the value of a cognitive psychological approach. The present research attempts to contribute to knowledge about the psychological impacts of different environment types within a cognitive framework, while retaining links with the research conducted within the existing theoretical approaches. The following sections will discuss how the research questions can be addressed in this manner.

4.3 Methodological perspective

It is already well established that natural environments can be restorative, and that there might be public health benefits from introducing natural elements into various aspects of urban life. However, there are currently no comprehensive guidelines that allow planners, designers and other practitioners in real-world contexts to make evidence-based decisions about which natural elements to include, where, and in what quantities to harness the maximum potential benefits. As well as providing foundations for design and practice, such an evidence base might also be relevant to arguments about conserving natural landscapes as well as natural features within urban areas. In order to justify and inform practical application, both evidence and theory are required. This need for generalizable information, and the consequent advantages of developing an understanding of the underlying psychological processes, have led to quantitative methods becoming the predominant approach in the restorative environments field of research. Although some studies in this area have made use of qualitative methods (e.g., Ashbullby, Pahl, Webley and White, 2013; Bell, Phoenix, Lovell and Wheeler, 2015; Irvine, Warber, Devine-Wright and Gaston, 2013; Keniger, Gaston, Irvine and Fuller, 2013; Lengen, 2015) this work has not, so far, contributed to theory development[45] and is less easily applicable in practice than the body of research broadly underpinned by the principles of scientific inquiry[46]. Therefore, as well as being standard in the field, a quantitative approach is justified in the present context.

4.4 An experimental approach

The manner in which the broad research question should be approached is dependent on the aims and objectives of the research. In line with the aims of this thesis relating to both

[45] This should not be taken to imply that this work is not useful; it complements the quantitative research and has value in its own right.

[46] These principles, which define the scientific method, can be characterized as: replicability (of results), precision (of theoretical definitions), falsifiability (of theories) and parsimony (of explanations) (Bhattacherjee, 2012). This philosophical stance on what constitutes science comes from Popper's (1959, 1962) critical rationalism and is implicit in the review of the literature in the previous chapters, the formulation of the research questions and the studies reported in the next chapter.

the theoretical background (and its need for refinement in order to be able to explain the empirical findings) and the potential practical applications (hence the need for the results to be replicable, generalizable and controlled), an experimental approach was the most appropriate for tackling the research questions. These questions themselves constrain the methodological possibilities, particularly with the focus on implicit attitudes; the established implicit measurement procedures are all experimental (Nosek, Hawkins and Frazier, 2011). The questions are amenable to scrutiny via experimental methods by controlling and manipulating aspects of scene content and measuring the impact of these manipulations on participants' responses. The particular choice of methods will be explained in Section 5 below. The present section discusses the basis for adopting this approach in the context of the research questions.

4.4.1 Implicit attitudes

Although quantitative methods are common in restorative environments research, experimental investigations in this area are fewer in number. In a review of the literature on restoration in urban green space, Kabisch, Qureshi and Haase (2015) found that the methodology used in the majority of studies was questionnaire-based. One of the potential weak points of this research[47] is its reliance on introspection and the assumption that it is possible to assess the restorativeness of a scene by (effectively) asking people how restorative they judge it to be. While this may provide an indication of explicit attitudes[48], it is not necessarily the case that the psychological processes underlying restorative effects

[47] This potential weakness is general and does not refer to any particular study. Further, it is only a potential weakness in the absence of corroborating evidence from different methods; replication of the pattern of restorative environments findings across different methodologies enhances their robustness (Valtchanov and Ellard, 2015).

[48] As mentioned previously, an attitude is defined as an evaluative response towards an entity (Vogel and Wanke, 2016). Implicit affective states (a result of unconscious emotional reactions) constitute the underlying component of attitudes; the explicit component is conscious evaluation, though behaviour is also sometimes also included as an explicit component (Verplanken, Hofstee and Janssen, 1998). A rough way of characterising the distinction between the unconscious reaction and conscious evaluation might be the difference between *feeling* and *thinking* in everyday language (Verplanken *et al*., 1998). Note, however, that this is not a definition. In Chapter 1 it was pointed out that affect is assumed to be part of cognition, not a separate or fundamentally different phenomenon (Bower, 1981).

will be accessible to introspection[49] either practically or in theory. Although asking direct questions might seem straightforward, the problem lies in the assumption that people will be both willing and able to accurately report the psychological attributes of interest. For example, participants may differ with respect to, or have limits on, their motivation to make a particular response; they may face constraints on their responses (due to circumstances of measurement); they may have limits on the ability to convert mental content into a consistent response; or it might be that the particular mental content is beyond conscious awareness in principle (Wilson and Brekke, 1994).

In contrast, implicit measures are designed to reflect psychological phenomena without the need for participants to make explicit their subjective assessment of these phenomena (Gawronski and Houwer, 2011). The advantage of measuring implicit attitudes via experimental procedures is that these potential limitations of methods that rely on conscious, deliberative responses can be bypassed. This is both practically useful, in that it eliminates the possibility of confounding variables, and also theoretically desirable when it is the underlying psychological processes that are of interest, since such methods are able to 'tap in' to those processes directly, without requiring an extra level of conscious processing and the possible distortion that may bring.

Research into implicit cognition has become a well-established area of psychology, particularly in the investigation of social psychological phenomena such as attitudes, stereotypes and self-concepts and their roles in social judgement (Greenwald and Banaji, 1995; Nosek *et al*., 2011). It has proved particularly useful to be able to measure implicit attitudes in these areas, where (e.g., due to social pressures) there may be a distinct gap between what people say and how they feel, think and behave. For example, it has been found that implicit measures of attitudes may be a better predictor of discriminatory behaviours than self-reported attitudes (Greenwald *et al*., 2009; Lane, Kang, and Banaji,

[49] They might be, but should not be assumed to be. Only a small proportion of brain activity is available to consciousness, and what is conscious at any moment does not necessarily reflect the most important factors underlying a response (Bargh and Chartrand, 1999; Nisbett and Wilson, 1977).

2007): implicit attitudes reflecting a negative bias towards people of different ethnicities are associated with discrimination in employment decisions (Bertrand *et al*., 2005) even when explicit attitudes do not correlate with the discriminatory behaviour. A similar phenomenon in a different area was demonstrated by Green *et al*. (2007), who measured implicit and explicit racial bias in doctors and investigated whether there was a link between racial bias and the emergency treatment of black and white patients presenting with acute coronary symptoms[50]. Green *et al*. found that while there was no difference in explicit attitudes towards black or white patients, implicit measures revealed a significant preference amongst the doctors for white patients. Further, when it came to treating the patients via thrombolysis, it was found that as the implicit bias in favour of white people increased, so did the likelihood that a particular doctor would treat a white patient and not treat a black patient with identical symptoms. In an earlier study using a procedure involving videogames, Correll, Park, Judd and Wittenbrink (2002) found that when making judgements about whether to shoot or not shoot a potential target who was either armed or unarmed implicit associations (between white faces and good and between black faces and bad) predicted the likelihood of shooting unarmed black or white men. This was not explainable by the ethnicity of the shooter or their explicit attitudes – both black and white shooters were more likely to shoot unarmed black men and this was associated with their implicit attitudes. These studies demonstrate both that implicit and explicit attitudes can differ, and that implicit attitudes can be more important when it comes to explaining the psychological processes underlying behaviour than people's explicit reports of their own attitudes. While the difference between implicit and explicit attitudes may not be so marked in relation to other phenomena, the work on attitudes towards ethnicity[51] shows that the potential for difference exists and that explicit responses might not always correspond with the underlying psychological processes. Given the reliance on explicit attitude

[50] The study used a realistic, computer-based clinical exercise with simulated patients.
[51] Attitudes to ethnicity is not the only area in which there is evidence of the importance of implicit attitudes and the potential dissociation between implicit and explicit attitudes; it is merely illustrative of the phenomenon. Other areas include political behaviour (Galdi, Arcuri and Gawronski, 2008; Nosek, Graham, and Hawkins, 2010), mental health (Nock *et al*., 2010) and consumer behaviour (Maison *et al*., 2004).

measurements in restorative environments research (particularly in the context of the need for theory development and new explanations of the underlying psychological mechanisms) and the potential for explicit responses to be misleading, investigating their implicit correlates is justified both from a theoretical and a practical point of view.

4.4.2 Methods for measuring implicit attitudes

There are a large number of methods that have been used in the investigation of implicit attitudes. In a review of the procedures used in published research, Nosek *et al*. (2011) found that the most commonly used methods were the Implicit Association Test (Greenwald, McGhee and Schwartz, 1998), Sequential Evaluative Priming (Fazio, Sanbonmatsu, Powell and Kardes, 1986) and the Affect Misattribution Procedure (Payne, Cheng, Govorun and Stewart, 2005). These methods come with the advantage of having been tried and tested in thousands of studies (Nosek *et al*., 2011) and their reliability has been assessed and quantified (Gawronski and Houwer, 2011).

4.4.2.1 Implicit Association Test

The Implicit Association Test (IAT) is a computer-based procedure which has high reliability and is the most commonly used implicit method (Gawronski and Houwer, 2011). This procedure measures implicit attitudes by assessing the strength of associations between pairs of contrasting concepts (e.g. *male* vs. *female*) and evaluations (e.g. *strong* vs. *warm*) or stereotypes (e.g. *manager* vs*. receptionist*). It is based on the assumption that responses (key presses) to words and images on the screen are facilitated when stimuli that are more closely associated share the same response key. (Greenwald *et al*., 2009). The IAT has been widely used to reveal implicit gender and ethnic stereotypes that are a better predictor of real-world behaviour than explicit, self-reported attitudes (Nosek, Greenwald and Banaji, 2005). Although this procedure was not best suited to tackling the present

research questions, it is mentioned here because its extensive use has demonstrated the validity and reliability of its underlying assumptions. That is, viewing an image or a word activates both the underlying concept as well as related concepts; this activation can affect subsequent responses; and these responses based on activation of implicit psychological relationships may differ from explicitly generated responses. These assumptions underlie all the experimental implicit methods.

4.4.2.2 Sequential Evaluative Priming

Sequential Evaluative Priming is the second most commonly used implicit method (Nosek *et al*., 2011). It uses a computer-based sequential priming procedure to investigate evaluative responses (Fazio *et al*., 1986). Participants view a stimulus (the prime) followed by a positive or negative target word. Their task is to decide whether the target word is positive or negative and respond as quickly as possible by pressing predesignated keys. If viewing the prime results in a faster response to a positive word (compared with a neutral stimulus), it is associated with a more positive valence; if it results in a faster response to a negative word, it is associated with a more negative valence (Gawronski and Houwer, 2011). While the procedure in this form was not suitable for addressing the present research questions due to it being restricted to binary positive-negative evaluations, there is a related method that overcomes this restriction: Semantic priming measured by lexical decision is rarely used in implicit social cognition research (an exception is Wittenbrink, Judd and Park, 1997) but has been commonly used in experimental cognitive psychology since its origins in the 1970s (Meyer and Schvaneveldt, 1971; Meyer *et al*., 1975). Just as evaluative priming is based on the finding that the response to an evaluatively valenced target is faster when the target is preceded by a prime with the same perceived valence, semantic priming is based on the finding that the response to a target word (e.g. *table*) is faster when it is preceded by a semantically related (or associated) prime word (e.g. *chair*) than when it is preceded by an unrelated word (e.g. *rabbit*) (Perea and Rosa, 2002). This

priming effect is apparent when participants are asked to respond as fast as they can according to whether the target is a word or a non-word[52] (i.e. make a lexical decision) (Holcomb and Neville, 1990).

The general method of semantic priming, along with the lexical decision procedure, formed the basis of the method used in Study 4, reported in Chapter 5, Part 4. Although the basic method is well established, robust and a standard procedure in psychology (Harley, 2013), its use in a restorative environments context has not yet been reported in the literature. However due to its potential to shed light upon semantic and conceptual relationships, together with its procedural flexibility (Förster, Liberman and Friedman, 2009) it is possible to design a method to address the question of whether the semantic coherence of a scene might be a factor in affective responses. This method will be outlined in Section 5 below, then described in more detail in Chapter 5.

4.4.2.3 Affect Misattribution Procedure

The Affect Misattribution Procedure (AMP) is a more recently developed method, but it is becoming one of the most widely used[53] measures of implicit attitudes (Nosek *et al*., 2011). In this procedure, participants are asked to make evaluative judgements about ambiguous (i.e. affectively neutral) targets. Before viewing the neutral target (such as an abstract symbol), the participant views a prime which may give rise to a positive or negative affective response (such as a picture of a politician). Participants are instructed to ignore the prime and evaluate the target on the basis of whether they find it more visually pleasant than average or less visually pleasant than average (Payne *et al*., 2005). Based on the phenomenon of affective transfer (Murphy and Zajonc, 1993) in which the affective response to the prime can influence the evaluation of the target, positive evaluation of a

[52] A non-word could be either a random string of letters (e.g. *wkgcfe*) or a pseudo-word, constructed according to the orthography of the language of the experiment (e.g. *greckip*).
[53] If minor variations to the IAT are regarded as the same method, the AMP was the third most commonly used implicit measurement procedure in Nosek *et al*.'s (2011) review.

neutral target is more likely after viewing a prime that elicits positive affect, whereas negative evaluation of a neutral target is more likely after viewing a prime that elicits negative affect (Payne *et al*., 2010). This happens without participants' conscious awareness and the effect persists even when participants are instructed not to allow the prime stimulus to influence their subsequent judgement (Payne *et al*., 2005). In addition, when participants are encouraged to rely on their gut feelings (which might correspond to affective responses) when evaluating the targets, even stronger misattribution effects have been found (De Houwer and Smith, 2013). Feelings evoked by the prime are mistakenly attributed to the target when prime and target are presented in rapid succession, thus providing an insight into the implicit affective response to the prime.

This procedure is most often used in social cognition research and, as a result, it is common for studies to have used primes comprising photographs of people. However, there is no reason in principle why the AMP cannot be used to assess implicit affective responses to pictures of any type. Consequently, and taking into account its large effect sizes and high reliability (Gawronski and Houwer, 2011), the AMP was chosen as a methodological starting point for the studies reported in this thesis. With some novel modifications (described in Section 5 below and explained in detail in Chapter 5) to make it suitable for assessing implicit affective responses to scenes, this procedure was used in both Study 1 and Study 3.

4.4.3 Implicit affective priming in a restorative environments context

The first published study to use priming methods to investigate implicit attitudes towards environment types was conducted by Korpela, Klemettilä, and Hietanen (2002), who used a variation of the evaluative affective priming method described above. Korpela *et al*. compared the impact of implicit affective evaluations of natural and urban scenes on reaction times to vocal expressions of joy and anger. In this procedure, participants (n = 28) were presented with an image of an urban or a natural scene (the prime) before hearing a

vocal expression of anger, joy or neutrality[54]. Their task was to decide whether the vocal expression was associated with anger or joy and to respond accordingly as quickly as possible (there was a key to press corresponding to each emotion). The results showed that reaction times to expressions of joy were faster when preceded by an image of nature than when preceded by an urban image. Conversely, reaction times to expressions of anger were faster when preceded by an urban image than when preceded by a nature image. The authors interpret these findings as being indicative of a positive affective response to the natural scenes and a negative affective response to the urban scenes. The direction of the main findings was as expected by the authors and is in line with explicit affective reactions to natural versus urban environments (e.g. Hinds and Sparks, 2011). However, the important contribution of this study was that it demonstrated both that affective reactions to environment types are rapid and automatic, and that these reactions may be susceptible to investigation by standard implicit (priming-based) experimental methods.

Extending their initial study, Hietanen *et al*. (2006: Experiment 1) used a similar priming method to investigate implicit affective responses to urban scenes containing varying amounts of vegetation. In this experiment, the priming images were systematically manipulated along a built-natural continuum. This consisted of five categories ranging from entirely built to entirely natural, though all were urban scenes to which progressively larger amounts of foliage were added digitally. The (subsequently presented) targets were facial expressions of either happiness or disgust, which participants were instructed to classify as such as quickly as possible. Hietanen *et al*. found that when there was more vegetation in the priming scene, responses correctly classifying a subsequently presented facial expression of happiness were faster. Conversely, when more of the scene was occupied by buildings, responses to disgusted faces were faster. Further, the results showed evidence of a dose-response relationship, with response times to happy faces decreasing linearly as the

[54] The vocal expressions were in the language of the study, which was Finnish. All consisted of the word *hei* (a Finnish exclamation for 'hey') uttered by native Finnish speakers (8 female and 7 male) and pre-recorded for use in the experiment.

amount of vegetation in the scene increased; the opposite pattern was observed for response times to disgusted faces. In a second experiment, Hietanen *et al*. (2006: Experiment 2) ruled out the possibility that the priming effects could have been caused by the varying colours or shapes in the different image categories, leading the authors to conclude that it was the implicit affective response to the scene itself that influenced the subsequent recognition of facial expressions.

Since these pioneering experiments, there is little evidence of priming methods in the restorative environments literature until more recently, with a couple of studies being published in the past few years. In a study investigating perceived environmental restorativeness, Stevens (2014) turned the priming procedure around, using environmental scenes as the targets to be rated following presentation of a prime intended to manipulate participants' affective states in a positive or negative direction. These primes consisted of newspaper articles to be read by the participants[55]. After reading the article (either positive or negative), participants were asked to rate a series of six images (three nature scenes and three urban scenes) on a 7-point Likert scale. The results showed that participants who had read the negative article gave higher (and more variable) environmental ratings. That is, having been primed with an affectively negative stimulus, participants rated a subsequently presented target more highly than when the preceding prime was affectively positive. This was true for both urban and natural scenes, suggesting that the pattern of results may have been due more to the nature of the priming stimuli than the characteristics of the target items. This seems particularly likely given the complexity of the primes and the difficulty of controlling their impact on the participants. While this study did not measure implicit attitudes towards scenes (the restorativeness ratings were explicit and followed the common pattern of natural scenes being rated more highly than urban scenes), its findings do suggest that prior affective state may have an impact on restorativeness ratings.

[55] The negative prime was an article about unavoidable effects of climate change; the positive prime was an environmental article, "emphasising autonomy and self-empowerment via community and individual initiatives." (Stevens, 2014, p. 52).

In the sole reported use of an affect misattribution procedure in a restorative environments context, Joye, Pals, Steg and Evans (2013) compared implicit affective reactions to urban and natural images. Participants viewed a briefly presented (75ms) scene (the prime) before viewing a Chinese character[56] (the target). As per the conventional AMP procedure, the participants' task was to rate the target according to its visual pleasantness by pressing a predesignated key (one representing, 'more pleasing than average' and another representing, 'less pleasing than average'). Joye *et al*. found that participants rated the Chinese characters positively more often when the preceding image was a nature scene than when it was an urban scene. These results suggest that the natural scenes gave rise to more positive implicit affect than the urban scenes. This is an important finding and the study further demonstrates that the AMP is usable in a restorative environments context. However, the reliance of the AMP on requiring participants to make forced positive-negative distinctions potentially limits its usefulness, since this binary categorisation is unable to capture more subtle differences in affective responses to environments.

In order to develop the AMP to be able to investigate attitudes that go beyond the simple positive or negative, it is necessary to include a way of measuring intermediate points along the positive – negative continuum. The next section describes how the methods for the present studies accomplish this in their design.

4.5 Strategy and research design

4.5.1 Overview

All four studies reported in Chapters 5, 6 and 7 were based on experimental designs. All use quantitative methods, i.e. measuring participants' responses on certain measures. Studies 1 and 3 made use of an adapted AMP (responses were made on a 7-point computerised rating scale) to assess implicit attitudes to different scene types. Study 2 recorded explicit ratings

[56] That is, a Chinese logogram.

to the same scenes as used in Study 1 via a computerised rating scale and Study 4 used lexical decision response times to assess the contribution of certain elements to scene coherence. Studies 1-3 aimed to measure positive affect as an indirect indicator of an environments' restorative potential. This is an established way of differentiating between scenes on the basis of their potential restorativeness (Van den Berg *et al*., 2003). As a result, though, any direct conclusions can only be about affect. However, they can be taken as being suggestive of restorative potential[57] and so form the basis for further work looking at actual restoration. Study 4 investigates the impact of artificial objects on scene coherence. This study is not attempting to distinguish scenes on the basis of their potential restorativeness. Following on from the results of Studies 1-3, the aim is to explore a possible new explanation for the differential impact of artificial objects on blue and green space scenes. The procedures used in each of the four studies will be described in detail in the Methods sections of Chapter 5. The following section will provide a broad overview of the research design.

4.5.2 Quantitative Methods and Measures

4.5.2.1 AMP to assess implicit affect

The Affect Misattribution Procedure was chosen as a method because it is a well-established measure of affect whose standard procedure can be adapted to address the research questions motivating both Study 1 and Study 3. Since it assesses implicit affect, it offers the advantage of greater objectivity than the standard self-report measures used in restorative environments research (Joye *et al*., 2013).

A standard AMP procedure was used, with one important modification: the use of a 7-point rating scale to record responses, as opposed to the usual binary positive-negative forced choice in this procedure. The motivation for this was that since all the scenes used in Study

[57] It is for this reason that the thesis often refers to restorative potential, rather than restoration *per se*.

1 were composed predominantly of natural elements (even with the addition of artificial objects) it was expected (on the basis of the research reviewed in Chapter 2) that affective reactions to these might be generally positive. Therefore the traditional positive-negative distinction would not capture any more subtle differences caused by the addition of the artificial objects. This type of response scale has not been reported in an AMP study before. Informal pilot testing suggested it might be viable, however Study 1 was partly exploratory in its use of this alteration to the standard procedure. As well as expanding the potential uses for the AMP, this modification enabled Study 2 to be designed in such a way as to directly compare explicit affect with implicit affect, using the same stimuli and the same response scale in a different procedure. There are currently no reports of such a direct comparison in the restorative environments literature.

