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Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes

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ABSTRACT

Although theorists have suggested that aquatic environments or “blue space” might have particular restorative potential, to date there is little systematic empirical research on this issue. Indeed the presence of water has, unintentionally, been a confounding factor in research comparing people’s reactions to built and natural environments. Whereas aquatic features (rivers, lakes, coasts) are frequently present in visual stimuli representing natural environments they are rarely incorporated in stimuli portraying built environments. As many towns are, for good reason, located near water this is a potentially significant oversight. The current research collated a set of 120 photographs of natural and built scenes, half of which contained “aquatic” elements. Proportions of “aquatic”/“green”/“built” environments in each scene (e.g. 1/3rd, 2/3rds) were also standardised. Two studies investigated preferences (attractiveness, willingness to visit and willingness to pay for a hotel room with the view), affect and perceived restorativeness ratings for these photographs. As predicted, both natural *and* built scenes containing water were associated with higher preferences, greater positive affect and higher perceived restorativeness than those without water. Effect sizes were consistently large. Intriguingly, images of “built” environments containing water were generally rated just as positively as natural “green” space. We propose a number of avenues for further research including exploration of the mechanisms underlying these effects.

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1. Introduction

1.1. Overview

The role fresh water plays in our physiological health is clear. We can survive only a few days without it. The role water plays in our psychological health is far less obvious. We know that aquatic environments were revered in many ancient societies (e.g. Egypt, Greece, Rome; Solomon, 2010) and that such reverence continues today (Ruback, Pandey, & Kohli, 2008). Many religions promote ritual washing and/or immersion and specific aquatic environments continue to have spiritual importance: For example, the Ganges in Hinduism, the Well of Zamzam in Islam and Lourdes in Roman Catholicism. At a secular level people are prepared to pay more for houses and hotel rooms with views of water (Lange &

Schaeffer, 2001; Luttik, 2000), and aquatic environments are a frequent aspect of people’s favourite places (Kaplan & Kaplan, 1989; Korpela, Ylén, Tyrväinen, & Silvennoinen, *in press*), preferred leisure destinations (Natural England, 2009) and recollections of positive childhood activities (Waite, 2009). Yet despite the enormous cultural and economic importance of aquatic environments we still know very little about people’s perceptions of these environments in psychological terms.

From an evolutionary perspective the reverence of water makes sense. Early humans attracted to aquatic environments with supplies of fresh water may have been more likely to survive than those attracted to non-aquatic environments. Additionally, salt-water environments provided food and migratory corridors and it has been suggested that Omega 3 fatty acids present in large amounts in fish and shellfish may have played a crucial role in the development of the brain and the evolution of modern humans (Hardy, 1960; Morgan, 1997). Thus it seems reasonable to argue that we have evolved preferences for such environments (Kaplan & Kaplan, 1989; Ulrich, 1983). Perhaps this apparently obvious

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connection is one of the reasons why aquatic environments have been relatively under-researched in environmental psychology. Instead, studies investigating the actual or perceived restorativeness of different environments have typically focused on the natural vs. built distinction and only rarely examined the role of water within these two categories.

The aim of the current research was to help redress this imbalance. Employing the simple but widespread method of asking people to rate photographic scenes we systematically explored reactions to natural and built environments with or without aquatic elements. Following on from previous research we measured people's preferences for the different scenes as well as their affective reactions and perceived restorativeness. Our main hypothesis was that people would respond favourably to both natural and built environments containing water. Moreover, since we controlled the amount of water visible in the scenes we were also able to examine possible dose-response relationships: Are people sensitive to the proportion of water in a scene?

1.2. Effect of aquatic environments: direct evidence

For the purposes of the present research we consider an