The target items (i.e. items to be rated by the participants) consisted of Chinese characters, as per the standard AMP. The possibility of using different targets (including geometric shapes, fonts and inkblots) was considered. However, systematically constructing a set of affectively neutral items from a particular category proved difficult due to controlling the affective valence of the items (Doyle and Bottomley, 2006; 2010) and created the concern that introducing target items that were not tried and tested might unnecessarily create an uncontrolled variable. Therefore, it was decided to use the conventional AMP target items. Although these may not form an ideal affectively neutral set, they have the advantage of having been tried and tested in hundreds of experiments (Nosek *et al.*, 2011) and their suitability for use in the procedure is established.

The AMP method used in Study 1 and Study 3 employed a within participants design (repeated measures), i.e. the participants were exposed to all the experimental conditions. The main advantage of this design is that it means that any differences in the dependent variable (implicit affect) in response to the independent variables (presence/absence of objects and scene type, respectively) cannot be due to differences between individuals, since the individuals are exposed to all levels of the independent variable (Field and Hole,

2003). In an area such as environmental perception, where it is at least possible that individual differences may have an impact (Lyons, 1983), this design is preferable since it allows the potential to observe effects that are general, over and above individual differences.

4.5.2.2 PRS to assess explicit affect

Despite the potential limitations of explicit measures highlighted above, it was decided to carry out a study to measure explicit affect for two reasons: firstly, to be able to make a direct comparison between implicit and explicit affect for the same scenes by the same participants. It was not known whether implicit and explicit affective responses would follow the same pattern. Secondly, to situate the series of studies within a framework whereby it would be possible to compare the findings to previous research which has mainly used explicit ratings and the Perceived Restorativeness Scale (PRS). This also provided an opportunity to aim to replicate one of the basic findings in blue space research (i.e. a preference for scenes containing water), by comparing explicit affective responses to blue and green space. Such replication is not only useful in itself in terms of contributing to knowledge (Simons, 2014), but would also confirm that there was nothing particularly unusual about the particular materials selected for use in the studies reported in this thesis.

The PRS (Hartig, Kaiser and Bowler, 1997; Hartig, Korpela, Evans and Gärling, 1997) is a standard tool in restorative environments research. It includes 29 statements intended to measure perception of five restorative qualities derived from Attention Restoration Theory: fascination, coherence, scope, compatibility and being-away (Korpela and Hartig, 1996). It is also common practice to use a shorter version of the PRS with just one item per restorative quality (e.g. Berto, 2005; Han, 2003). The objective in Study 2 was to obtain an indication of explicit affect in a manner that would be comparable with the results from Study 1. This requirement to include the same scenes as used in Study 1 limited the amount of time that could be devoted to each item in the interests of a manageable procedure length

(i.e. it was not practical to ask participants to rate each item 29 times). This consideration, coupled with the requirement to be comparable with previous research (hence the decision to use a method derived from ART), led to the decision to use a short PRS.

Study 2 employed a within participants design using the same participants, stimuli (i.e. the scene images) and rating scale as Study 1, thus allowing a direct comparison between the implicit and explicit ratings. The use of Likert-type scales is the norm in such procedures, due to their usefulness in measuring evaluative responses that may lie on a continuum. However, the range of the scale varies from usage of a 5-point scale (e.g. Chang, Chen, Hammitt and Machnik, 2007) up to an 11-point scale (e.g. Hartig *et al.,* 1997). In Studies 1, 2 and 3, a 7-point scale (the most common approach) was used in order to simplify the response decision while retaining enough possibility for differentiation. Participants were instructed to make their responses as quickly as possible, without conscious deliberation.

4.5.2.3 Scene semantic priming to assess conceptual congruence

The objective of Study 4, to investigate a possible role for scene coherence in explaining the results from the previous studies, necessitated a different experimental design and method. The scene semantic priming method was selected, based on a study by Vo and Wolfe (2014). The context of Vo and Wolfe's work was scene processing in a more general sense (they used indoor scenes and everyday objects), however the method can be adapted to address the research question motivating study 4. This method (originating from the field of visual perception research) has not, so far, been reported in the restorative environments literature. However, Vo and Wolfe's results provide evidence that scene semantics can prime lexical access, which is a promising methodological starting point for Study 4.

As with other varieties of semantic priming, as mentioned above, scene semantic priming is based on the idea that stimuli which have some characteristic in common or which are consistent (in terms of processing mechanisms or mental representations) are easier to

process when presented in quick succession. So, just as reading (or hearing) the word *bread* would be expected to speed the response time (in a lexical decision task) to the subsequently presented word *butter* (compared with an unrelated word such as *squirrel*), it would be expected that lexical decision response time to a semantically congruent word presented with a scene (e.g. the word *soap* with a picture of a bathroom washbasin) would be faster than to an incongruent word (such as *egg*) (Vo and Wolfe, 2014).

In Study 4, the lexical decision response time was the dependent variable. Independent variables were scene type (this was a between participants factor) and object type (this was a within participants factor). This study made use of a mixed model (split plot) design, including both within and between participant factors (Ellis, 1999). All participants were exposed to the within participants factor, and were assigned randomly to the between participants factor.

While it would have been preferable to use a wholly within participants design in Study 4, it was necessary to use a mixed design, including a between participants factor, for practical reasons: In a procedure including a lexical decision task, the target words ideally need to be matched for frequency[58], since these factors affect response times (Hudson and Bergman, 1985; Gardner *et al*., 1987). Due to the constraints on the choice of words (i.e. the categories from which they were drawn and their appropriateness to the scene stimuli) it was not possible to find suitable words matched for frequency in each category that could be used. A solution to this problem was to use the same words as targets (for the lexical decision task) in both types of scene used in this study. This made it possible to make a direct comparison of the impact of the underlying scene on response times. However, since experiencing a word once can have an impact on subsequent recognition, therefore subsequent response times (Forster and Davis, 1984; Dannenbring and Briand, 1982) each

[58] That is, the frequency with which a particular word occurs in a particular language. For British English this is calculated based on the British National Corpus, which contains samples of written and spoken English comprising around 100 million words. These samples are selected to constitute a balanced corpus so that it is reasonable to extrapolate from corpus data to make general inferences about the language (Leech and Rayson, 2014).

participant could be permitted to see each target word only once. This meant it was necessary to use a between participants design, in which each participant received all of the target items but only half of the possible prime-target combinations. An additional downside of this type of design is the need for more participants (double, in this case) in order to be able to satisfy the requirements of the statistical assessment of the results. Random allocation of participants to groups was deemed appropriate, since the numbers were large enough (with a minimum of 30 in each study) to mean that the impact of any individual differences should not affect the overall results (i.e. as the number of participants increases, the potential impact of individual differences decreases (Field and Hole, 2003)).

4.5.3 Materials

All four studies used images (photographs) of scenes. Although viewing an image of a scene is not the same as being in a real environment, there is a large enough body of research showing that indications of restorative effects can be detected from just looking at photographs of scenes (e.g. Berto, 2005). Stronger effects have been observed in real environments, though the pattern of findings is the same (Kjellgren and Buhrkall, 2010). The implication of this is that if the effects under investigation are subtle, a method using images of scenes might not necessarily detect these effects which nonetheless could be present when experiencing real scenes. However, while this possibility was borne in mind, the advantages of being able to systematically alter scene content in experimental designs made the use of images preferable.

For studies 1 and 2, photographs of real scenes containing anthropogenic objects were chosen. To create the object-no object pairs required for the procedure, the artificial objects were removed using Photoshop. This was judged to be a more effective method (in terms of resulting in realistic images) than trying to add objects digitally. Studies 3 and 4 also used photographs of real scenes; the content of these did not need to be digitally manipulated.

All materials are reproduced in the Appendices and further details are given in the Method section for each study.

4.5.4 Participants

Participants for the studies were 116 volunteers recruited from both academic and non-academic contexts: UCLAN's School of Sport, Tourism and the Outdoors (staff and students) in Preston; an estate agent/surveyor's offices in Keswick and Windermere; The offices of Copeland and Allerdale Borough Councils in Cumbria, and Westlakes Science Park in Cumbria. The minority of students in this sample makes it unusual in experimental psychological research, which has a tendency to use convenience samples consisting of students, which may not only be atypical of their own societies but also of the human population at large (Henrich *et al*., 2010)[59]. This can be seen as a strength of the work, in that it may make the sample more representative of the population in general. No attempt was made to control the social or personal characteristics of the participants; the only requirements were that English should be their first language (for Study 4) and that they should not be able to speak or read Chinese (for Studies 1 and 3). Numbers of participants required were based on the statistical analysis planned for each experiment (this is discussed in Section 6 below as well as in the Results sections of Chapters 5, 6 and 7). In all cases, the minimum number required were exceeded.

4.5.5 Limitations

While the scientific method brings advantages through its objectivity, it also places limits on the scope of the investigation. Due to the necessity of controlling variables and ensuring

[59] Henrich *et al*. coined the acronym WEIRD (Westernised, Educated, Industrialised, Rich and Democratic) to describe the (predominantly North American student) populations upon which many supposedly universal psychological findings are based. Although this thesis, and the restorative environments research, assumes that it may be valid to talk about psychological (and other) characteristics in a general manner (i.e. in terms of them applying to humans in general) it is worth bearing in mind the possibility that the WEIRD subpopulation, from which the results arise, might not be representative.

that the data are suitable for statistical analysis, it is only possible to isolate a few factors per study for investigation, even though a full understanding of restorative environments phenomena is unlikely to be gained from studying any particular factor alone. This means that no one study, or small set of studies, can provide a full answer to the broad research question; each can only add incrementally to understanding and will, almost inevitably, raise further questions during the process.

One of the particular limitations of the studies reported here comes from the problem of classifying scenes and objects in a conceptually satisfactory manner. For example, Study 1 looks at the impact of artificial objects in natural scenes. At the outset of this work, the possibility of classifying objects into categories was considered, recognising the possibility that different types of anthropogenic objects might have different impacts. However, upon attempting to do this, it soon became clear that it was not practicable to make such a classification in a manner that did not seem arbitrary. Since there was no clear theoretical basis for making such categorisations, it was decided not to differentiate object types in the design of the experiment or the analysis of results; thus to regard anthropogenic objects as a single category. However, this brings with it the danger that any hypothetical differences between object types (whatever their relevant categories) may be missed. Since this study was partly exploratory (both in its method and its objectives) this limitation was recognised and deemed acceptable.

A similar issue applies to the selection and categorisation of scenes. Although this might appear to be more straightforward (e.g. distinctions between blue space, green space, natural scenes, built scenes, etc.), it is still the case that the experimental design imposes categories that may or may not be the most relevant categories in terms of psychological processing. For scene types, at least, there is evidence that the natural-built categories commonly assumed do have psychological validity (Rousselet *et al*., 2005). However, while each example of a natural scene is a member of that category, there may be heterogeneity within that category; it is difficult to select category exemplars in a theoretically defined

manner. Although care was taken to select images that were comparable across categories used in the studies, there is necessarily a subjective component involved in this. Further, since the stimuli were photographs of real scenes, it was not possible to control all potential extraneous variables. One of the strengths of the experimental design however, is that the number of images and the number of participants should form a large enough sample to be regarded as generally representative, despite variation in both participants and stimuli. It is important, though, to acknowledge the possibility (even if only in theory) that the design of the experiment may not incorporate the potential to detect all the phenomena that could be relevant.

4.5.6 Ethical considerations

The research was carried out in accordance with fundamental ethical principles of scientific research: scientific honesty, carefulness, intellectual freedom, openness and the principle of credit (Resnik, 1993). In addition, since the four studies involved human participants, care was taken to adhere to the primary ethical principles of: autonomy (the right of an individual to decide what they will or will not participate in), beneficence (the obligation of the researcher to minimize harm to the participant and maximise benefit to society at large) and justice (equitable selection of participants, without coercion of vulnerable populations)[60]. Before any practical work was undertaken, ethical approval was sought and granted from UCLAN. All studies were conducted in accordance with UCLAN's ethical policies and procedures.

[60] As defined in the Belmont report (National Institutes of Health, 1979), which lays out ethical principles and guidelines for the protection of human participants in research and has been adopted as a worldwide standard.

4.6 Data collection and analysis

4.6.1 Data collection

The procedures for all four studies were run on a laptop computer: an HP ZBook 15 with an Intel Core i7 processor, 15.6 inch LED anti-glare display and NVIDIA Quadro K1100M graphics card. This was used to run the experiments and displayed all instructions and experimental items. Data was collected by automatic recording (via the computer program) of participants' responses as key presses or mouse clicks. The mouse[61] used was a Razer Abyssus 2014 USB Gaming Mouse with an optical 3500 dpi sensor and ambidextrous design. In Studies 1-3 the content of the response was recorded (i.e. the rating, recorded numerically). In Study 4, the response time was recorded (in milliseconds). The software used to construct the experiments was PsychoPy (Peirce, 2007; Peirce, 2009). This software was used to create a program for each study which enabled participants to complete the experimental procedure without intervention from the researcher. It was chosen because of its track record as a dependable experimental tool (Garaizar and Vadillo, 2014) as well as its flexibility in terms of the potential to customise standard experimental designs by adding code in the Python programming language (Peirce, 2010). All programming and experiment construction was performed using the HP ZBook that was also used to run the experiments. The output file of results from the PsychoPy program was imported into a spreadsheet format (Microsoft Excel), then arranged into a format suitable for statistical analysis using SPSS.

4.6.2 Data analysis

Studies 1, 2 and 3 measured responses on a 7-point rating scale, with the mid-point representing an affectively neutral response. Participants used the mouse to click on the

[61] Not all mice are equal. This particular (corded) model was chosen because of its high sensitivity and responsiveness (it is marketed as a computer games mouse) and low click latency (time it takes for the computer to register a click).

scale to register their rating and the response was recorded automatically. There is debate about the appropriate statistical tests to use for analysis of data gathered via rating scale instruments and whether parametric or non-parametric[62] tests are most appropriate (Sullivan and Artino, 2013). Some authors have criticised the use of parametric tests on Likert-type scale responses on the basis that the responses cannot be regarded as interval data (e.g. calculating the average of ratings such as 'never', 'sometimes' and 'rarely' makes little sense) (Jamieson, 2004). However, others have pointed out that different scales can provide interval responses and as long as the sample size is adequate and the data are normally distributed, parametric tests may be preferable for use with rating scale data, due to their greater statistical robustness (Norman, 2010). Although the participant ratings in studies 1-3 were not definitively interval data (in the sense that response times or frequencies would be), the nature of the scale response data had enough of a continuous quality to justify comparing means of the ratings. This meant the results could be analysed with parametric tests, providing that the data were normally (or near normally) distributed. In the case of Study 1 and Study 2, paired sample (dependent) *t*-tests were carried out[63]. Paired sample *t*-tests are appropriate because all the participants are assessed (in a repeated measures design) on the same dependent variable (implicit affect) on two occasions (with and without the presence of artificial objects) to determine whether there was a difference between the mean ratings in the experimental conditions (i.e. presence vs. absence of objects). This test requires that the distribution of the differences between the data from each condition be normally distributed (Rovai, Baker and Ponton, 2013), which was checked using the Shapiro-Wilk test of normality in SPSS before performing analyses.

The design of Study 3 was more complex, with four different environment types being compared, therefore a series of one-way repeated measures analyses of variance (ANOVA)

[62] To use parametric tests data must consist of interval or ratio data, measured on a continuous/quantitative scale and it must be normally distributed (Rubin, 2012).
[63] The most appropriate non-parametric alternative tests were also carried out, for informal comparison. Despite the reduced statistical power of the non-parametric tests (Wilcoxon signed ranks tests, in this case), which compared medians rather than mean ratings, there was no difference in the significant effects detected by the non-parametric and parametric tests.

was used to compare ratings for the different environments. The ANOVA calculates whether the means for all the experimental conditions are the same by comparing the amount of systematic and non-systematic variance in the data (Field, 2009). If the analysis finds that there is an effect of the independent variable (scene type, in this case) on the dependent variable (the rating indicating implicit affect, in this case) it is then necessary to perform further tests (pairwise comparisons) in order to identify what that effect is specifically. This, together with the performance of post hoc tests to guard against Type 1 and Type 2 errors[64], can all be done within SPSS.

Due to the mixed design of Study 4, which included both within and between participant variables, plus the nature of the data which was unambiguously interval data (response times), a mixed ANOVA was performed, since this enables to both variables to be compared simultaneously (Field, 2009). This analysis indicates whether there is an interaction between the between participants variable (in this case, environment type) and the within participants variable (in this case, object type) that affects the dependent variable (in this case, response time).

For all the statistical analyses, a significance[65] level of 5 percent (i.e. $p \leq 0.05$) will be adopted as the standard. Although this is an arbitrary threshold (statistical significance in this sense is not necessarily aligned with practical importance (Gelman and Stern, 2006)), it is in line with statistical convention, both in psychology and across the social sciences (Kantowitz *et al*., 2014). In the results sections in Chapter 5, results with $p \leq 0.05$ will be treated as significant, however the actual *p*-values will also be reported.

[64]A Type 1 error occurs when an effect is identified where none exists in the data; a Type 2 error occurs when an effect that does exist in the data is not identified (McKillup, 2011).
[65] That is, the probability that the result is not due to the operation of chance or random factors. It enables the rejection of the assumption that there is no difference between the experimental conditions (also known as the null hypothesis) (Dahiru, 2008).

4.7 Summary

This chapter has identified and justified appropriate experimental methods with which to address the research questions. In doing so, it has highlighted methodological innovations that form part of this thesis, namely:

- Use of a continuous response scale in the AMP.
- Use of the AMP to investigate multiple scene types, going beyond the green/built dichotomy.
- Use of the AMP to investigate specific scene content, in particular the presence of artificial objects.
- Use of implicit and explicit methods with the same participants and the same materials in a restorative environments context (thus enabling comparison between implicit and explicit attitudes).
- Use of scene semantic priming with natural aquatic and non-aquatic scenes.
- Investigation of blue space as a separate category in an implicit priming experiment.

The next chapter will report the individual studies and discuss their findings.

Chapter 5

Implicit and explicit attitudes towards aquatic scenes with and without artificial objects: Study 1 and Study 2

5.1 Introduction

Chapter 2 reviewed the extensive evidence that demonstrates the importance of natural environments to human physical and mental health and wellbeing. Since its beginnings in the 1980s, restorative environments research had focused on the benefits of green space, with vegetated scenes and vegetation in urban scenes being regarded as representative of nature (e.g. Ulrich, 1983; Tennessen and Cimprich, 1995; Berman, Jonides and Kaplan, 2008; Bratman, Hamilton and Daily, 2012). Despite a long history of popular belief in the salutogenic potential of blue space, however, environments containing water were rarely investigated as a potentially separate category. This changed with a landmark paper by White *et al*. (2010), who noted the lack of empirical research on the subject. Their studies found consistently greater preferences for blue space (compared with green space and urban scenes) as well as increased positive affect and higher perceived restorativeness. This work paved the way for a new strand of restorative environments research into blue space (e.g. Völker and Kistemann, 2011, 2015; White *et al.*, 2013; Bell *et al.*, 2015; Cracknell *et al.*, 2015; Finlay *et al.*, 2015; Foley and Kistemann, 2015; Nutsford *et al.*, 2016).

This growing body of work indicates that aquatic environments might be especially beneficial to wellbeing, although the underlying reasons are not yet well understood. Further, studies that have attempted to systematically investigate constraints on blue space effects are scarce. Factors that have been shown to reduce positive responses to blue space include poor water quality (Wilson *et al.*, 1995) and litter (Wyles *et al.*, 2015). Both of these are elements that represent a scene that has been degraded (Pretty *et al.*, 2005) in a manner that also applies to vandalism such as graffiti (Budruk and Manning, 2006). While litter

could be classed as a sub-category of anthropogenic objects, it may not be appropriate to generalise on the basis of litter to all other objects, due to the specific nature of what is regarded as litter[66] and its inherent negative connotations. Litter, by definition, is something that should not be present, therefore might be expected to have a negative impact on responses to a scene, as found by Wyles *et al*. (2015). However, these findings could be due to the overall degraded character of the scene (as with graffiti or dirty water) rather than the presence of the objects themselves. How other scene elements that are not necessarily indicative of a degraded scene might impact upon responses to blue space is still an open question.

Regarding the impact of non-litter anthropogenic objects on the restorative potential of natural landscapes, little research has been published. White *et al.* (2010) found that the presence of objects had a negative impact on restorativeness ratings in their scenes (which consisted of built-natural and green-blue combinations). This work did not isolate the impact of objects on green scenes compared with blue scenes, however in a later study Motoyama and Hanyu (2014) did compare the impact of objects on affective responses to different environments. The authors investigated the influence of public art (sculptures) on perceptions of urban and natural landscapes and asked participants to rate scenes on the basis of their attractiveness, with and without computer-generated sculptures[67]. It was found that sculptures in natural scenes significantly reduced their pleasantness ratings, however, sculptures in urban scenes had no effect on pleasantness (2014: Study 1). Motoyama and Hanyu also looked at urban scenes separately and found that the sculptures consistently increased arousal, but had mixed effects on pleasantness in different urban environments (2014: Study 2). In their final study, it was found that the effect was dependent on the pleasantness of the sculpture: the sculptures that were rated as more attractive increased the pleasantness ratings of urban scenes, whereas the sculptures that

[66] "Rubbish … left lying in an open or public place." Concise Oxford English Dictionary (2011).

[67] Although this study looked at a particular type of object, it is relevant since the sculptures were anthropogenic objects in natural scenes.

were rated as less attractive decreased the attractiveness rating of the scene. This does suggest that the participants could have been (perhaps inadvertently) rating the sculptures themselves rather than the scenes in these two experiments, so caution is needed in interpreting the results. Nonetheless, the finding that the same object might have a different impact on the affective reaction to different landscapes is interesting, as it suggests that the type of landscape might be an important factor in the impact of an artificial object on overall restorative potential.

The results from both of these studies suggest that the presence of artificial objects may have a negative impact on responses to natural scenes. Beyond this, two findings of the studies are relevant for present purposes: Firstly, the finding of White *et al*. (2010), that blue space gives rise to more positive affect than green space, which in turn induces more positive affect than urban space; secondly, the finding by Motoyama and Hanyu that artificial objects had a more negative impact on green space than urban space. When these results are considered together, it is possible to propose that artificial objects may be more likely to have a negative impact as the restorative potential of the scene increases. Thus, it might be expected that, given the general preference for and restorative potential of blue space, artificial objects would have a more negative impact on explicit responses to blue space than green space scenes. Further, on the basis of Joye *et al*.'s (2013) findings that natural scenes elicited more positive implicit affect than built scenes (suggesting a parallel between explicit and implicit affect), it would be expected that the presence of artificial objects might reduce the positivity of implicit affective reactions to natural scenes.

The present chapter reports two of the studies conducted for this thesis. Study 1 investigated implicit attitudes towards natural scenes with and without artificial objects, while Study 2 investigated explicit attitudes towards the same scenes. The studies will be reported in turn, then the findings for implicit and explicit attitudes will be compared and discussed.

5.2 Study 1 Overview and Hypotheses

Research Question 1: *Does the presence of anthropogenic objects modify implicit affective responses to natural aquatic scenes?*

Since little is known about implicit reactions to natural scenes, it was decided that natural scenes both with and without water should be included in the study. If only blue space scenes had been included, it would not have been possible draw conclusions based on the aquatic nature of the scenes rather than their naturalness, or some other characteristic. In order to answer the research question, two hypotheses were proposed.

Hypothesis 1.1: The literature discussed above suggests that implicit affective responses to natural scenes are likely to be positive. Based on the small amount of previous work that has found evidence of a reduction in preferences for natural scenes when objects are present, it is hypothesized that: *implicit affective responses to natural scenes will be less positive when artificial objects are present.*

Hypothesis 1.2: Given the tendency for blue space scenes to elicit more positive affect than green space scenes, together with the finding that objects might have different impacts depending on scene type, it is hypothesized that: *implicit affective responses to blue space will be more negatively affected than affective responses to green space by the presence of artificial objects.*

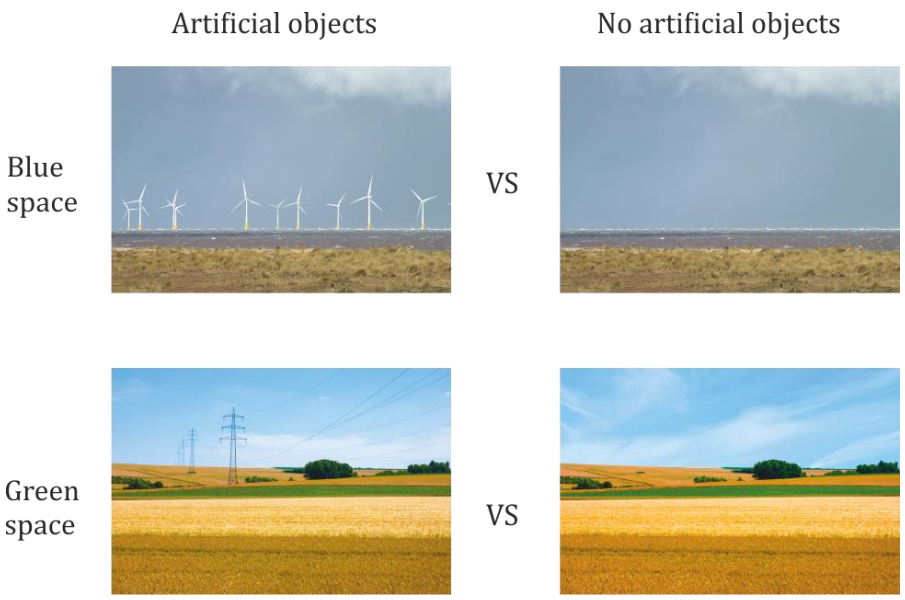

Figure 5.1. *Illustration of the investigation: Do implicit attitudes to these scenes differ?*

5.2.1 Study 1 Method

5.2.1.1 Study 1 Participants

Participants were recruited from the School of Sports, Tourism and the Outdoors at the University of Central Lancashire, including students and staff, and from the offices of an Estate Agent based in Cumbria. All participants were volunteers and were not compensated for their participation. Thirty participants were recruited, 17 female and 13 male. Mean age of participants was 41.4 years (range 21 - 66). None of the participants were Chinese speakers.

5.2.1.2 Study 1 Materials and Design

The materials consisted of 24 photographs of natural landscapes containing artificial objects. Images were collected from online image libraries and were selected so that a range of object types were represented, including wind turbines, electricity pylons, buildings, fences, boats and benches. Attempts were made to select scenes with objects that might

appear in both blue and green[68] space, in order to reduce any potential impact of object type. The blue and green scenes were not matched on any quantified dimension[69]. Of these 24 scenes, 12 contained water. All 12 of the aquatic scenes were seascapes. Although it is possible that different types of water may give rise to different affective responses (Nasar and Lin, 2003), it was decided to use only one type of aquatic landscape in this study in order to be able to focus on the impact of objects and avoid the combinatorial complexity of an experimental design including both different objects and different types of water. The green space scenes included fields, mountain views and coastal scenes without water. All images depicted clement weather conditions. Again, it is possible that climatic conditions may have an impact on affective responses to scenes (White *et al.*, 2013), however including weather as a variable would have been beyond the scope of this study as well as the objectives of the thesis in general. The photographs were manipulated in Adobe Photoshop to remove the artificial objects, creating a matching set of 24 objectless scenes, resulting in 48 images in total. These 48 images served as the primes in the experimental procedure. The target items (items to be rated) used in the procedure were a set of 12 Chinese characters[70]. Each of the Chinese characters appeared 4 times for each participant during the procedure. The pairs of images (i.e. the same image with and without artificial objects) appeared with the same Chinese character, so that any differences in ratings of the characters could be attributed to the differences in the priming images. The 48 priming images are reproduced in Appendix 1.

The experiment used a within-participants design, meaning that all the participants completed all the experimental items. The within-participant variables were the photographs, which were manipulated for presence/absence of objects (the independent variable). The dependent variable was the rating given by participants to the Chinese

[68] In the reporting of this study, blue space is used to refer to scenes that are composed mainly of natural elements and which contain water. Green space is used to refer to scenes composed mainly of natural elements without the presence of water.
[69] The possibility of removing/adding water to be able to compare responses to exactly the same scene with and without water was considered, but rejected on the grounds that it produced unnatural-looking scenes.
[70] Representing the 12 Chinese months of the year, though this is incidental since none of the participants were familiar with spoken or written Chinese.

character that they saw following presentation of one of the photographs. The experiment was programmed using PsychoPy software (Peirce, 2007) and run on an HP ZBook computer with a 17 inch screen. The screen refresh rate was 60Hz; this was used to calculate timings in the experiment.

5.2.1.3 Study 1 Procedure

On arriving at the testing room, participants were verbally briefed about the general nature of the study and reminded that they were free to withdraw at any point before or during the procedure. They were then seated in front of the computer screen (adjusted to eye level) and told that before the actual study began, they would have the opportunity to practice the procedure. Instructions, adapted from the standard Affect Misattribution Procedure (AMP) (Payne *et al.*, 2005), appeared on the screen in white text on a grey background, informing participants that they would see a series of pictures presented rapidly, followed by random shapes. Their task was to rate the visual pleasantness of the shapes, ignoring the pictures that preceded them. Ratings were made on a 7-point scale, with 1 representing very unattractive and 7 representing very attractive. Participants were instructed to make a decision based on their 'gut feeling' and to respond as quickly as possible without deliberation. Responses were made by clicking on the scale. The practice session consisted of 10 trials. After completing the practice, the participants were given a two-minute rest before beginning the experimental procedure. Instructions were displayed on the screen before the beginning of the procedure and were identical to the practice instructions, with the exception that instead of being asked to rate shapes, participants were asked to rate Chinese characters. The screen instructions for both the practice and the experiment are reproduced in Appendix 2.

The experimental procedure is depicted in Figure 5.2, below. Each of the 48 experimental trials was preceded by a white fixation point that appeared in the centre of the grey screen for 400ms. After this, one of the 48 priming images appeared for 400ms. Images appeared

in a different random order for each participant. Next, a Chinese character appeared on the screen for 200ms. Then, the rating scale appeared and remained on the screen for up to 2500ms to allow the participants to respond. This relatively short presentation of the scale (2.5 seconds maximum) was to put the participants under time pressure to encourage them to respond as rapidly and unreflectively as possible. The rating scale disappeared once participants had responded and the next trial began immediately. Trials were presented consecutively until all items had been completed.

Figure 5.2. *Flow of the Affect Misattribution Procedure used in Study 1*

5.2.2 Study 1 Results

Paired sample *t*-tests were appropriate for the statistical analysis of results because all the participants were assessed on the same dependent variable (implicit affective responses to natural scenes)[71] to determine whether there was a difference between the mean ratings in the two experimental conditions (presence/absence of objects; the dependent variable). This test requires that the distribution of the differences between the data from each condition be normally distributed (Rovai, Baker and Ponton, 2013), which was checked using the Shapiro-Wilk test of normality in SPSS before performing analyses. For any results found to be significant, it was then necessary to calculate the effect size. Effect size shows how large the impact of the independent variable is on the dependent variable (Rosenthal, 2009). This is important since it provides an indication of the practical consequences of the

[71] Strictly speaking, the dependent variable was the rating given the Chinese character; in the standard AMP this is assumed to reflect implicit affect.

results. For example, it would be possible to detect an effect that was consistent enough to be statistically significant, but so small as to be of little consequence practically (Lakens, 2013)[72]. The appropriate test of effect size for a repeated measures *t*-test (i.e. a comparison between two means) is Cohen's *d*. For interpreting the effect size calculation result, the benchmarks suggested by Cohen (1988) are small (d = 0.2), medium (d = 0.5) and large (d = 0.8). Although these are essentially arbitrary values, they have been widely adopted as conventional (Thompson, 2007) and will be adhered to here.

When all the results were taken as a whole, a paired-samples *t*-test indicated that the mean ratings for Chinese characters preceded by scenes containing artificial objects (M = 4.16, SD = .64) were significantly lower than mean ratings for characters preceded by scenes without artificial objects (M = 4.30, SD = .67), $t(29) = 2.87$, p = .008. The effect size was medium, d = 0.5. As predicted by Hypothesis 1.1, implicit affective responses to natural scenes were less positive when artificial objects were present.

When the results were broken down into categories of green space and blue space, the overall pattern was not reflected equally in both categories. In the statistical analysis for blue space priming scenes, a paired-samples *t*-test indicated that the mean ratings for Chinese characters preceded by scenes containing artificial objects (M = 4.02, SD = .68) were significantly lower than mean ratings for characters preceded by the same scenes without artificial objects (M = 4.21, SD = .75), $t(29) = 3.06$, p = .005. The effect size was medium, d = 0.6. This finding, as depicted in Figure 5.3, was consistent with Hypothesis 1.1.

[72] Note though, that a small effect size does not necessarily mean that a finding is unimportant. A small effect that applies to the whole population might still have practical consequences: Lakens (2013) gives the example of an intervention to reduce suicide rates that is statistically reliable but has a small effect size of d = 0.1 would nevertheless have important practical consequences. Findings with small effect sizes might also provide insight into underlying mechanisms, thus having theoretical consequences.

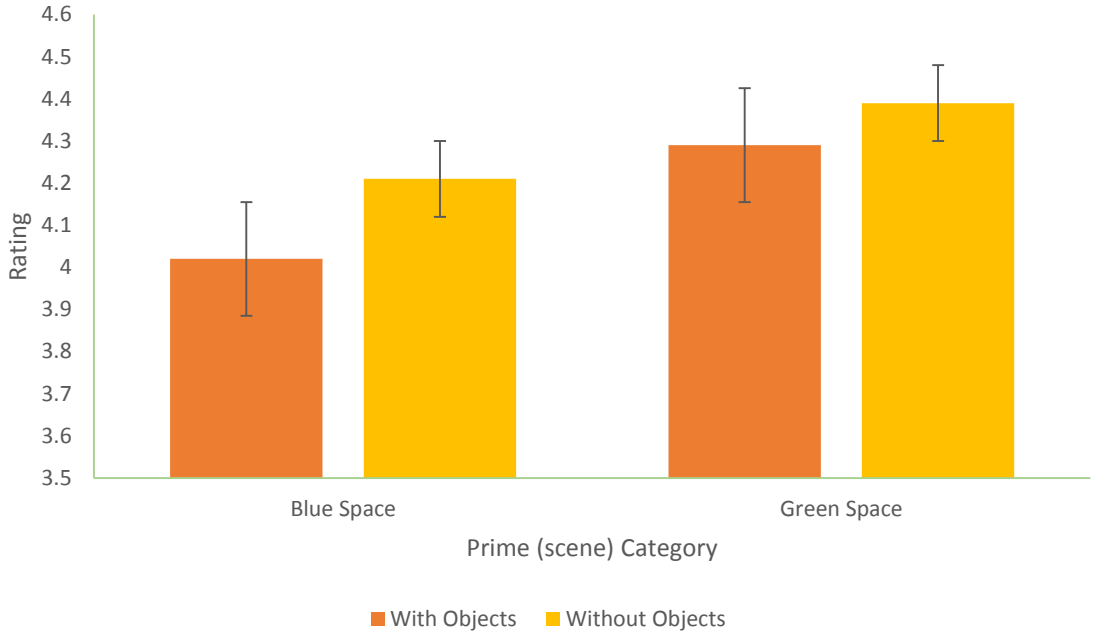

Figure 5.3. *Bar chart showing mean attractiveness ratings for the Chinese characters preceded by scenes with and without artificial objects for blue and green space scenes. Higher ratings represent more positive responses.*

For green space priming scenes, however, a paired-samples *t*-test indicated that the mean ratings for the Chinese characters preceded by green space scenes containing artificial objects (M = 4.29, SD = .75) was not significantly different from the mean ratings for characters preceded by green space scenes without artificial objects (M = 4.39, SD = .70), $t(29) = 1.05$, $p = .304$. There was a small effect size, $d = 0.2$. While this result was not consistent with Hypothesis 1.1, which predicted a significant difference, the disparity in the findings relating to blue and green space scenes did provide support for Hypothesis 1.2, that implicit affective responses to blue space would be more negatively affected than affective responses to green space by the presence of artificial objects.

5.2.3 Study 1 Discussion

The main aim of this study was to investigate the impact of artificial objects on implicit affective responses to blue space scenes. Due to the lack of knowledge about implicit

affective responses to natural scenes in general (and resulting absence of a point of comparison for blue space), it was also necessary to investigate green space scenes in the same way. It was expected that artificial objects would have a negative impact on responses to both scene types, since they were natural scenes, but that the effect might be greater for blue space scenes. The AMP was used to reveal information about implicit affective attitudes by harnessing the tendency to misattribute the affective response to a prime (the scene) to an affectively neutral target stimulus (the Chinese character).

As hypothesized, the mean ratings following all scenes were lower when the scenes contained artificial objects. However, when the results for blue and green space were analysed separately it seemed that this overall effect was disproportionately due to the impact of objects on blue space scenes. Although it was unexpected that the difference in mean ratings following green space scenes with and without objects was not significant, the greater impact of objects on ratings following blue space scenes was as hypothesized at the outset. That is, the presence of artificial objects in a blue space scene had a negative impact on implicit affective responses.

For the green space scenes it was expected, on the basis of the research discussed above, that implicit affect would be less positive towards scenes containing artificial objects. Although there was an indication that this was the case (mean ratings following green space primes with objects were lower than ratings following green space primes without objects), the difference was not statistically significant. Despite the non-significant difference, the difference between the means was in the predicted direction, and there was a small effect size. Although the lack of statistical significance means it cannot be assumed there is a real difference, it is possible that if the impact of artificial objects on green space scenes was subtle, the method used might not have been sensitive enough to detect it. Whether the impact was small or did not exist, the lesser impact of artificial objects on implicit attitudes to green space is a finding that requires further investigation.

A more surprising finding to emerge from this study was that ratings following green space primes were, on average, higher than ratings following blue space primes. This suggests that the implicit affective reactions to blue space were less positive than implicit affective reactions to green space in this study. Although this was not what the experiment was designed to test, it would not have been predicted, since most studies that have compared attitudes towards green versus blue space have found more positive reactions to blue space. While previous work has focused on explicit attitudes, there were no theoretical or empirical grounds for expecting the pattern of implicit attitudes to differ in this manner. Although the finding is unexpected, this comparison between blue and green space was not part of the experimental aims or design, so the apparent difference must be treated with caution. It is not appropriate to analyse it in the same manner as the other results; calculating the probability after the event on the basis of noticing a peculiarity is not valid (Gigerenzer, 2004). Having noticed something unusual in the data it is not good practice to assess this statistically from those same data. It is instead necessary to do another experiment to test the hypothesis implied by what has been noticed in the data, then those results can be treated to the usual statistical analysis (Feynman, 2014). Due to the danger of "hindsight bias" (Hoffrage, Hertwig and Gigerenzer, 2000), the apparent difference between implicit affective responses to blue and green space will not be treated as an experimental finding here. To avoid the methodological error of overfitting the data (Hitchcock and Sober, 2004), i.e. assuming that random noise reflects an underlying relationship, this observation will form the basis for Study 3, to investigate whether it is a real effect.

The main finding that artificial objects had a negative impact on implicit affective responses to natural scenes, particularly blue space scenes, was predicted on the basis of the small amount of relevant previous work. In terms of explaining the results, however, the main theories in the field (Attention Restoration Theory and Stress Reduction Theory) do not provide the basis for a straightforward account. Despite the promise of newer theories based on visual processing, it is also not clear how such theories might account for the

results found in this study. One possibility that has received little attention in the literature is the role that the overall semantic coherence of a scene might play in affective responses. For example, if a scene is perceived as a coherent whole (as opposed to a collection of individual objects) it is possible that the composition of the scene might have an impact on its perception as such. That is, the addition of certain objects or features might make it more or less coherent overall. This possibility will be considered further in Chapter 7.

An additional aim of this study was to pilot the use of a modified AMP, using a rating scale instead of the usual positive-negative binary response. The overall results indicate that the procedure was successful and priming effects (misattributions of affective attitudes) were detected, thus endorsing the modifications that were made. As expected, on the basis that all the images depicted natural landscapes, the priming scenes generally gave rise to positive implicit affect[73], with all mean ratings being above the neutral mid-point of the scale. The mean differences between implicit affect generated by the scenes with and without objects were small, and may not have been captured by a binary or more coarsely defined scale. This justified the use of a 7-point scale as well as demonstrating that such a scale can be deployed effectively in an AMP method. Further, the success of this method provides evidence that the affective evaluation of scenes happens rapidly and automatically without conscious reflection. The question of whether these implicit reactions are congruent with explicit responses to the same scenes was examined in Study 2.

5.3 Study 2 Overview and Hypotheses

A standard procedure in restorative environments research involves presenting participants with images of scenes to be rated on a number of dimensions assumed to be related to the restorative potential of the scene (e.g. Herzog, Maguire and Nebel, 2003). A commonly used instrument is the Perceived Restorativeness Scale (PRS) (Korpela and

[73] No urban scenes were included, but it would have been interesting to gauge the impact of such scenes on implicit affect in this procedure.

Hartig, 1996; Hartig, Kaiser and Bowler, 1997) which includes 16 items to assess the four dimensions of restorativeness proposed by Attention Restoration Theory. Shortened versions of the scale have also been used successfully (e.g. Berto, 2005). Despite the theoretical shortcomings of ART (as discussed in Chapter 3), it was decided to make use of a modified version of the PRS for Study 2 due to the advantages of making the results comparable with the large body of previous work in the field. Whether or not the results obtained using variations of the PRS can be explained by ART, it appears to be the case that they do provide an indication of a scene's perceived restorative potential (Pasini *et al.*, 2015). It was therefore an appropriate instrument with which to investigate explicit attitudes to natural scenes with and without artificial objects.

Since a short, modified PRS was used, it was possible to include an extra item asking participants to indicate their willingness to pay (WTP) for a (hypothetical) hotel room with the view pictured in each scene. Previous work (e.g. White *et al*., 2010) has successfully included this measure in a similar procedure. It is an interesting addition to the standard PRS items because although it is a measure of an explicit attitude, it can also be considered an indicator of 'revealed preference' (White *et al*., 2010) that is potentially informative about behaviour. It would be preferable to observe actual behaviour i.e., how much people actually do pay for hotel rooms with different views, as in the study by Lange and Schaeffer (2001) mentioned in Chapter 1. However, WTP has been widely used as an indirect indicator: for example as a measure of cost-benefit analysis in economics (Bala, Mauskopf and Wood, 1999), in marketing (Breidert, Hahsler and Reutterer, 2006) and tourism research (Kang *et al.*, 2012). Despite the danger that different biases might have an impact when people are making a hypothetical judgement compared with a real payment situation (Blumenschein *et al.*, 2014), the advantage of using a WTP measure in an experimental design is that it allows comparison of responses to the same hypothetical hotel room under different experimental manipulations of the window view, which would be more difficult to accomplish in the real world. Since such studies can have within-participants designs, the impacts of individual biases are reduced. White *et al*. (2010) found that participants in their

study were willing to pay more for a hypothetical hotel room with a blue space view, compared with green space or urban views. A similar WTP question was included in the present study in order to investigate firstly whether this result was replicable and secondly whether the presence of artificial objects would also have an impact on WTP.

Research Question 2: *Do implicit affective responses differ from explicit affective responses to natural scenes containing anthropogenic objects?*

Study 2 was designed to focus on explicit responses, since implicit responses had been measured in Study 1. The same scene images were used in both studies, with the same participants, so that the implicit and explicit responses would be comparable.

Hypothesis 2.1: Explicit responses to natural scenes containing artificial objects. The research reviewed above suggests that the presence of artificial objects may have a negative impact on preferences and ratings of natural scenes. Therefore, it is predicted that ratings for scenes with artificial objects will be lower than for the same scenes without objects.

Hypothesis 2.2: Objects in blue and green space. It is not clear from previous research whether the presence of objects might have a different impact on explicit attitudes to blue and green space. Based on the results from Study 1, however, which showed a greater impact of artificial objects on attitudes to blue space than green space, it is predicted that explicit affective responses to blue space will be more negatively affected by the presence of artificial objects than responses to green space.

Hypothesis 2.3: Affective responses to blue and green space. The research reviewed above indicates that explicit affective responses to blue space are likely to be more positive than responses to green space. This study examines whether these previous findings are replicable. It is predicted that preferences and ratings will be higher for blue space scenes than green space scenes.

5.3.1 Study 2 Method

5.3.1.1 Study 2 Participants

The same 30 participants who completed Study 1 (as described in Section 5.2.1.1 above) also took part in Study 2.

5.3.1.2 Study 2 Materials and Design

The stimuli (images) were identical to those used in Study 1, reproduced in Appendix 1. The rating scale was also the same, and images and scale were presented on the same computer. The experiment was programmed using PsychoPy software (Peirce, 2007). The response scale was used together with a customised short version of the PRS, consisting of three items from the long PRS (Korpela and Hartig, 1996): One of these related to the hypothetical dimension of *fascination* ('I'd like to spend more time looking at these surroundings'), one related to *being away* ('This is a place to get away from it all'), one related to *compatibility* ('I have a sense of oneness with this setting'), and another two items to measure explicit affect. Two items were chosen since affect was the dimension of most interest in order to be able to compare implicit and explicit responses. One of these questions related to aesthetic preference ('This is an attractive view') and the other to valence, i.e. positive or negative attitude ('Spending time here would be pleasant'). The final item was not part of the usual PRS, it was a Willingness To Pay (WTP) measure ('How much would you be willing to pay for a room with this view?'), which can be considered an indirect measure of likely real-world behaviour, as discussed above. Since this was a within-participants design, all participants completed all the experimental items. Items were presented in a random order determined by the computer program. This order was different for each participant.

5.3.1.3 Study 2 Procedure

Participants completed Study 2 on the same day as Study 1, after a 5 minute break. After a brief verbal introduction and a chance to ask questions, participants were presented with instructions for completing the experiment on the computer screen. Once they were happy to proceed, the experiment began. Each experimental image was presented in turn on the screen, accompanied by a statement and the rating scale. Participants were required to indicate how much they agreed or disagreed with the statement with reference to the image. When a response had been made on the rating scale, the next statement and a fresh rating scale appeared underneath the image. When all six statements had been rated for a particular image, the screen went blank for one second before presenting the next image together with its first statement and rating scale. For five of the statements, the 7-point scale was used to indicate the level of agreement with the statement; for the WTP item participants used the same 7-point scale to indicate how much they would be willing to pay for a hotel room with the view pictured. The scale ranged from £40 to £100 in this case. The order of presentation of items was random (determined by the computer program) and differed for each participant.

5.3.2 Study 2 Results

Paired samples *t*-tests were carried out for ratings on each of the six items, comparing the blue space scenes with and without objects and the green space scenes with and without objects. A further comparison was carried out between blue space (all scenes) and green space (all scenes). Cronbach's alpha was calculated for the five items relating to perceived restorativeness[74] and was found to be high (.96), indicating that the items were well correlated and could be considered to be a measure of the same underlying variable (assumed to be perceived restorativeness for the PRS).

[74] The sixth item, Willingness to Pay, was an additional measure not usually included in assessments of perceived restorativeness so was not included.

5.3.2.1 Blue space scenes with and without objects

In the blue space category, for the item relating to *fascination* in ART, ratings for scenes with objects (M = 5.00, SD = .83) were significantly lower than ratings for scenes without objects (M = 5.25, SD = .79), $t(29) = 3.29$, p = .003. The effect size was medium, d = 0.6.

For the item measuring affective valence, ratings for scenes with objects (M = 4.99, SD = .75) were significantly lower than ratings for scenes without objects (M = 5.25, SD = .75), $t(29)$ = 3.75, p = .001. The effect size was medium, d = 0.7.

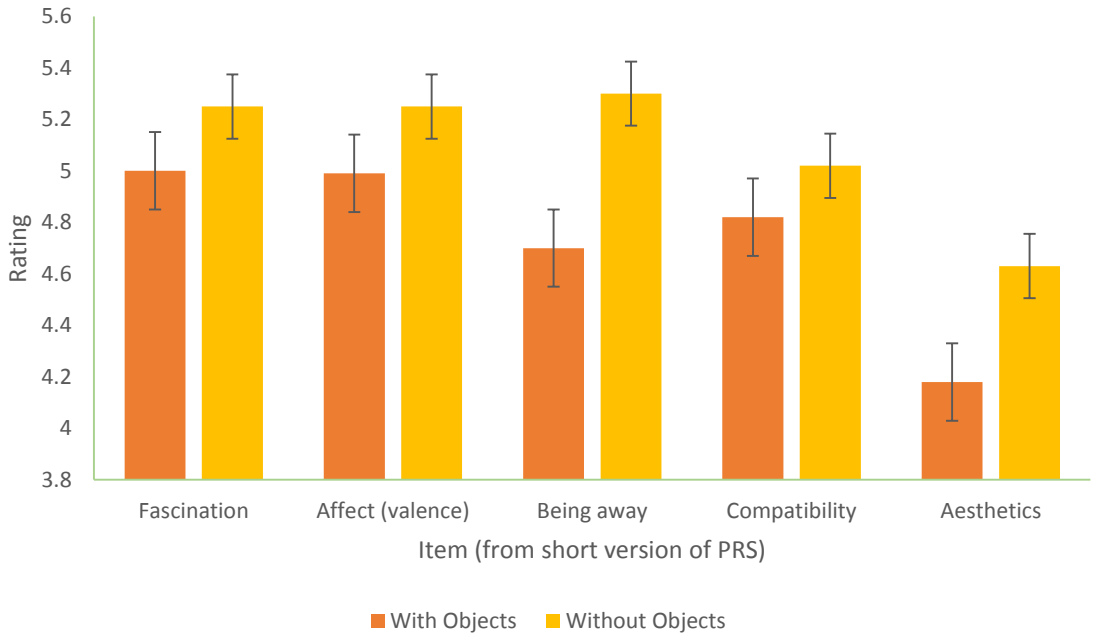

Figure 5.4. *Ratings for blue space scenes with and without artificial objects on each of the items related to perceived restorativeness. Higher ratings represent more positive responses.*

For the item relating to *being away* in ART, ratings for scenes with objects (M = 4.70, SD = .87) were significantly lower than ratings for scenes without objects (M = 5.30, SD = .86), $t(29) = 3.29$, $p < .001$. The effect size was large, d = 1.2.

For the item relating to *compatibility* in ART, ratings for scenes with objects (M = 4.82, SD = .77) were significantly lower than ratings for scenes without objects (M = 5.02, SD = .80), $t(29) = 2.33$, $p = .027$. The effect size was small, $d = 0.4$.

For the item measuring aesthetic preference, ratings for scenes with objects (M = 4.18, SD = .96) were significantly lower than ratings for scenes without objects (M = 4.63, SD = .98), $t(29) = 4.43$, $p < .001$. The effect size was large, $d = 0.8$. In summary, as shown in Figure 5.4, for blue space scenes, the presence of artificial objects had a statistically significant negative impact on all measures.

5.3.2.2 Green space scenes, with and without objects

In the green space category, for the item relating to *fascination* in ART, ratings for scenes with objects (M = 4.60, SD = .89) were significantly lower than ratings for scenes without objects (M = 5.22, SD = .86), $t(29) = 6.18$, p <.001. The effect size was large, $d = 1.1$.

For the item measuring affective valence, ratings for scenes with objects (M = 4.59, SD = .80) were significantly lower than ratings for scenes without objects (M = 5.11, SD = .70), $t(29) = 5.46$, $p < .001$. The effect size was large, $d = 1.0$.

For the item relating to *being away* in ART, ratings for scenes with objects (M = 4.44, SD = .82) were significantly lower than ratings for scenes without objects (M = 5.21, SD = .85), $t(29) = 9.11$, $p < .001$. The effect size was large, $d = 1.7$.

For the item relating to *compatibility* in ART, ratings for scenes with objects (M = 4.39, SD = .84) were significantly lower than ratings for scenes without objects (M = 4.89, SD = .76), $t(29) = 5.73$, $p < .001$. The effect size was large, $d = 1.0$.

For the item measuring aesthetic preference, ratings for scenes with objects (M = 3.97, SD = .96) were significantly lower than ratings for scenes without objects (M = 4.41, SD = 1.04), $t(29) = 4.73$, $p < .001$. The effect size was large, $d = 0.9$. In summary, as shown in Figure 5.5,

for green space scenes, the presence of artificial objects had a statistically significant negative impact on all measures.

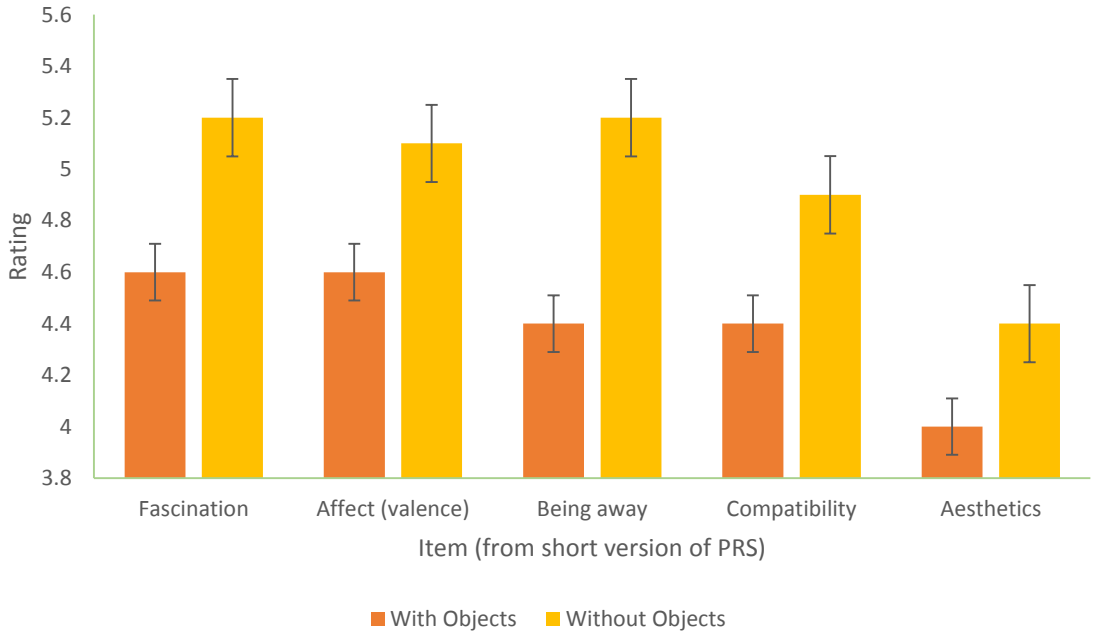

Figure 5.5. *Mean ratings for green space scenes with and without artificial objects on each of the items related to perceived restorativeness. Higher ratings represent more positive responses.*

5.3.2.3 Willingness to Pay

For the WTP item with blue space views, amounts for scenes with objects (M = £67.31, SD = 11.03) were significantly lower than WTP amounts for scenes without objects (M = £70.92, SD = 11.95), $t(29) = 4.26$, $p < .001$. The effect size was large, $d = 0.8$. The WTP results are shown separately in Figure 5.6, since participants rated this item on a scale ranging from £40 to £100. Similarly, for the green space category, WTP amounts for scenes with objects (M = £62.39, SD = 10.56) were significantly lower than WTP amounts for scenes without objects (M = £66.35, SD = 10.93), $t(29) = 4.34$, $p < .001$. The effect size was large, $d = 0.8$.

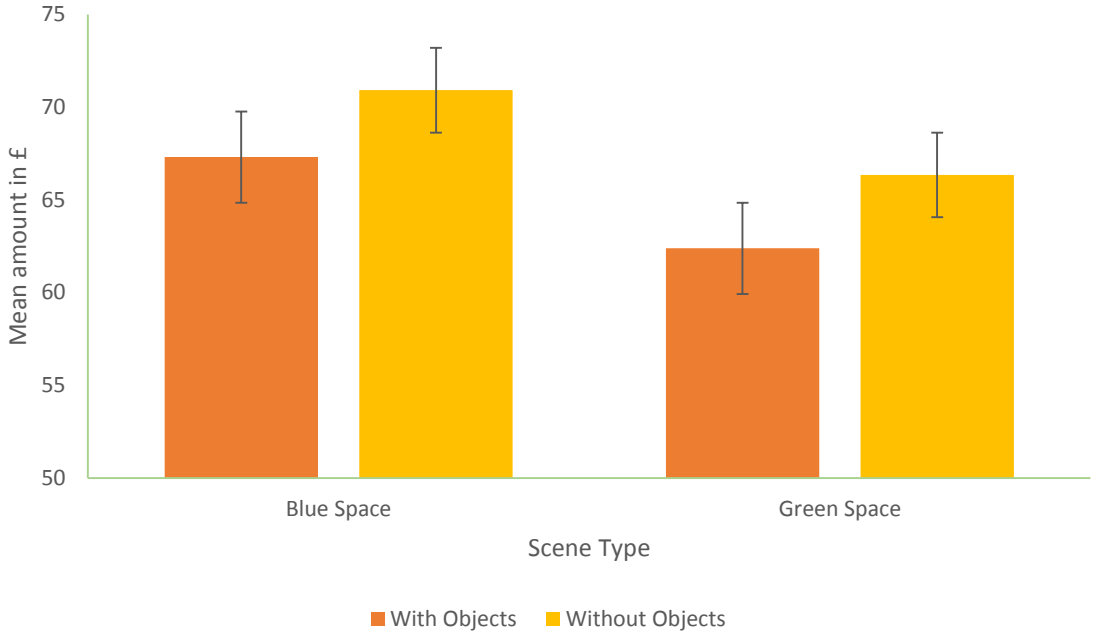

Figure 5.6. *Willingness to pay for a hotel room for green space and blue space views with and without artificial objects*.

5.3.2.4 Ratings for blue space and green space compared

When ratings for all the items on all the scenes were compared according to whether the scene was a blue space scene or a green space scene, for the item relating to *fascination* in ART, ratings for blue space scenes (M = 5.13, SD = .79) were significantly higher than ratings for green space scenes (M = 4.91, SD = .83), $t(29) = 2.25$, $p = .032$. The effect size was small, $d = 0.4$.

For the item measuring affective valence, ratings for blue space scenes (M = 5.13, SD = .73) were significantly higher than ratings for green space scenes (M = 4.85, SD = .71), $t(29) = 3.53$, $p = .032$. The effect size was medium, $d = 0.6$.

For the item relating to *being away* in ART, ratings for blue space scenes (M = 5.00, SD = .83) were significantly higher than ratings for green space scenes (M = 4.82, SD = .80), $t(29) = 2.40$, $p = .023$. The effect size was small, $d = 0.4$.

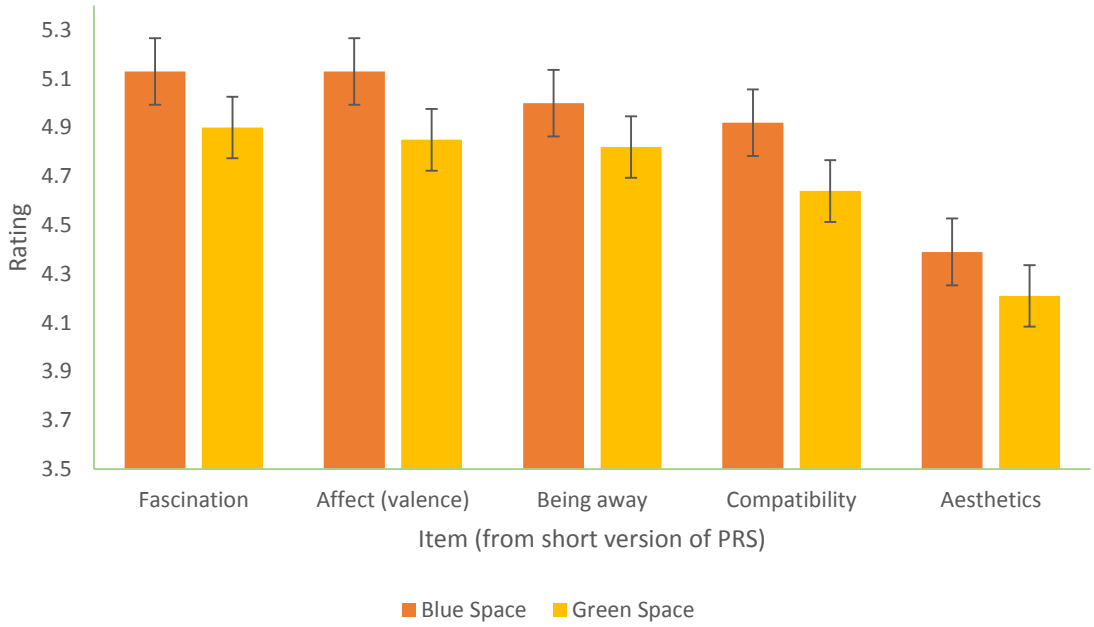

Figure 5.7. *Mean ratings for blue space scenes and green space scenes on each of the items related to perceived restorativeness.*

For the item relating to *compatibility* in ART, ratings for blue space scenes (M = 4.92, SD = .75) were significantly higher than ratings for green space scenes (M = 4.64, SD = .76), $t(29)$ = 2.25, p = .032. The effect size was small, d = 0.4.

For the item measuring aesthetic preference, ratings for blue space scenes (M = 4.39, SD = .97) were not significantly higher than ratings for green space scenes (M = 4.21, SD = .94), $t(29)$ = 1.49, p = .148. There was a small effect size, d = 0.3.

For the item measuring willingness to pay, WTP amounts for blue space scenes (M = 69.11, SD = 11.26) were significantly higher than ratings for green space scenes (M = 64.40, SD = 10.48), $t(29)$ = 4.73, p < .001. The effect size was large, d = 0.9. In summary, as shown in Figure 5.7, ratings for blue space scenes were higher on all measures. The difference was significant in all cases except the measure of aesthetic preference where, although there was a difference in the same direction (higher mean ratings for blue space), the effect size was small and the difference was not statistically significant.

5.3.2.5 Hypotheses

Hypothesis 2.1: Explicit responses to natural scenes containing artificial objects. It was predicted that ratings for scenes with artificial objects would be lower than for the same scenes without objects. The results found this to be the case.

Hypothesis 2.2: Objects in blue and green space. It was predicted that explicit affective responses to blue space would be more negatively affected by the presence of artificial objects than responses to green space. This was not found to be the case. Both blue and green space scenes were negatively affected by the presence of artificial objects.

Hypothesis 2.3: Affective responses to blue and green space. It was predicted that preferences and ratings would be higher for blue space scenes than green space scenes. This was found to be the case.

5.3.3 Study 2 Discussion

Overall, the results from Study 2 indicate a general preference for and positivity towards natural scenes without artificial objects and a preference for blue space over green space. These results are broadly consistent with previous work. More specifically, regarding explicit responses to natural scenes containing artificial objects, it was hypothesized that ratings for scenes with artificial objects would be lower than for the same scenes without objects. When explicit ratings based on perceived restorativeness were compared for blue space and green space scenes with and without objects, it was found that ratings were more positive for scenes without objects on all measures. This was consistent with Hypothesis 2.1 and indicates that the presence of artificial objects is associated with lower perceived restorativeness. In addition, the amount that participants indicated they were willing to pay for a hotel room with a view of a natural scene decreased significantly when that scene included artificial objects.

Comparing the impact of artificial objects on responses to objects in blue and green space, it was predicted (Hypothesis 2.2) that explicit affective responses to blue space would be more negatively affected by the presence of artificial objects than responses to green space. This was not found to be the case. The presence of artificial objects had a statistically significant negative impact on both blue and green space scenes. As far as affective responses to blue and green space in general were concerned, it was predicted (Hypothesis 2.3) that ratings would be higher for blue space scenes than green space scenes. This was found to be the case for all items except the measure of aesthetic preference. There was a difference in mean ratings for this item, which followed the same pattern as the other measures (the blue scenes were rated more highly than the green scenes on aesthetics). However, this difference was small and not statistically significant. Possible reasons for this lack of a significant difference might be that either the blue scenes might have happened to be overall less aesthetically pleasing to the participants than a (stereo)typical blue space scene, or, that the green scenes might have happened to be particularly aesthetically pleasing examples of green space. Either of these alternatives, if the case, would be expected to narrow the gap between the aesthetic ratings and would explain the results found here. However, since there were 12 examples of each scene type, this explanation does not seem likely. A further possibility is that the nature of the measure itself may have had an effect: this item differed from the others in that it required a more direct evaluation of the scene (a subjective assessment of its attractiveness). The other items were concerned with how participants might relate to or interact with the scene (e.g. wanting to spend time there). The overall pattern of results, however, do indicate that the blue space scenes were associated with greater restorative potential and the high correlation between the items indicates that they were reflecting the same underlying factor (perceived restorativeness). Further, participants indicated that they were willing to pay significantly more for a hypothetical hotel room with a blue space view than a green space view. Another notable result from the WTP measure, which is assumed to be a reflection of preference, is that although the presence of artificial objects was associated with a lower WTP for all scenes,

blue space scenes attracted a higher WTP than green space scenes even when the blue space scene contained artificial objects and the green space scene did not. The pattern of results here suggests that the presence of water in a view may be the most important factor in determining WTP, even though the overall rating may be adversely affected by other scene characteristics.

5.4 Parallels between implicit and explicit attitudes

Because Study 1 and Study 2 used the same images to assess implicit and explicit attitudes in the same participants, the findings from the two studies can be compared without the concern that individual characteristics (of either the images or the participants) might be the source of any overall differences.

The main observation from comparing the findings of the two studies is that implicit and explicit attitudes are not perfectly congruent. It is interesting to note however, that if the results for blue space and green space were combined into a single category of natural scenes (typical of the category that is often used in restorative environments research), it would seem as though the presence of artificial objects had a negative impact on both implicit and explicit attitudes. That is, if the scenes were considered as a whole, it would appear that implicit and explicit attitudes were congruent. However, when the results from blue and green space are looked at separately, the picture that emerges is more complex. For implicit affective responses, which are rapid, automatic and not necessarily conscious, the impact of artificial objects was more negative for blue space scenes than for green space scenes. When participants' responses revealed explicit affect, which allows more time for conscious reflection, this difference between the impact of objects on blue and green space was not apparent. It seems that there is an immediate affective response to natural scenes, which is sensitive to scene content as well as scene type. However, this immediate affective response is not necessarily reflected in slower, conscious evaluations of a scene. The manner in which the (implicit) immediate affective response and the (explicit) conscious

reflective response relate to the actual restorativeness of a scene, as well as to each other, will need to be addressed in future research.

That this difference between responses to blue space and green space would have been missed if both scene types had been considered simply as natural scenes, without specifying the presence or absence of water, highlights an issue relevant to restorative environments research in general: categorising scenes on the basis of being only natural or urban, as is usual in the field, might be missing potentially important differences between scene types. One finding that emerges from the blue space research, in Studies 1 and 2 as well as in the existing literature, is that not all types of natural scene are equal. Further, it is not yet understood how scenes (natural or otherwise) should be categorised in a meaningful manner. Although both studies reported in this chapter support the idea that blue space should be regarded as a category in its own right, it should not be assumed that aquatic environments constitute a homogeneous category any more than natural environments do. Study 3, reported in Chapter 6, investigates this issue further.

As far as explaining the results is concerned, both for the individual studies and for their comparison, the main theories (ART and SRT) are not well specified enough to be able to account for the implicit or explicit response differences between blue and green space. When formulating the hypotheses for the two studies, it would have been preferable for these to have been theoretically motivated, rather than driven by previous empirical findings. However, neither ART nor SRT make clear predictions about the impact of artificial objects in either green or blue space. It may be possible to construct some general predictions: for example SRT might predict that since all the positive adaptive features of the original natural scene remain, artificial objects should have no impact, regardless of whether the scene is green or blue, whereas ART might predict that responses would be influenced to the extent that each of the four essential components of the theory are affected by the objects. However, there is an unsatisfactory arbitrariness about these predictions, firstly in their formulation (it is not clear that they are required by the

theories as opposed to being broadly compatible with them); secondly in assessing them. For example, for ART, unless each of the components can be defined and measured (which is not currently the case) it is not possible to test the prediction suggested above, or other similar predictions.

What Study 1 and Study 2 jointly contribute to the overall body of knowledge in terms of their findings is: firstly, the indication that blue space is a functionally distinct category (from both studies); secondly, blue space is more preferred and perceived as being more restorative (from Study 2); thirdly, blue space may be particularly susceptible to impacts from other scene characteristics at a subconscious level (Study 1), although how this might manifest itself in more realistic settings has yet to be investigated.

5.5 Summary

Study 1 found that the presence of artificial objects has a negative impact on implicit affective responses to natural scenes, particularly when those scenes contain water. Further, this study demonstrated the usefulness of implicit priming in this context, and confirmed that the modifications made to the standard AMP method were workable.

Study 2 found that the presence of artificial objects had a negative impact on explicit ratings of both blue and green space scenes. This study provided a point of comparison and linkage with previous work that uses explicit ratings-based methods. The results of Study 2 replicated some of the previous findings about blue space, which is not only positive in the demonstration of replicability, but also in that it indicates that the materials (scene images) used in this study were not exceptional, but in line with materials used in other studies. Since it is difficult to standardise scene content in a satisfactory manner, this validation (albeit indirect) of the materials used is important.

Taken together, these two studies suggest that implicit and explicit attitudes towards natural scenes may not always match. The theoretical consequences of this observation are

not yet clear, though any complete explanation of restorative phenomena would need to be able to account for the differences.

Several questions have been raised by the findings of these studies, particularly Study 1, two of which will form the basis for studies 3 and 4. Study 3 is motivated by the need to investigate the apparently more positive implicit affect generated by green space compared with blue space in Study 1. Since Study 1 was not designed to make this comparison, it is necessary to design a new study for this purpose. Study 3 will therefore investigate the implicit affect generated by different scene types. This study is reported in Chapter 6.

The finding from Study 1 that artificial objects had a more negative impact on blue space than green space was not unexpected, based on combined predictions from empirical findings relevant to blue space and artificial objects in natural scenes. However, the theoretical basis for these results is less clear. Since there is currently no satisfactory explanation for why artificial objects would have a more negative impact on implicit affective responses to blue space, Study 4 was designed to test a possible explanation based on the overall coherence of the scene. This study is reported in Chapter 7.

Chapter 6

Implicit attitudes to different scene types: Study 3

6.1 Introduction

Study 1, reported in Chapter 5, investigated implicit affective responses to blue space and green space scenes with and without artificial objects. Although that study was not designed to compare implicit affective responses to blue space with responses to green space, it was noticeable from the results that the implicit affect generated by green space seemed to be more positive than the implicit affect generated by blue space. Such a difference would not have been expected on the basis of previous research into explicit attitudes towards scene types: blue space tends to give rise to more positive affective responses than green space (White *et al*., 2010). Indeed, Study 2 (also reported in Chapter 5), using the same materials and participants as Study 1, found evidence of more positive explicit affect generated by blue as opposed to green space. Knowledge of implicit affective reactions to scenes is not well developed and there are no indications from previous work as to whether there might be an implicit preference for green space over blue space. Such a preference would be surprising in that it would represent an opposite pattern from that revealed by explicit attitudes. It was important, therefore, to investigate this apparent difference to determine whether it represented a real result which would need to be accommodated theoretically, or a statistical quirk which could be discounted.

The few previous studies that have been conducted to investigate implicit attitudes towards scenes, have found that implicit attitudes towards natural scenes are more positive than implicit attitudes towards urban scenes (Hietanen *et al.*, 2006; Joye *et al.*, 2013). Neither of these studies categorised natural scenes according to different environment types, so it is not known whether different types of natural scenes give rise to more or less positive

implicit affect. This highlights a gap in knowledge that will be investigated in the present study. Although this question was motivated by the results of Study 1, it is a question that is worth answering in its own right since so little is currently understood about the impact that viewing different types of natural scenes might have on implicit attitudes.

In terms of explicit attitudes, some studies have been done looking at preferences for different scene types. The work by Balling and Falk, often cited as supporting the Savanna Hypothesis (Balling and Falk, 1982; Falk and Balling, 2010) as discussed in Chapter 3, found a preference for savanna (grassland) over other types of environment. Other research has failed to replicate these results, instead finding that wooded scenes evoke the most positive reactions from people (Han, 2007). Since the findings from studies investigating explicit attitudes are not consistent regarding natural environment types, there are no predictions that follow straightforwardly from this work that might apply to implicit attitudes. It is also not known whether implicit and explicit attitudes are necessarily congruent, though Study 1 suggests perhaps not. This is another gap in knowledge that will be investigated in the present study.

6.2 Overview and Hypotheses

Since the main objective of Study 3 was to compare implicit affective responses to blue space and green space, artificial objects were not investigated in this study. Omitting this variable made it possible to include additional scene types in the experimental design to expand the range of comparisons. In addition to blue space and green space, an urban scene category and an indoor scene category were added. The blue and green space categories, which were the focus of the study, were further divided into sub-categories representing different types of each natural scene with and without water.

Research Question 3*: Does the presence of water influence implicit affective responses to natural scenes?*

In order to address this research question, Study 3 was designed to test a hypothesis based on the unexpected pattern of results observed in Study 1.

Hypothesis 3.1: *Implicit affective responses to green space will be more positive than implicit affective responses to blue space*.

It was also possible to address other issues raised by the first two studies in the design of Study 3: Firstly, an urban category was included to be able to make a comparison between implicit responses to natural and urban scenes. Although this comparison has been made before (Joye *et al.,* 2013), findings in this area are scarce, therefore replication of results, especially using different materials and methods, is important. In addition, such a comparison has not been performed previously using a scale (as opposed to a positive-negative binary rating); it was not known whether this would affect the findings for natural versus urban scenes. Further, this has not been done with systematic subcategorisation of scene types; it was not known whether natural scenes form a homogeneous category with respect to the implicit affect they give rise to. As well as the urban category in this study, an additional indoor category was added, partly for the items to act as filler images to break up the natural scenes, but also as an exploratory category: scene types used in restorative environments research are usually outdoor scenes, it was not known whether implicit affective responses to indoor scenes would be more or less positive.

The absence of objects in this study enabled the procedure to be designed to compare subcategories of blue and green space. In Studies 1 and 2, the only type of aquatic scenes used were seascapes. However, it is possible that implicit affective responses to different types of aquatic scenes may differ. Whether this is the case is not yet known and no reports of such an investigation were found in the literature. Therefore, for this study, the blue space scenes were selected to represent the categories of sea, lakes and rivers. Following similar

logic, the green space scenes were selected to represent different categories: desert, forest and grassland.

No specific hypotheses were advanced in respect of which of the subtypes might give rise to more positive implicit affect; the question in this study was whether they differed at all. Nevertheless, the grassland category was included in the green space scene types because of its relevance to SRT and the Savanna Hypothesis, which would predict that affective responses to grassland/savanna scenes should be the most positive of all those generated by the natural environments.

6.3 Method

6.3.1 Participants

Participants were volunteers recruited from businesses located on Westlakes Science Park near Whitehaven in Cumbria and the offices of Allerdale and Copeland Borough Councils, also in Cumbria. 31 people took part, 19 female and 12 male with an average age of 39.9 years (range 22-54). None of the participants had taken part in studies 1 and 2 and none were speakers of Chinese.

6.3.2 Materials and design

Since Study 1 had used the modified Affect Misattribution Procedure (AMP) successfully, the same implicit priming method was used in the present study. A different set of images were used for the natural scenes, but the target items (Chinese characters) were the same as those used in Study 1. The priming items consisted of 48 colour photographs of scenes. Images were sourced from online photo libraries and were different from the images used in studies 1 and 2. Scenes were divided into four categories (blue space, green space, urban space and indoor space), with 12 images in each category. The blue space and green space

categories might be better described as 'natural scenes with water' and 'natural scenes without water' respectively, since, particularly for the scenes without water, they did not necessarily match their designated colours. However, in order to maintain consistency with the rest of the thesis, the labels blue and green are used. These should be understood as referring to a particular type of scene (one that is natural, with or without water) rather than referring to the dominant colour in that scene (which might be neither blue nor green). Previous research using monochrome images of built and natural scenes has shown that the colour of a scene is not the source of preference and perceived restorativeness (Mathew P. White, Cracknell, *et al.*, 2013), therefore it was not considered to be an important characteristic of the scenes used in this study.

The images of most interest to the aims of the study (investigating implicit affective responses to natural scenes) were the blue space scenes and the green space scenes. As mentioned above, since there were no artificial objects in these scenes[75], it was possible to include different types of blue and green space; attempting this in Study 1 would have resulted in an experimental design that was over-complex and would have required more participants. In this study, the blue and green space categories were divided into three subcategories: Of the 12 blue space images, four comprised seascapes, four were river scenes and four were lake scenes. In the green space category, four images were grassland scenes, four were desert scenes and four were woodland scenes. This was to enable a comparison both between the blue and green space categories and a comparison of scene types within those categories.

For symmetry in the design of the experiment, the urban and indoor scene types were also subdivided into three categories, however this was not necessary for the purposes of

75 Although the blue and green space scenes were free of anthropogenic objects, the urban and indoor categories both (necessarily) contained such objects, since the scenes themselves were of obvious human construction.

addressing the experimental questions and these subdivisions were not intended to be subject to statistical analysis. All the priming images are reproduced in Appendix 3.

6.3.3 Procedure

The same computer program that had been constructed for the modified AMP used in Study 1 was also used for Study 3. Timings, instructions and the rating scale were identical to those described in Section 5.2.1. Volunteers arrived at the testing room at pre-arranged time slots. The general nature of the study was verbally explained to them and they were reminded that they were free to withdraw at any point before or during the procedure. The participants sat at a table in front of the computer screen (adjusted to eye level) and were given an opportunity to ask questions and practice the procedure before the experiment began. Instructions (reproduced in Appendix 2), adapted from the standard AMP (Payne *et al.*, 2005), appeared on the screen in white text on a grey background, providing participants with the information that they would see a series of pictures presented rapidly, followed by random shapes. Participants were asked to rate the visual pleasantness of the shapes, ignoring the pictures that preceded them. Ratings were made on a 7-point scale, with 1 representing very unattractive and 7 representing very attractive. Instructions specified that each decision should be based on 'gut feeling' and responses should be made as quickly as possible, without deliberation. Responses were made by using the mouse to click on the scale that appeared on the screen after each shape. The practice session consisted of 10 trials. After completing the practice, participants were given a two-minute rest before beginning the experimental procedure. Instructions were displayed on the screen before the beginning of the procedure and were identical to the practice instructions, with the exception that instead of being asked to rate shapes, participants were asked to rate Chinese characters. The screen instructions for both the practice and the experimental procedure are reproduced in Appendix 2.

The experimental procedure was identical to that depicted in Figure 5.2. Each of the 48 experimental trials was preceded by a white fixation point that appeared in the centre of the grey screen for 400ms. After this, one of the 48 priming images appeared for 400ms. Images appeared in a different random order for each participant. Next, a Chinese character appeared on the screen for 200ms. Then, the rating scale appeared and remained on the screen for up to 2500ms (2.5 seconds) to allow the participants to respond. This relatively short presentation of the scale was to put the participants under time pressure to encourage them to respond as rapidly and unreflectively as possible. The rating scale disappeared once participants had responded and the next trial began immediately. Trials were presented consecutively until all items had been completed. Participants were thanked for taking part and debriefed before leaving.

6.4 Results

6.4.1 Type of scene

Results showed that mean ratings were highest ($\bar{x}$ = 4.44) when preceded by blue space primes. Ratings following green space priming scenes were lower ($\bar{x}$ = 4.20), with ratings following urban primes ($\bar{x}$ = 3.86) and indoor scenes ($\bar{x}$ = 3.80) lowest of all. These results are shown in Figure 6.1. Since the neutral (mid-point) on the rating scale was 4, these results show that when the neutral target was preceded by a natural scene (blue or green space) it was rated as being more visually attractive than average, whereas when the target was preceded by an urban or indoor scene it was rated as being less visually attractive than average.

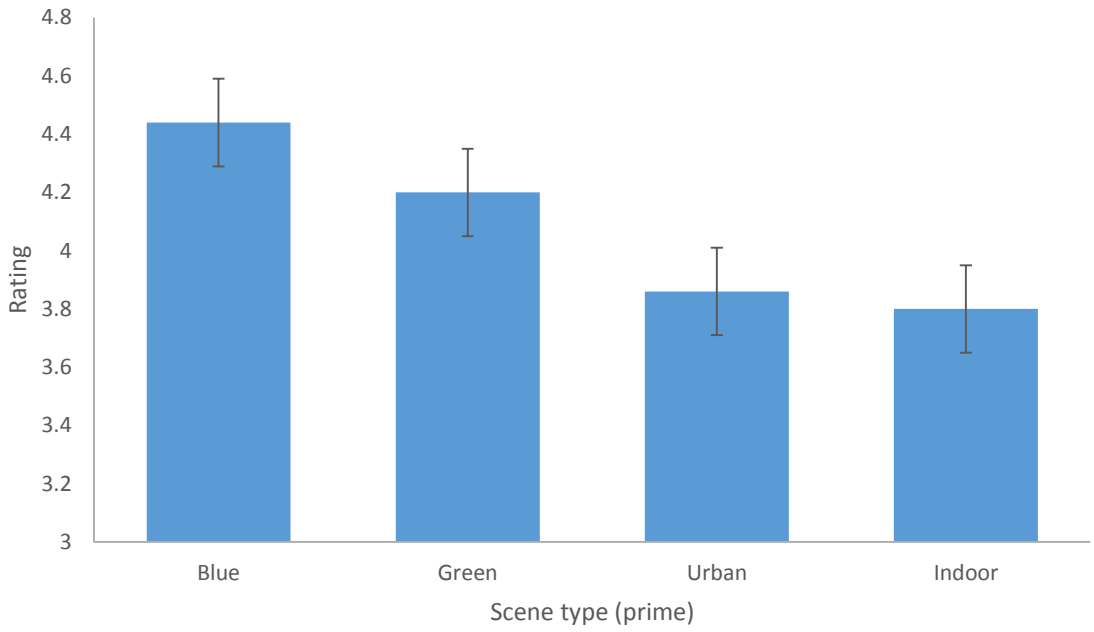

Figure 6.1. *Ratings of a neutral target following presentation of a priming scene. Higher ratings are more positive.*

A one-way repeated measures ANOVA was conducted to compare the effect of scene type on implicit affect in the four conditions: blue space, green space, urban space and indoor space. It was found that there was a significant effect of scene type, $F(3,90) = 12.03$, $p < .001$, $\eta^2 = .29$, showing that implicit affect differed between the different scene categories. Pairwise comparisons were then carried out for the main effect of scene type (corrected using Bonferroni adjustments) as shown in Table 6.1. These pairwise comparisons indicate that the significant main effect reflects a significant difference ($p = .048$) between responses following blue space and green space scenes; that is, affective responses to a neutral target were more positive following blue space primes than green space primes . Responses following blue space scenes were also significantly higher ($p = .007$) than responses following urban scenes, as well as indoor scenes ($p = .001$). After viewing green space scenes, subsequent responses were significantly more positive than after viewing indoor scenes ($p = .018$). Although responses following urban scenes were less positive than responses following green space scenes, this difference did not reach significance ($p = .065$).

These results, showing that ratings following blue space primes were significantly more positive than ratings following green space primes, contradict Hypothesis 3.1, which predicted the opposite pattern of results.

Table 6.1. Pairwise comparisons for the different scene types

(I)scene type	(J)scene type	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
blue	green	.25*	.09	.048	.002	.502
	urban	.59*	.16	.007	.124	1.047
	indoor	.65*	.15	.001	.215	1.085
green	blue	-.25*	.09	.048	-.502	-.002
	urban	.33	.12	.065	-.013	.680
	indoor	.40*	.12	.018	.050	.746
urban	blue	-.59*	.16	.007	-1.047	-.124
	green	-.33	.12	.065	-.680	.013
	indoor	.07	.06	1.000	-.092	.221
indoor	blue	-.65*	.15	.001	-1.085	-.215
	green	-.40*	.12	.018	-.746	-.050
	urban	-.07	.06	1.000	-.221	.092

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

6.4.2 Blue space scenes

No specific hypotheses were advanced regarding subcategories of blue space. The results showed that ratings of the neutral targets were highest when preceded by blue space priming scenes containing sea ($\bar{x}$ = 4.69), with scenes containing rivers associated with lower subsequent ratings ($\bar{x} = 4.45$) and scenes containing lakes associated with the least positive ratings of the blue space scenes, although still more positive than average ($\bar{x} =$ 4.20). Pairwise comparisons, shown in Table 6.2, indicate that the only significant difference in the blue space category was between the scenes containing sea and those containing lakes (p = .013).

Table 6.2. Pairwise comparisons for different types of water

(I) type_of_water	(J) type_of_water	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
sea	river	.24	.17	.494	-.189	.672
	lake	.49*	.16	.013	.087	.897
river	sea	-.24	.17	.494	-.672	.189
	lake	.25	.16	.416	-.167	.667
lake	sea	-.49*	.16	.013	-.897	-.087
	river	-.25	.16	.416	-.667	.167

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

6.4.3 Green space scenes

As for blue space, no specific predictions were made regarding differences between scene types for the green space images: the aim was simply to investigate whether there was a difference within the category of green space. Mean ratings of the neutral targets when preceded by grassland scenes were highest ($\bar{x}$ = 4.44), ratings following desert scenes were lower ($\bar{x}$ = 4.14), and ratings following forest scenes were the least positive of the green space scenes ($\bar{x}$ = 4.01).

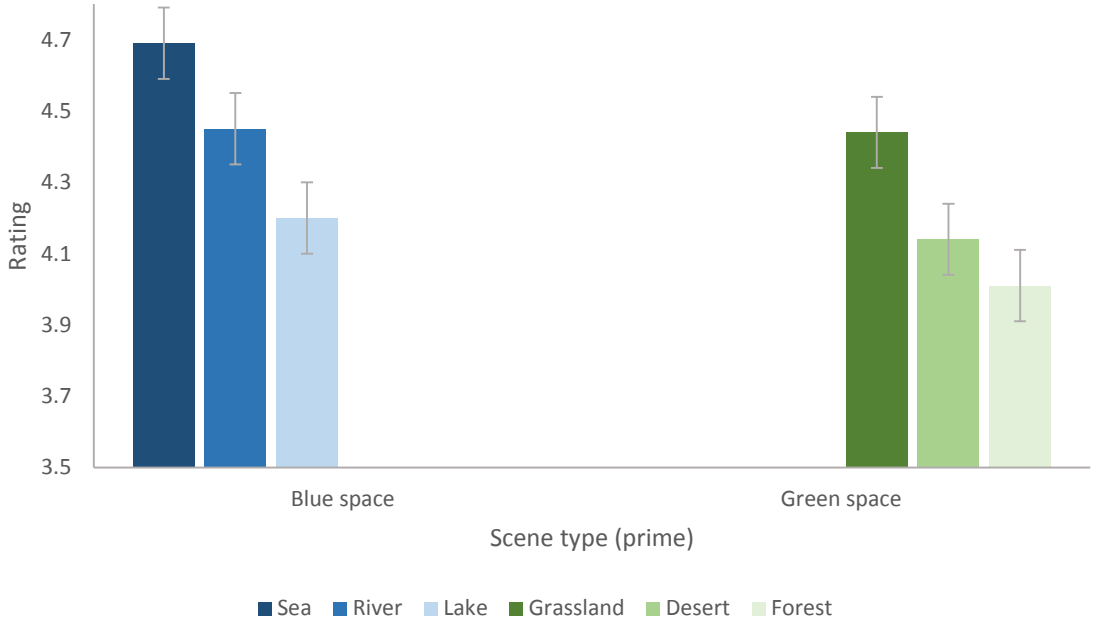

Figure 6.2. *Ratings of a neutral target following presentation of a priming scene for different types of blue and green space scenes. Higher ratings reflect more positive affect.*

Pairwise comparisons for the different categories of green space priming scenes, shown in Table 6.3, indicate that only the difference between grassland and forest scenes was significant (p = .04).

The breakdown of results for the different categories of blue and green space is illustrated in Figure 6.2, which shows that although the blue space scenes were associated with higher implicit affect overall, there was some overlap in the mean ratings between the subcategories of blue and green space.

Table 6.3. Pairwise comparisons for different types of green space

(I) type_of_green	(J) type_of_green	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
desert	forest	.13	.18	1.000	-.318	.576
	grassland	-.31	.16	.192	-.710	.097
forest	desert	-.13	.18	1.000	-.576	.318
	grassland	-.44*	.17	.040	-.855	-.016
grassland	desert	.31	.16	.192	-.097	.710
	forest	.44*	.17	.040	.016	.855

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

6.5 Discussion

The main aim of this study was to test the hypothesis, motivated by an apparent pattern in the results of Study 1, that green space scenes would give rise to more positive implicit affect than blue space scenes. The results show that this hypothesis can be rejected. Not only did green space scenes not give rise to more positive implicit affect, blue space scenes were associated with significantly more positive affective responses. It is therefore possible to conclude that implicit affective responses to blue space are more positive than implicit affective responses to green space.

Within the green and blue space categories, differences were also found between scene types. For scenes containing water, seascapes were associated with the most positive ratings of the neutral targets, which were significantly more highly rated than when preceded by lake scenes. For natural scenes without water, grasslands were associated with the most positive ratings; targets were significantly more highly rated than when preceded by forest scenes. These results show that not all environments which might be classed as natural scenes are perceived equally. Participants were only exposed to each scene for 400ms, yet differences in affective attitudes were detected, suggesting that affective responses to scenes arise rapidly and spontaneously, without the need for conscious deliberation. The more positive implicit affect generated by blue space scenes is congruent with the findings from previous work, reported above, that explicit affective responses, including attractiveness ratings and perceived restorativeness ratings, tend to be more positive for blue space than for green space. Previous work has not systematically investigated explicit attitudes to different types of blue space, so it is not known whether the differences in implicit affect generated by scenes containing sea, rivers and lakes might also be reflected in explicit attitudes.

As for green space, one of the subcategories in the green space scenes included in this study represented grasslands. The grassland subcategory was selected with the Savanna Hypothesis in mind, although the study was not designed to test that theory (which, as discussed in Chapter 3, is not well specified enough to be able to provide a useful explanatory framework). However, it is worthwhile considering the results from this perspective. If the results from the green space scenes were looked at alone, it might appear that they provide support for the Savanna Hypothesis (and, by extension, SRT), since the implicit affect generated by grassland scenes was more positive than that generated by the desert or forest scenes. What is more, the finding that grassland is associated with more positive implicit affect than the other green space scene types is congruent with findings from the studies that have asked participants for explicit ratings of scenes (Balling and Falk, 1982; Falk and Balling, 2010). When regarded in the context of all the results, however, the

findings for green space are not supportive of the idea of an innate preference for savanna landscapes: the scenes that generated the most positive implicit affect were not the grassland scenes, but the blue space scenes, in particular the seascapes.

In common with studies 1 and 2, these results suggest that research which assumes a general definition of natural scenes (as is common in the restorative environments literature) may miss important differences which arise from different scene types, both between blue and green space scenes, and also within those categories. Although blue space scenes gave rise to the most positive implicit affect overall, when the blue and green space scenes were subdivided the results indicate that not all the blue space scenes gave rise to more positive implicit affect than all the green space scenes: for example, the ratings of a neutral target following scenes containing flowing water (the river category) were almost identical to ratings following the grassland scenes. The results from the scene subcategories suggest that it is perhaps not only the presence of water that increases positive affect (although this was found to be the case), but that the particular type of water is also important, with seascapes generating the most positive implicit affective responses of all.

The results from this study are not easily explained by either ART or SRT. As indicated above, the Savanna Hypothesis is not consistent with the results found here. Similarly, the evolutionary underpinnings of SRT do not provide a clear basis for predicting the adaptive value of a rapid, positive affective response to seascapes over other natural scene types included in the study. As for ART, the theory is not well specified enough to make predictions about how its four hypothetical dimensions should necessarily differ systematically for seascapes over other blue and green scene types.

The indoor scenes in this study were included primarily as filler/control items, not as part of the experimental investigation. However, since it was not known whether such scenes would have an impact on affective responses, the results from this category were of interest. So far, most of the research into restorative environments has focused on outdoor environments (see Chapter 2 for a review of this literature). From the perspective of the

main theoretical positions though, ART would not necessarily preclude indoor scenes from having restorative potential, thus giving rise to positive affective responses. As far as SRT is concerned, the version of the theory based on Savanna Hypothesis principles would not predict that indoor environments would possess restorative potential. The results from Study 3 show that the implicit affect generated by indoor scenes was the least positive of all the scene types, though did not differ significantly from the urban scenes.

6.6 Summary

This study has shown that viewing images of scenes can give rise to more or less positive implicit affect, depending on the type of scene. Natural scenes (as opposed to urban and indoor scenes) induce more positive implicit affect than average. Within the category of natural scenes, aquatic scenes give rise to more positive affect than scenes that do not contain water. However, there are also differences within aquatic and non-aquatic scene types, with seascapes generating the most positive implicit affective responses of all the scene types studied.

As far as the relationship between implicit and explicit attitudes is concerned, the results seem broadly consistent with findings based on explicit responses to viewing scenes. That is, natural scenes were associated with more positive affect and within the category of natural scenes, blue space scenes were associated with more positive affect than green space scenes. However, results from subcategories of the broad scene types in this study suggest that the standard, general scene classifications may conceal more subtle effects and preferences. Not all natural scenes are equal with respect to the affective responses they induce; blue space and green space differ. Similarly, and within those category distinctions, not all blue space and green space scenes are equal in the affective responses they may induce. Too little is known about the role of scene content and the overall meaning of scenes to be able to attempt to explain these differences at this point. Study 4, reported in Chapter 7, attempts a preliminary investigation in this area.

Chapter 7

Conceptual congruence of objects in natural aquatic and non-aquatic scenes: Study 4

7.1 Introduction

The main finding of Study 1, reported in Chapter 5, was that implicit attitudes to blue space were more negatively affected by the presence of artificial objects than attitudes to green space were. The main theoretical frameworks, Stress Reduction Theory (SRT) and Attention Restoration Theory (ART), are not sufficiently specified to be able to explain this result. That is, neither theory makes specific predictions regarding anthropogenic objects in natural scenes, nor do they predict or explain the preference for or greater restorative potential of blue space over green space scenes. The more recent theories which have attempted to explain some of the differences in the restorative potential of different environments similarly do not offer a clear explanatory pathway for the impact of artificial objects on responses to natural scenes. The visual processing theory, proposed by Joye *et al*. (2015), relies on the fractal properties of the scene. Since the addition of artificial objects does not reduce the fractality already present in the scene, it is not clear how this framework might straightforwardly accommodate the results. Although it could be argued that artificial objects tend to be less fractal in character than natural objects, if this was the source of the impact of those artificial objects, no difference would have been expected between the impact on blue space and green space scenes. A similar issue applies to the theory proposed by Valtchanov and Ellard (2015), which argues that restorative responses arise from the processing of low-level visual properties of scenes; in particular, visual spatial frequencies. The addition of artificial objects may have an impact on the spatial frequency information

of the scene, but when these objects are few in number and do not dominate the scene, this information is unlikely to allow differentiation between a natural object, such as a tree, and an artificial object, such as a wind turbine. Both these theories may appear to explain differences between scenes that differ categorically overall as well as differing on the theoretically important visual dimension, such as is the case for urban versus natural scenes. However, when it comes to explaining differences between scenes that differ on just one dimension, including the presence or absence of an object, neither theory provides a satisfactory explanatory framework.

In order to begin to formulate an explanation for the more significant negative impact of artificial objects in blue as opposed to green space, it was deemed appropriate to reconsider the apparently basic[76] question of what constitutes a scene. This is a consideration that is overlooked by the explanations based on low-level visual processing. Such theories are unable, in principle, to distinguish between a juxtaposition of characteristics and objects that is uninterpretable and a different arrangement that is perceived as a scene. In order to discern that something is a scene, the operation of high-level visual processes is necessary. These processes integrate lower level visual representations with meaning and other aspects of cognition, such as short-term memory and the identification of objects and scenes (Henderson and Hollingworth, 1999).

Accordingly, it is possible to define a visual scene as, 'a semantically coherent (and often nameable) view of a real-world environment comprising background elements and multiple discrete objects arranged in a spatially licensed manner' (Henderson and Hollingworth, 1999, p.244). So, when high-level visual processing is taken into account, there are structural and semantic regularities that enable something to be recognised not only as a scene, but as a particular type of scene (whether it be urban or natural, seascape, forest or

[76] The term is sufficiently unambiguous in everyday usage that it has been used throughout this thesis in its conventional sense, without requiring special definition or delimitation. The definition provided below makes explicit what we already implicitly understand.

desert, and so on). For example, the implicit knowledge that physical objects usually sit on surfaces (rather than floating in the air), or that certain objects tend to co-occur spatially (such as the computer keyboard and its screen) can be regarded as part of a 'scene grammar', or an underlying set of principles that define what constitutes a legitimate scene (Võ and Wolfe, 2015). As well as being structurally predictable, scenes possess semantic coherence; this makes them both nameable and comprehensible. There is evidence from research into the visual processing of scenes that confirms the perceptual importance of both the structural principles underlying a scene (Henderson, 2007) and its semantic coherence (Brockmole *et al.*, 2008).

This perspective allows the issue of the impact of artificial (or any type of) objects on responses to natural scenes to be framed slightly differently. It raises the question of whether placing anthropogenic objects into a natural scene might disrupt the conceptual (semantic or structural) coherence[77] of that scene, thus having an impact on implicit affect. If so, the further question would arise of whether it is possible that certain types of scene might be more prone to such conceptual disruption.

It is these questions, driven by the attempt to find a framework within which to explain the main finding from Study 1, that form the basis for the present study. It has been noticed that the body of restorative environments research has largely neglected the potential contribution of scene meaning to restorative phenomena (Ratcliffe, Gatersleben and Sowden, 2016). Although this observation was intended in relation to the individual meanings people might attach to scenes and components of scenes, there is also a lack of systematic investigation into the role of more general semantic and structural coherence in

[77] Attention Restoration Theory (ART) mentions the coherence of a scene as part of its theoretical *extent* component of restorative environments: "[a restorative environment] must … be rich enough and coherent enough so that it constitutes a whole other world." (Kaplan, 1995, p.173). Coherence is not defined further in ART, however this notion is broadly compatible with the proposal being tested in the present study. Some previous investigations into the perceived restorativeness of environments have included ratings related to scene coherence and have found it to be correlated with other measures of perceived restorativeness (Pasini *et al.*, 2015).

the restorative potential of particular environments[78]. This lack of previous research means that there are no established methods in the restorative environments field that are well suited to addressing the questions motivating the present study. The advantages of using implicit methods, as discussed in Chapter 4, apply here: people might perceive disruptions to scene coherence without necessarily being able to provide a verbal account of their perceived disruption. Implicit methods bypass this issue and remove the need for conscious introspection and the possible contamination of the results this may bring. Therefore, a scene semantic priming method adapted from visual processing research will be used to investigate perceived scene coherence in this study.

7.2 Overview and hypothesis

Research Question 4: *Can differences in implicit attitudes to natural aquatic and non-aquatic scenes containing artificial objects be attributed to differences in scene coherence?*

This question can be addressed by investigating whether artificial objects are less conceptually congruent with natural blue space scenes than natural green space scenes. In order to measure the conceptual congruence of objects with scenes, Võ and Wolfe (2014) developed a scene priming method using a lexical decision task. The lexical decision task in the context of scene semantic priming was introduced in Section 4.5.2.3. This procedure involves measuring the response time for participants to indicate whether a string of letters is a word in their language. These lexical decision response times can be affected by the context in which the task occurs, either before or during presentation of the word (Holcomb and Neville, 1990); the manipulation of this context can produce priming effects. As with the Affect Misattribution Procedure used in Studies 1 and 3, this method relies on the idea

[78] It is assumed, on the basis of the visual perception research (e.g. Henderson, 2007) that it is legitimate to assume broad principles of scene semantics and structure that apply in general, over and above individual personal associations. These might be regarded as analogous to semantics and syntactic principles in the study of language. For example, it is possible to examine the semantic and structural properties of any word or phrase in a language independently of any particular speaker of that language (e.g., Chomsky, 1965; Cruse, 1986).

of implicit priming (the process is rapid, automatic and does not rely on conscious introspection) where exposure to a given stimulus (the prime) affects the response to a subsequently presented stimulus (the target).

In a study investigating responses to object words superimposed on images of indoor scenes, Võ and Wolfe (2014) found that lexical decisions were affected by both the semantic and structural incongruity: for example, when the word *soap* was presented in the position in a bathroom scene where the soap would be expected to appear, reaction times for the lexical decision (correctly identifying *soap* as a word) were faster than when the same word appeared in an incongruent position in the scene (such as on the towel rail) and also faster than when a word representing an incongruent object (such as *egg*) was in the position where the soap would be expected to feature. This phenomenon of facilitation of responses to a congruent word and slowing of responses to an incongruent word forms the basis of the experimental methodology for the present study.

The study was designed to test two hypotheses: first, Hypothesis 4.1, that *lexical decision response times to words representing anthropogenic objects in natural scenes will be slower than response times to words representing natural objects.*

This hypothesis was based on the assumption that anthropogenic objects would be regarded as incongruent with the scene, whereas natural objects would be regarded as congruent. Thus, it sought to replicate the results found by Võ and Wolfe (2014) in outdoor, natural scenes.

Secondly, following on from this, the experiment was also designed to test Hypothesis 4.2, that *the difference between lexical decision response times to words representing anthropogenic objects and words representing natural objects will be larger in blue space scenes than green space scenes*.

That is, if artifical objects are perceived as being incongruent in natural scenes, lexical decision times should be slower for those words than for words representing congruent (natural) objects (Hypothesis 4.1). If artificial objects are more incongruent in blue space scenes than green space scenes, the negative impact on lexical decision times should be greater in the context of blue space than in green space (Hypothesis 4.2).

7.3 Method

7.3.1 Participants

Participants were staff working at Westlakes Science Park in Cumbria who volunteered to take part in the procedure. Due to the between participants element of the design (explained in Section 7.3.2), more participants were needed for this study than the previous three studies conducted for this thesis. Accordingly, 55 participants were recruited. The mean age of the participants was 41.2 years (range 19 – 62). Age was the only personal characteristic that was recorded.

7.3.2. Materials and Design

The materials for this study consisted of a set of 24 experimental images. Of these, 12 depicted blue space scenes and 12 depicted green space scenes. These images were the priming items in the procedure described in Section 7.3.3. In addition, there were 24 experimental lexical items (words); 12 words representing anthropogenic objects that might be found in natural scenes and 12 words representing natural objects that might be found in natural scenes. Words were selected to represent objects that might be found in both blue and green space scenes. The images used in this study are reproduced in Appendix 4 and the words used are reproduced in Appendix 5.

Each of the scene images (12 blue space and 12 green space) was paired with both a congruent (natural) word and an incongruent (artificial) word. Therefore, with the 24 target

words, each blue space scene appeared twice and each green space scene appeared twice. This resulted in 48 experimental word-scene combinations.

Although it would have been preferable for every participant to complete all the experimental combinations, the nature of the task precluded this. One of the factors that can influence lexical decision times is prior exposure to a word (Forster and Davis, 1984). This meant that each participant could only be exposed to each experimental lexical item once. Since the experimental words all appeared twice in the set of materials (once each with both a blue space scene and a green space scene), this meant that each participant could only complete half of the experimental items. Hence, the participants were randomly assigned to two separate groups: one completed the blue space items, the other completed the green space items. This meant that participants were exposed to all the words, but only half of the scene images. As a result, more participants were required for this study so that the results could be analysed separately in each group.

In order to accommodate both the within and between participant factors the study made use of a mixed model (split plot) design (Ellis, 1999). As described above, all participants were exposed to the within participants factor, and were assigned randomly to the between participants factor. The lexical decision response time was the dependent variable. Independent variables were scene type (blue or green), which was the between participants factor; and object word type (natural or artificial), which was the within participants factor.

To balance the experimental items and to ensure that the factors of interest to the study were not obvious to the participants, additional items were included in the procedure. Since this was a lexical decision task, non-words were required. Although response times to the non-words were not of interest to the study, their presence was an essential part of the procedure in order both to make it plausible and ensure that participants were undertaking the task as requested. For this purpose, 24 non-words were constructed (reproduced in Appendix 5). These were intended to match the experimental words in length (number of

syllables) and were all pronounceable combinations for English speakers. Each of the non-words was paired with one of 24 scene images, which differed from the experimental images and consisted of 12 blue space scenes and 12 green space scenes. In addition, there were 24 filler images (depicting urban scenes and indoor scenes), each of which was matched with a real word. Of these, 12 of the words were congruent with their scenes and 12 were incongruent. This meant that each participant completed 96 lexical decision items, 24 of which were of interest to the study. As with Studies 1, 2 and 3, the experiment was programmed using PsychoPy software (Peirce, 2007) and was run on an HP ZBook computer with a 17 inch screen.

7.3.3. Procedure

After arriving at the testing room, participants were informed about the general nature of the study and it was explained to them that they would be asked to classify strings of letters that appeared on the computer screen as words or non-words, as quickly as they could. They were informed that their responses (key presses) would be timed. Before the start of the experiment, participants were given the opportunity to practice the procedure in order to get used to the presentation of words and non-words on the screen and to become familiar with the response keys.

The experiment began with the presentation of instructions on the screen, reminding participants of the procedure. Screen instructions are reproduced in Appendix 2. They were informed that an image would appear on the computer screen, followed by a cue (a dot) which indicated where the string of letters would appear. As soon as the string of letters appeared on the screen, the task was to decide whether or not it was a word and press the designated key as quickly as possible. Two keys were used on the computer key pad, one to indicate the identification of a word and another to indicate the identification of a non-word. Participants used their dominant hand for both keys and were instructed to use a different finger for each key and keep these resting lightly on those keys throughout to ensure they

could respond as quickly as possible. The flow of the procedure is shown in Figure 7.1. Items were presented in a different pseudo-random order for each participant. The orderings were generated by the computer program in a pattern designed to intermingle presentation of the experimental items and filler items in an irregular manner, yet prevent the experimental items from clustering together. The position of the cue was different for each scene and was chosen to mark a place in the scene where the particular object would plausibly occur. This was to prevent effects arising from structural incongruities, which would be of less theoretical interest. For example, a slower response time to the word *bench* appearing in the sky would be expected on the basis of this violating the structural principles of scene coherence (Võ and Wolfe, 2014); such a finding would, however, be unlikely to contribute to an explanation of the impact of artificial objects on the perception of natural scenes, since it would be due to the unusual location of the object rather than any other characteristic.

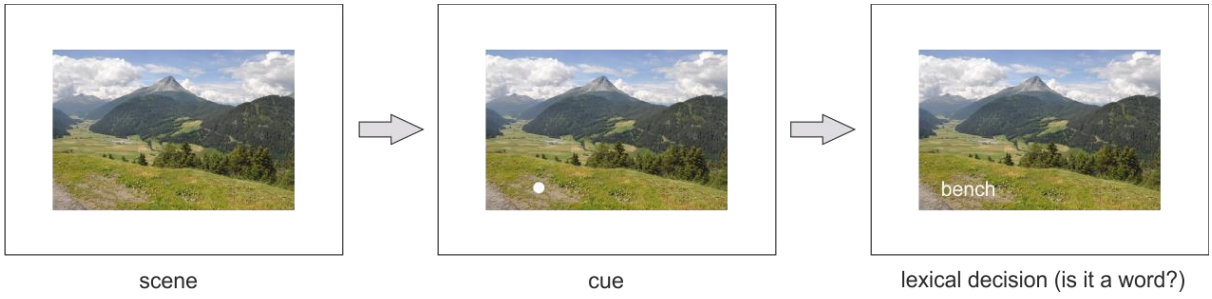

Figure 7.1. *Flow of the scene lexical decision procedure. The priming scene appeared on the screen for 500ms, followed by a cue for another 500ms to warn participants where the target word would appear.*

Participants were assigned to either the blue space group or the green space group alternately in the order that they turned up to take part in the study. The advantage of this was that it ensured approximately equal numbers in each group (28 participants in the blue space group and 27 in the green space group). The potential disadvantage was that this

prevented the groups from being balanced in any way, such as by age, which did differ slightly between the groups (the mean age of participants in the blue space group was 43.9 years; the mean age of participants in the green space group was 38.7 years).

7.4 Results

Results were analysed from the lexical decision response times to the target (natural and artificial) words. Error rates were also recorded and analysed.

Mean reaction times: For the natural words, the mean lexical decision reaction time was 676ms (*SD* = 98), whereas for the artificial words the mean reaction time was 703ms. When these results were analysed according to whether the words appeared with blue space scenes or green space scenes, the same pattern of slower responses to artificial words was apparent for both types of scene. For natural words in blue space scenes, the mean reaction time was 689ms (*SD* = 111) and for artificial words in blue space scenes the mean reaction time was 721ms (*SD* = 139). For natural words in green space scenes the mean reaction time was 663ms (*SD* = 82) and for artificial words in green space scenes the mean reaction time was 685ms (*SD* = 94). These results are depicted in Figure 7.2.

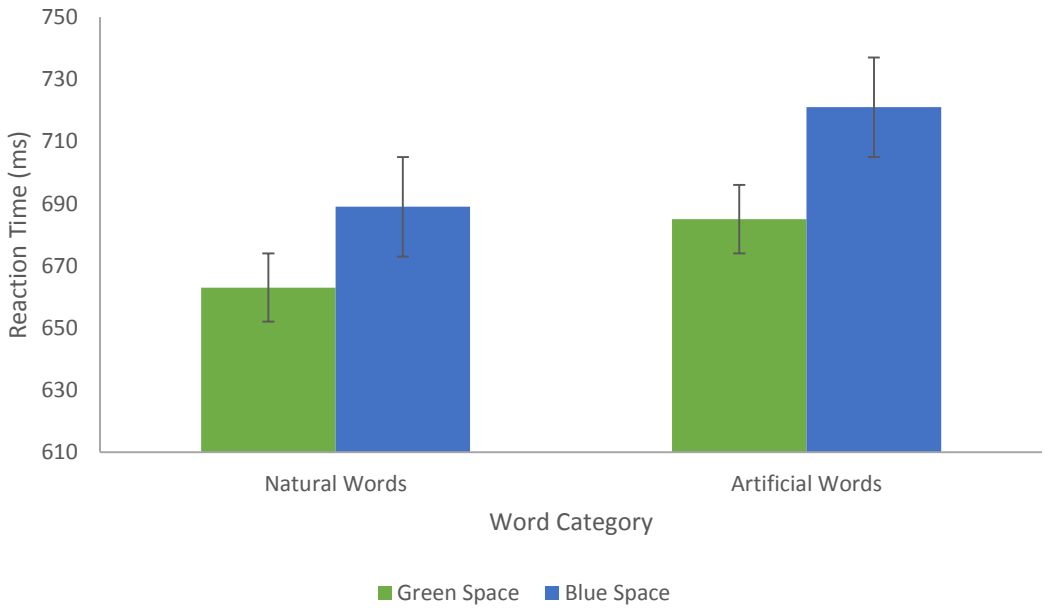

Figure 7.2. *Mean lexical decision reaction times for natural object words and artificial object words superimposed upon green and blue space scenes.*

A mixed ANOVA with object word type (natural, artificial) as a within participants factor and scene type (blue, green) as a between participants factor revealed a main effect of object word type, $F(1, 53) = 12.45$, $p = .001$, $\eta p^2 = .19$. Reaction times to natural object words superimposed on natural scenes were faster than reaction times to artificial object words. This was consistent with Hypothesis 4.1, which predicted that lexical decision responses times to words representing anthropogenic objects in natural scenes would be slower than response times to words representing natural objects.

The interaction between scene type and word type was not significant, $F(1,53) = .39$, $p = .53$, $\eta p^2 = .007$. This was not consistent with Hypothesis 4.2, which predicted that the difference between lexical decision response times to words representing anthropogenic objects and words representing natural objects would be larger in blue space scenes than green space scenes. Although there was a small apparent difference (the mean difference between response times to artificial object words and natural object words in blue space scenes was 10ms greater than the same difference for green space scenes) this was not statistically significant. Therefore, the results show no difference between blue space and green space in the response times to words representing artificial and natural objects.

Error rates were low across all experimental conditions. The mean percentage of errors in reacting to natural object words (i.e. classifying a real word as a non-word) was 1.2 (SD = 2.9), and the mean percentage of erroneous responses to artificial object words was 1.7 (SD = 4.3). A further mixed ANOVA was performed on the error results and revealed no significant main effects, $F(1,53) = .58$, $p = .45$, $\eta p^2 = .01$. It is possible that the error rate was too low to reveal any potential effects of word or scene type.

7.5 Discussion

The results reported above suggest that artificial objects are incongruent with natural scenes. Participants' responses to words representing natural scene objects which were both structurally and semantically congruent with the scenes provided a baseline for comparison. The artificial object words represented objects that would often be found in natural scenes, and were located in a plausible position in the scene to ensure that any effects were not due to violations of the principles of scene structure. Response times to these words were significantly slower than to the natural words, indicating semantic incongruity between the artificial objects represented by the words and the natural scenes they appeared with.

This finding replicates the results found by Võ and Wolfe (2014), who found that semantic incongruities slowed lexical decisions in indoor scenes. In addition, the present results extend the previous findings: Võ and Wolfe selected target words that were straightforwardly semantically incongruent with their scenes (such as *egg* compared with *soap* in a bathroom scene where the soap dispenser would be situated). In the present study, however, the anthropogenic target words were arguably much more congruent with the scenes upon which they appeared. All were examples of objects that would normally appear in those scenes and were ordinary enough that the participants were likely to have experienced natural scenes containing these objects. Therefore, on the basis of prior experience and the expectation of what might appear in a given scene, the presence of a bench or a signpost in an outdoor scene should be less surprising than finding an egg where the soap dispenser should be. Although it is not possible to draw any conclusions about the impact of prior experience of similar scenes from these results (since this was not measured in the participants), it seems unlikely that the findings could be explained by recourse to 'unusualness' in the same way that the egg/soap results might be argued to be. It appears to be the case that other factors, which might include the characteristics of the objects themselves, are important.

Thus, it is possible that while an object could be regarded as structurally congruent with a scene (in that it does not defy gravitational principles, for example) and pragmatically congruent with a scene (in that it ordinarily appears in that context in the real world), it might nevertheless be semantically incongruent, and this incongruence is reflected in slower lexical decision times. There is a parallel between these findings and those reported by Wyles, Pahl, Thomas and Thompson (2015), who found that explicit attitudes towards beach scenes were modified differently by the presence of natural debris (such as seaweed) and anthropogenic debris (litter), with litter having a more negative impact on explicit ratings of the scenes. In addition, Wyles *et al*., (2015) found that the type of litter had an effect, with public litter having a more negative impact than fishing litter. Although the negative connotations inherent in the meaning of litter (particularly public litter, which is likely to be most unambiguously *rubbish*) may have intensified this effect (as mentioned in Section 5.1) these findings are, nonetheless, consistent with the present results. The study by Wyles *et al*. (2015), however, only considered blue space scenes (beachscapes containing a view of the sea), so it is not known whether a similar pattern of results would have been found for scenes without water.

The present experiment was also designed to test the hypothesis that there would be a more negative impact on response times to artificial object words in blue space scenes than to artificial object words in green space scenes. That is, by extension, that artificial objects would be less congruent with blue space scenes than with green space scenes. This was not detected in the results, with artificial objects found to be incongruent with both types of scene, with no effect of scene type on the pattern of results. Therefore, it cannot be concluded that aquatic scenes are more prone than other natural scenes to conceptual disruption from the presence of artificial objects. This appears to rule out the possibility that semantic coherence might form the basis of the difference between implicit affective responses to blue and green space scenes found in Study 1.

7.6 Summary

The study reported in this chapter was designed to test a possible explanation for the earlier finding that artificial objects have a more negative impact on implicit affective responses to blue space scenes than to green space scenes. That explanation was based on the idea that the semantic coherence of blue space scenes may be more negatively disrupted by the presence of artificial objects than the semantic coherence of green space scenes. This idea was not supported by the results of the study. However, the results did indicate that commonly occurring artifical objects may be perceived as semantically incongruent with natural scenes, for both blue space and green space. It is possible that this finding may inform future theoretical development in restorative environments research, as it highlights the potential relevance of the concept of the semantic coherence of a scene, distinct from other scene characteristics.

Chapter 8

Discussion and Conclusions

8.1. Overview of findings

Experiencing natural environments, particularly those containing aquatic elements, can be beneficial to health and wellbeing. Environments with these restorative properties tend to be preferred; they also give rise to positive affective attitudes. However, the reasons why some environments are more restorative than others, as well as the constraints on restorative effects, are not well understood.

A particular question that remains underexplored, yet has practical implications, is whether placing anthropogenic objects into natural scenes has an impact on the restorative potential of those scenes. This is an especially pertinent issue for coastal environments under pressure from competing local and national interests. Consequently, this thesis investigated the impact on implicit and explicit responses to visually presented natural aquatic and non-aquatic scenes with and without the presence of anthropogenic objects. The overarching question of whether artificial objects influence affective reactions to natural scenes, especially aquatic scenes, was addressed via four research questions:

Research Question 1: *Does the presence of anthropogenic objects modify implicit affective responses to natural aquatic scenes?*

Research Question 2: *Do implicit affective responses differ from explicit affective responses to natural scenes containing anthropogenic objects?*

Research Question 3*: Does the presence of water influence implicit affective responses to natural scenes?*

Research Question 4: *Can differences in implicit attitudes to natural aquatic and non-aquatic scenes containing artificial objects be attributed to differences in scene coherence?*

These questions formed the basis of the original studies conducted for and reported in this thesis. The interest in implicit attitudes addressed a need to gain an insight into psychological processes that might underpin restorative effects. Implicit experimental methods allow examination of more specific constraints on affective responses to scenes than would be possible by methods relying on conscious introspection. Since previous research has not typically made use of such methods in the study of restorative environments, their deployment in this context was innovative.

The main findings from Study 1 were that the presence of artificial objects in a natural scene gives rise to a less positive affective response than when the same scene is viewed without the presence of artificial objects. Further, the impact of artificial objects on affective responses to natural blue space scenes is more negative than the same impact on natural green space scenes. Study 2 examined explicit attitudes to natural scenes containing artificial objects and found that explicit attitudes are not necessarily congruent with implicit attitudes to the same scenes. Study 3 investigated the impact of water in more detail, comparing implicit affective responses to different types of aquatic and non-aquatic natural environments. The most positive implicit affective responses to all the scene types studied were generated by seascapes. Study 4 focused on scene coherence to explore firstly whether semantic incongruities between artificial objects and natural scenes might exist and, secondly, whether such incongruities might explain the different impact of these objects on blue and green space scenes. Although this study did not illuminate the source of the differences between responses to blue and green space, it did provide evidence that at least some of the impact of artificial objects on natural scenes may derive from semantic incongruities rather than structural principles or pragmatic knowledge.

This chapter will consider the implications of these findings: firstly, broadly situating them within the restorative environments literature reviewed in Chapter 2; then discussing them from a theoretical point of view, in the context of the main theoretical frameworks reviewed in Chapter 3. Next, the chapter will move on to consider the limitations of the findings. Finally, it will discuss their practical significance, including implications for future research.

8.2 Restorative Environments

The idea that nature can be salutogenic is evident throughout human history (Ward Thompson, 2011). It is only recently that popular beliefs in this area have begun to be explored by academic research; however, findings to date have supported the idea that nature and natural elements can be beneficial to wellbeing. The burgeoning literature on the subject, reviewed in Chapter 2, shows that experiencing green space can have a positive impact on both physiological and psychological health. Although a much smaller body of research has focussed on blue space, it seems that water can be a particularly restorative feature both in urban environments as well as in wholly natural scenes (Volker and Kistemann, 2015). The findings from Studies 1-3 in this thesis fit neatly within this body of work. All three studies found differences between affective responses to green and blue space. Studies 1 and 3 found that implicit affective responses to natural scenes were sensitive to both scene category and scene content. These findings were consistent with previous research that has found evidence of other rapid, automatic, beneficial effects of viewing or experiencing nature; for example, impacts on cortisol levels, (Roe *et al.*, 2013), heart rate (Laumann, Garling and Stormark, 2003) and blood pressure (Hartig *et al.*, 2003), as well as being consistent with the suggestion that, over time, such short-term effects may lead to the health and wellbeing benefits that are associated with experiencing nature (Kuo, 2015). It is even possible that the rapid, automatic, unconscious affective responses to natural environments, as detected in the present studies, might underlie some of the physiological effects. This would further be consistent with proposals that negative affective

states might be underlying factors in the onset and course of various diseases, including cardiovascular disease (Kiecolt-Glaser *et al*., 2002). Further work will be needed to investigate whether implicit affective responses are related to physiological responses and, if so, how the processes may interact, as well as their potential for longer term health and wellbeing measures.

The findings from Study 2 replicated previous research that has found that explicit responses to natural scenes are more positive when water is present in those scenes (e.g. White, *et al*., 2010). This study built upon other work that has suggested that the presence of artificial objects might be detrimental to affective responses (e.g. Motoyama and Hanyu, 2014; Wyles *et al*., 2016) by confirming this for both blue and green space scenes. The results from Study 2, particularly on the Willingness to Pay measure, were further evidence of the potential positive effects of water, even in the presence of anthropogenic objects, consistent with the research that has found evidence of positive responses to blue space in built scenes (Volker and Kistemann, 2015).

Study 4 perhaps sits less neatly within the existing restorative environments literature, since its method has not previously been reported in this context. The results from this experiment are nonetheless relevant to the field since they suggest that the notion of the semantic-conceptual coherence of a scene may be important in understanding the affective responses it gives rise to. This study showed that while artificial objects may disrupt the semantic-conceptual coherence of a scene, this disruption was present for both blue and green space scenes. Therefore, although this semantic disruption does not seem to be the source of differences between responses to blue and green space, it is possible that it might underlie the impact of artificial objects on affective responses to natural scenes in a more general way. More work is needed to explore the underlying processes that result in the differences in responses to blue and green space and how these relate to restorativeness. However, the ideas motivating and generated by Study 4 resonate with a new strand of

research investigating how the meaning of places may be relevant to restorative experiences (Ratcliffe and Korpela, 2016).

8.3 Theoretical implications

8.3.1 The main theories: ART and SRT

Attention Restoration Theory (ART) (Kaplan and Kaplan, 1989; Kaplan, 1995) and Stress Reduction Theory (SRT) (Ulrich, 1983) may be flawed as theoretical frameworks, as argued in Chapter 3. However, these theories established the field of restorative environments research and continue to define it. The results from the studies in this thesis bear upon ART and SRT in several ways. Firstly, the finding from Study 1, replicated in Study 3, suggests that viewing scenes gives rise to rapid, automatic affective responses and that different scene types or aspects of scenes can moderate those responses. ART and SRT make different predictions about the nature of the speed and character of the reaction to experiencing a scene. While SRT predicts a quick affective response, ART does not require that the response is rapid or unconscious: the dimensions of ART are compatible with slower, reflective processes, and time is likely[79] to be required for their operation in the restoration of attention, which is hypothesized to be the primary mechanism. Thus, the very existence of implicit affective priming effects that are sensitive to the content of natural scenes is supportive of SRT as a framework more than ART. It is worth noting that the most substantive criticisms of SRT stem from its evolutionary underpinnings. Although the evolutionary arguments are an integral component of the theory as it stands, it is conceivable that a version of SRT might be proposed that is based on actual psychological processes in modern humans as opposed to hypothetical evolutionary accounts. Such a shift of emphasis would have the benefit of generating testable hypotheses. In addition,

[79] ART does not make specific predictions about the time course of restorative effects, however there is no implied role for rapid, unconscious mechanisms, unlike in SRT, which argues that the immediate affective response to natural environments drives evolutionarily adaptive behaviours.

discarding the evolutionary backstory would lead to greater clarity with no necessary loss of explanatory power.

ART does focus on current psychological processes; however, its proposal that attention restoration is at the heart of restorative effects is problematic, as discussed in Chapter 3. Further, the hypothesized essential components of ART (*fascination*, *compatibility*, *being-away* and *extent*) lack theoretical motivation and are not defined specifically enough to be either testable or to account for the effects of different environments on those who experience them. However, as with SRT, it is possible that elements of this theory may be relevant to developing a more satisfactory explanation of restorative phenomena. In relation to the current research, the finding from Study 4 that the semantic coherence of a scene may be disrupted by artificial objects could provide a means of linking the underspecified dimension of *coherence* invoked by advocates of ART (e.g. Korpela and Hartig, 1996; Bowler, Kaiser and Hartig, 1999; Jagt *et al.*, 2014) with the actual psychological processes involved in scene perception and understanding.

8.3.2 Other theories: visual processing

Recently emerging alternative theories of restorative phenomena have been based on the processing of low-level visual features, including fractal structures (Joye *et al*., 2015) and visual-spatial frequency information (Valtchanov and Ellard, 2015). It is too early to assess these theories comprehensively, as they have not yet been elaborated or tested beyond their initial publications. These theories raise the interesting possibility that if the restorative properties of natural scenes are due to low-level visual features, nature might not be essential to the restorative potential of environments[80]. If this was the case, there would be no reason why completely built scenes or unreal, abstract views could not be just as

[80] While this is also the case for ART (but not SRT), which does not specify the presence of nature or natural elements, an association between natural scenes and restoration is usually assumed by researchers working in an ART framework (e.g. Felsten, 2009; Green, 2012; Wilkie and Clouston, 2015). It is rare for studies to focus on the restorative potential of non-natural environments (but see Ouellette, Kaplan and Kaplan (2005); Packer and Bond, (2010); Rosenbaum *et al.*, (2015) for exceptions).

restorative as natural scenes, as long as their low-level visual features were in line with the relevant dimension. Future research would be able to address this question by investigating responses to natural and built scenes matched for fractality or visual-spatial frequency information. However, in focusing on low level visual features, these theories are not able to account for higher level cognitive phenomena. This is a potentially serious omission, since the results of Study 4 suggest that the semantic coherence of a scene might play a role in explaining restorative phenomena. Low level processing theories cannot take the meaning of a scene into account, thus are not able to explain effects that result from this higher level of processing. The main contribution of these visual processing theories, so far, is that they highlight the possibility that ease of cognitive processing of a scene might underlie its restorative potential. Although the details of the theories encounter problems when faced with results such as those from Study 4, the logic of this idea of ease of processing is potentially consistent with the findings from Study 4. For example, it is possible that scenes that are less semantically coherent might be harder to process, requiring increased cognitive effort due to their lower conceptual fluency. This suggestion, together with the tendency of potentially restorative scenes to evoke positive affective responses, is consistent with research that has found that exposure to stimuli (such as word triads) that are semantically coherent can trigger physiological indications of positive affect in facial muscles, even when participants are unaware of the underlying semantic structure (Topolinski *et al.*, 2009). Whatever the factors that determine the conceptual coherence of a scene turn out to be, this is an area of research that needs to be developed in the drive to understand restorative phenomena.

8.4 Limitations

This thesis adopted an original methodological approach in the context of restorative environments research. The use of implicit methods is justified by the theoretical insights (about speed and nature of processing) gained, as mentioned in the previous section. The

existence and possible relevance of a rapid automatic response could not have been detected using the more traditional, questionnaire-based, methods in the field. The value of a novel methodological approach goes beyond the findings of individual studies, however, as the successful use of new methods prompts the framing of questions that might not otherwise have been raised, as well as suggesting new ways of answering these questions. Such a process was apparent in the current thesis: The implicit priming method used in Study 1 was innovative and the findings from this study represented an original contribution to knowledge. However, an indirect contribution of the study came from the question it raised about the different impact of artificial objects in blue as opposed to green space scenes. The subsequent attempt to answer this question resulted in a further methodological innovation, that is, the use of scene semantic priming, which had not previously been reported in the context of restorative environments research. The successful use of this method conferred two benefits: firstly, it provided evidence that the procedure itself was sensitive to more subtle dimensions of meaning than had been previously investigated using this method (Võ and Wolfe, 2014) as well as similar studies that have investigated categorization of incongruent objects in scenes (e.g. Rémy *et al.*, 2014); secondly, the results from the study suggested that scene semantic coherence may be a factor in need of further investigation in restorative environments research.

One of the limitations of this thesis is the necessary[81] working assumption that artificial objects comprise a legitimate category, psychologically. There is evidence that this is the case from language processing research (e.g. McKenna and Parry, 1994) and the present findings also lend support to the idea. However, it is unlikely to be the case that all artificial objects are equal in the context of natural scenes: They may differ in terms of their subcategory membership (e.g. vehicles, buildings), with the potential for different subcategories to have varying impacts on responses. They may also differ with respect to their individual characteristics and the affective responses these generate (de Houwer,

[81] Necessary in order to construct manageable experimental designs.

2009). Whether the impact on responses to natural scenes might differ according to the sub-types of artificial objects present, as well as the individual exemplars of those types, was a question beyond the scope of this thesis. It should, however, be addressed by future research.

A similar issue applies to the classification of scenes. A discovery from both Study 1 and Study 3 was that scenes which are often classed as a single category in restorative environments research (natural scenes; blue space scenes; green space scenes) are not necessarily homogeneous categories, but may be comprised of subtypes, which evoke different affective responses. This was particularly notable in the results of Study 3, where different types of blue and green space were associated with varying levels of affective positivity. Although this did not undermine the results of the present studies (rather, it added to their contribution to knowledge), these findings demonstrate how effects of certain scenes might be missed when different sub-types are investigated as equivalent members of a single category. This is another subject that requires further research to determine what level of generalisation is appropriate when classifying environments on the basis of their restorative potential.

Regarding the notion of restorative *potential*, it is important to remember that although the context of this thesis was the field of restorative environments, no actual restoration was involved in the studies conducted and no physical environmental settings were included: affective responses were taken as an indicator of restorative potential, with all the stimuli being images of scenes. Regarding measures of restoration, affect is one of the primary psychological indicators of restoration and, thus, is standardly used as a measure of restorative potential (Staats *et al*., 1997). In common with other work in the field, the studies in this thesis can make no claims about the actual restorative properties of the scene types under investigation. Regarding the use of images of scenes instead of actual scenes, this is conventional in the field and there is plentiful evidence showing that responses to scene images show the same patterns as responses to actual scenes, and that images of

scenes can be regarded to possess restorative potential (e.g. Van den Berg, Jorgensen and Wilson, 2014). The risk of using images is that since effects may be smaller than with exposure to actual scenes, it is possible that effects that are subtle or slight may be missed. The opposite possibility (that of finding effects that do not occur in real environments) has not, so far, been reported in the literature. Despite the large body of evidence showing congruence between responses to real scenes and images of those scenes, it should not be assumed that results will necessarily predict responses in real situations. This is particularly important for new findings such as those reported in this thesis. It is possible, for example, that even if the same effects arise in real environments, the experience of being immersed in a multi-dimensional environment, rather than viewing a two-dimensional image, might have an impact on responses. Although it may turn out to be the case that other aspects of real scenes (for example, sounds and smells) play a part in creating the restorative potential of an environment, isolating certain aspects (such as the visual composition, as in the present studies) is necessary in order to elucidate the role of such factors individually.

A further limitation the present work shares with the majority of investigations into restorative environments phenomena is that the participants in the studies were from a relatively homogeneous sample than cannot be assumed to be representative of the global human population (Henrich, Heine and Norenzayan, 2010). While the working assumption is that the findings apply generally, until the potential impacts of culture and background are explored, this should not be taken for granted. Investigations of whether restorative effects apply cross-culturally and in the same manner across cultures are essential to developing a full understanding of restorative environments phenomena. One of the strengths of the present work is the development of the implicit methods in the context of investigating the psychological impact of different scenes. Since the Affect Misattribution Procedure does not require participants to express themselves linguistically, it is well suited to being used across cultures and language groups in a way that explicit methods requiring extensive translation and interpretation of task demands and responses might not be. Such

cross-cultural studies should be a priority for future research in order to be able to disentangle the potential impacts of cultural and geographical factors and identify the role of general psychological processes, common to all humans.

Even within cultures, it could be the case that individual differences might have an impact on susceptibility to restorative effects from environmental characteristics. The assumption that restorative effects apply generally across the population was justified for the purposes and context of this thesis on the basis of previous research that has found that these effects do apply on a large scale when individual differences are controlled (Cohen-Cline, Turkenheimer, and Duncan, 2015). However, this does not mean that individual factors cannot have an influence on these effects. A complete account of restorative phenomena will need to account for the impact of any such factors. It has been suggested that childhood experience of nature and individual connectedness to nature are elements that may influence restorative effects (Korpela *et al.*, 2008; Capaldi, Dopko and Zelenski, 2014). These, as well as other possible factors, will require further investigation as understanding of restorative environments expands.

8.5 Practical implications

The evidence that experiencing certain environments can be beneficial to health, wellbeing and happiness has far-reaching practical implications. The idea is not new and restorative environmental principles are already sometimes included in landscape architecture and horticultural therapy (Stigsdotter and Grahn, 2002). Even without an understanding of the underlying principles and effects, people may spontaneously seek restorative settings, for example, choosing to spend time in nature for recreation and relaxation. However, in order to maximise the potential benefits from exposure to restorative environments, it is necessary to increase understanding of what it is that makes a particular environment restorative and how that restorative potential can be either protected, enhanced or diminished.

The results from the studies reported in this thesis indicate that the siting of artificial objects in natural scenes can reduce the level of positive affect those scenes might generate. Further, this impact may be greater for aquatic scenes, particularly coastal scenes. Given the importance of the coast for recreation and tourism, as well as its location as a human habitat, this insight could begin to inform decisions about future development of coastal areas. Further research will be needed to unravel the impact of different types of objects and whether these impacts differ according to factors such as the type of coastal or aquatic scene, the location of the artificial objects within the scene and the visual dominance of the object(s) in the scene.

The present results suggest that it may be beneficial to evaluate any new development that affects green or blue space in terms of the restorative potential of the environments being developed. Considerations about the visual impact of objects such as, but not limited to, wind turbines should perhaps go beyond subjective assessments of whether such objects spoil the view aesthetically (though this may itself be related to restorative potential) and be framed in terms of potential benefits and detriments to public health and wellbeing. However, the results reported in this thesis are best regarded as a preliminary exploration: they do not provide evidence that can be used as the basis for practical guidelines at this stage. This is partly because of the limitations discussed in Section 8.4 above – that is, that there was no actual restoration involved in the present work, only affective responses. Although affective responses to images of scenes are a standard indicator of restorative potential of actual scenes, further research is needed to investigate the role of artificial objects before conclusions can be drawn about their impact on restorative environments.

In addition, more work is needed to elucidate the relationship between implicit and explicit affect. In particular, if there are consistent differences between implicit and explicit affective responses, how do these differences relate to restoration and the restorative potential of

environments? Until this is known, the practical significance of the present findings should not be assumed. For example, if siting artificial objects in blue space has a more negative impact on implicit affect than siting artificial objects in green space, but there is no corresponding difference in the impact on explicit affect, it could be the case that the impact on implicit affect has no practical consequences. Future work will be needed to unravel the relationship between implicit affect and restoration. It is possible that these implicit measures might provide a more accurate picture of the psychological impact, since they tap more directly into psychological processes without the need for additional levels of processing required by explicit responses. However, it is also possible that the initial, implicit, affective response may not be the most relevant factor in terms of restoration. For example, it could be the case that the conscious processing involved in explicit responses is more important for, or directly related to, restorative processes. These opposing possibilities will need to be disentangled by further research before the practical implications of the present studies can be clarified.

Hence, the main practical implications from these studies concern future research priorities more than they have real-world significance. While the body of future work that is suggested by the implicit findings might have direct practical consequences, such as for the siting of new development and building in green and blue space, at this stage there is only the potential that they might be relevant.

Perhaps the only immediately practical implications justified by the results of the studies come from the Willingness to Pay (WTP) measure in Study 2. The results from this measure showed that people judged that they would be willing to pay less for a natural view when that view contained artificial objects. This effect was apparent for both blue and green space. However, the results also showed that people were potentially willing to pay more for a blue space view than a green space view overall – even when that blue space view contained artificial objects. The important factor in determining WTP seemed to be the presence or

absence of water. Thus, if the price that can be gained from selling a hotel room is the key priority, it could be argued that the economic impact of siting artificial objects in blue space views might actually be lower than siting them in green space views, since people were still potentially willing to pay more for blue space views containing artificial objects than green space views with or without objects. However, short-term economic benefit for those selling the views would need to be weighed against any potential wider public health impacts of siting those objects in blue space. Exactly what those public health impacts, and their economic consequences (on health spending, for example) might be, requires further research. The present studies are an indication that the area is worth investigating in more depth, but they do not in themselves provide answers to these important questions.

8.6 Conclusions

This thesis started with a question about blue space scenes: Is it correct to assume, as is commonly believed, that siting developments such as wind turbines just off the coast has less psychological impact than similar onshore development? The short answer, on the basis of the previous research reviewed and the original research conducted here, is: no. The longer (though incomplete) answer comprises the thesis itself. Guided by gaps in understanding of the phenomenon of restorative environments, the original informal query was reformulated as an overarching research question which asked whether the presence of artificial objects influences affective reactions to natural aquatic and non-aquatic scenes.

The objectives of the thesis, as set out in the Introduction were:

Firstly, to assess the main current theories that are used to explain restorative environments phenomena. This was accomplished in Chapter 3, which argued that neither of the main current theories are adequate for explaining restorative environments phenomena. These theories were discussed further in the present chapter, in the light of the findings from the original studies reported in this thesis.

The next objective was to explore the relationship between implicit and explicit reactions to natural landscapes with and without water. All four studies contributed to this objective: Studies 1, 3 and 4 are unusual in the area of restorative environments research in that they investigated implicit phenomena. The results from these studies, particularly in conjunction with Study 2, which examined explicit attitudes, show that implicit and explicit attitudes to green and blue space scenes are not always congruent.

The main objective of this thesis was to increase understanding of the impact of anthropogenic objects on the restorative potential of blue space. This objective was met with the results from Study 1, which demonstrated a more negative impact of the presence of artificial objects on implicit affective reactions to blue space scenes than green space scenes. Study 2 contributed further to this objective, with its finding that explicit attitudes to blue space scenes were less positive when those scenes contained artificial objects. Study 4 also added to this objective, with the discovery that when it comes to assessing the impact of artificial objects, the semantic coherence of the scene may play a role.

This thesis has demonstrated the importance of increasing understanding of the restorative effects of environments. Natural green and blue space scenes are more than simply the pleasant backdrops as which they are often portrayed. These environments should perhaps be considered as public health resources whose benefits could be more widely and effectively utilised. Further, their restorative potential may be disrupted by development that has hitherto been assumed to be benign. Accordingly, safeguarding the potential of natural environments to benefit wellbeing, as well as maximising the exposure to nature of urban populations, should be treated with the same importance as other public health objectives.

In order to harness the restorative potential of green and blue space to the full, it will also be necessary to develop an understanding of the underlying processes. This will require

further investigation of the interaction between cognition and environment, recognising that this is a two-way process. The environments that affect us are of our own making; we are not separate from them (Hinde, 1998). The intertwining of humans and nature may occur on many levels, but the brain-environment interaction is of primary importance. Without our particular cognitive processes we would not perceive, experience or understand blue or green space as we do – but we would also not create the urban spaces that we do. Increasing knowledge of how these cognitive processes shape and are shaped by the environment should reinforce the case for conserving the natural spaces we live with. Doing so has the potential to benefit humans as well as the rest of the natural world.

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Appendix 1 Images used in Study 1 and Study 2





































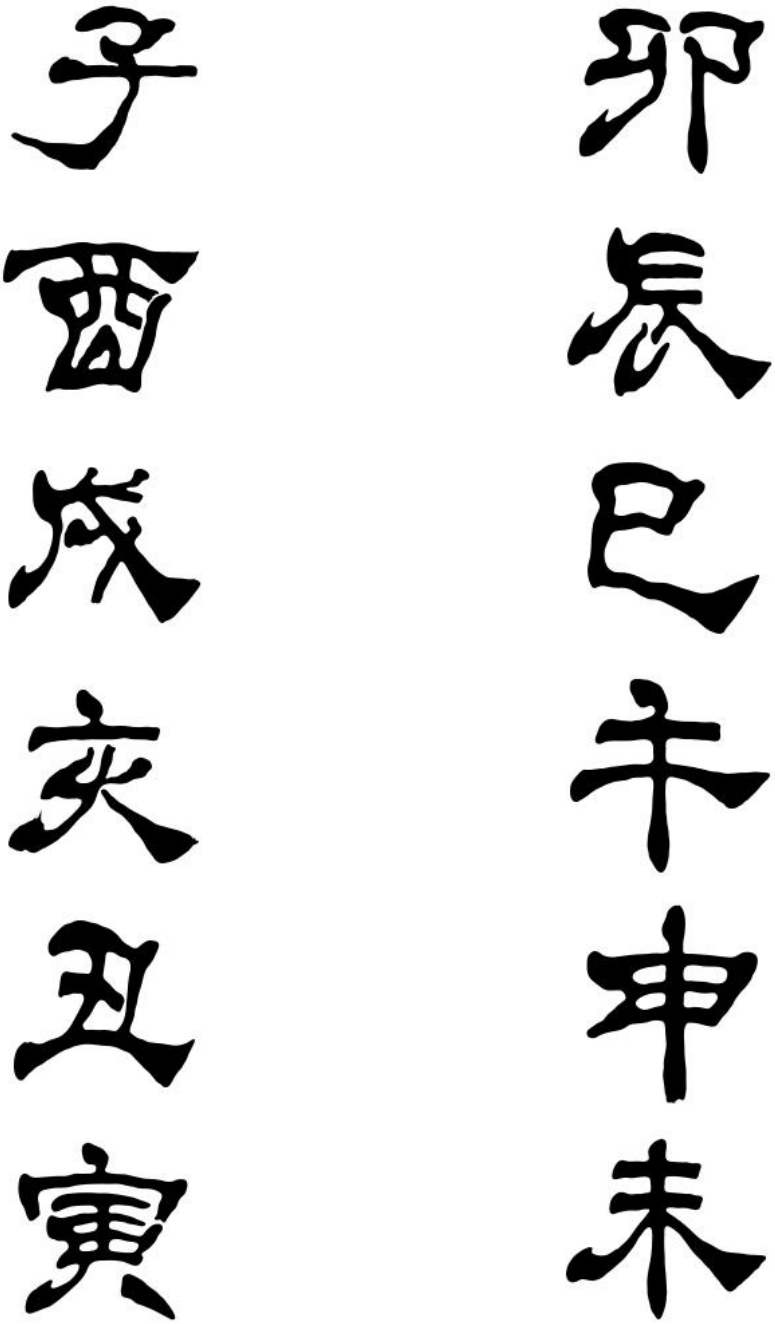








Appendix 2 Chinese Characters used in Studies 1 and 3



Appendix 3 Screen Instructions for Studies 1 - 4

Study 1 and Study 3: Practice

FIRST SCREEN: This task deals with how people make quick judgments. You will see pairs of pictures flashed one after the other. The first is a photograph of an outdoor scene. The second is a simple shape. The photograph is an indication that the shape is about to appear, and can otherwise be ignored. Your task is to judge the visual pleasantness of the shapes.

At first, it might seem strange to judge how attractive you feel the shapes are, but research has shown that such judgments do lead to meaningful results, provided that the judges rely on their intuition or 'gut instinct'. Hence, try to judge as much as possible in a spontaneous manner, based on your first impression.

Press SPACE BAR to continue

SECOND SCREEN: When the shape appears, respond as quickly as you can. Making a judgment about how pleasant it seems to you, select the appropriate point on the scale and click the mouse.

The central point on the scale represents a neutral judgment – choose a point towards the 'dislike' end of the scale if you find the shape less pleasing than average; choose a point towards the 'like' end of the scale if you find the shape more pleasing than average. Feel free to make use of the full scale, remembering that the extreme points represent 'dislike strongly' and 'like strongly'.

When you have clicked, please return the cursor to the white dot at the bottom of the screen, ready to begin the next trial.

Press SPACE BAR to begin

Study 1 and Study 3: Experimental Procedure

FIRST SCREEN: Just as in the Practice, this task deals with how people make quick judgments. You will again see pairs of pictures flashed one after the other. The first is a photograph of an outdoor scene. This time, the second picture is a Chinese character. The photograph is an indication that the character is about to appear, and can otherwise be ignored. Your task is to judge the visual pleasantness of the Chinese characters.

At first, it might seem strange to judge how attractive you feel the characters are, but research has shown that such judgments do lead to meaningful results, provided that the judges rely on their intuition or ‘gut instinct’. Hence, try to judge as much as possible in a spontaneous manner, based on your first impression.

Press SPACE BAR to continue

SECOND SCREEN: When the Chinese character appears, respond as quickly as you can. Making a judgment about how pleasant it seems to you, select the appropriate point on the scale and click the mouse. When you have clicked, please return the cursor to the white dot at the bottom of the screen, ready to begin the next trial.

Sometimes, the preceding pictures might distort your judgments. Because we are interested in how strongly people can resist this, you should do your best to not let your judgment be influenced by the preceding photographs. Give an honest, spontaneous judgment of the Chinese characters, independent of the preceding pictures.

Press SPACE BAR to begin

Study 2: Experimental Procedure

SCREEN 1: You will see a series of 48 landscape photographs with five statements (shown in turn) about the attractiveness of the scene. Your task is to decide how much you agree or disagree with each statement then click the appropriate point on the scale below it.

Please feel free to make full use of the scale – the mid-point is neutral, with the extreme ends representing ‘disagree strongly’ and ‘agree strongly’.

Press SPACE BAR to continue

SCREEN 2: After you have seen the five statements, you will be asked to decide how much you would be willing to pay for a hotel room with the view shown in the photograph. Imagine that you are staying in a hotel where rooms range in price from £40 per night to £100 per night. The rooms are all identical with the exception of the view from the window. Click the point on the scale that indicates the price you would be willing to pay for the room with the view shown.

Press SPACE BAR to begin

Study 4: Practice and Experimental Procedure

SCREEN 1 (practice trials):

In the following task a '*' will appear on the screen, followed by a string of letters. Your task is to decide whether or not the letters form a valid English word.

If the letters are a valid word, press the left arrow key (same key as '4' on the number pad).

If the letters are not a word, press the right arrow key (same key as '6' on the number pad).

Try to classify the letters as words or non-words as quickly and accurately as you can.

You will start with a few practice trials. Get ready for the task by placing two of your right-hand fingers on the arrow keys.

When you are ready to begin, press the spacebar.

SCREEN 2 (experimental procedure):

The practice is now over and the task will begin. This time, the words may appear at different places on the screen. The '*' lets you know where to expect the next word. If you have any questions, please ask now.

As a reminder:

If the letters are a valid word, press the left arrow key (same key as '4' on the number pad).

If the letters are not a word, press the right arrow key (same key as '6' on the number pad).

Try to classify the letters as words or non-words as quickly and accurately as you can.

When you are ready to begin, press the spacebar.

Appendix 4 Images used in Study 3

Natural Scenes

Aquatic: Lake




Aquatic: River




Aquatic: Sea




Dry: Forest




Dry: Savanna

Dry: Desert

Urban scenes

Street




Traffic




City skyline



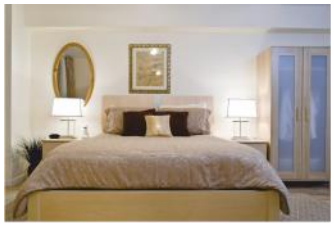

Indoor Scenes

Office




Food shop

Bedroom



Appendix 5 Images used in Study 4

Experimental Images

Blue Space

Green Space

Filler Images

Urban Scenes

Indoor Scenes

Scenes for non-words

Blue Space











Green Space



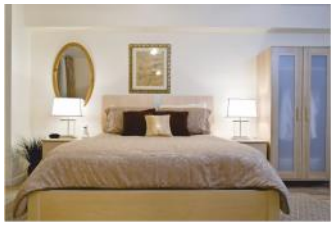









Filler – Indoor












Filler – Urban












Scenes for non-words












Appendix 5 Words and non-words used in Study 4 for Lexical Decision Task

Target Words: Green Space and Blue Space

Congruent/Natural

sky
stone
hill
plant
sunlight
haze
cloud
rock
grass
tree
sand
shadow

Incongruent/Artificial

turbine
hotel
bench
railway
sculpture
road
caravan
signpost
car-park
fence
house
pylon

Non-words

slep
spom
murgit
plen
sib
mert
claip

rist
greck
trub
sorch
balf
torpind
hanip
borke
regront
scapdun
reeb
copinpod
sabdue
cof-dorp
fapse
hewf
pumbo
baffing
shub
clim
crog
deel
toffin-mep
moodoo
cremtipteg
chaz
criptip
cubrop
dolx
bezit
skod
sarfy
boz
trobef
heg
sheekol
kargle
bomtep
tand
lofmeyer
beld

Filler words

building
shop
car
clock
door
traffic-light
mirror
computer
chair
cushion
counter
desk
butter
soap
sofa
bed
towel
hat
shower
kettle
beehive
tent
lawnmower
bike

Glossary of Abbreviations and Terms

Affect	The valenced experience of emotion.
AMP	Affect Misattribution Procedure.
ANOVA	Analysis of variance.
ART	Attention Restoration Theory.
Blue Space	Scenes comprising predominantly natural elements, including aquatic elements.
BMI	Body Mass Index.
BVP	Blood Volume Pulse.
EEG	Electroencephalography.
EMG	Electromyography.
Explicit (attitude/affect)	Conscious, deliberately formed, accessible to self-report.
GPS	Global Positioning System.
Green Space	Scenes comprising predominantly natural, often vegetative, elements.
Implicit (attitude/affect)	Occurring without conscious awareness.
IAT	Implicit Association Test.
NCPT	Necker Cube Pattern Test.
PRS	Perceived Restorativeness Scale.
Restoration	Renewal of mental or physical resources that have become depleted.
Restorative Environments	Settings or scenes that promote and/or permit restoration.
Semantic Priming	Implicit phenomenon whereby exposure to one stimulus influences the response to another stimulus.
SRT	Stress Reduction Theory.
UK	United Kingdom.
WTP	Willingness to pay.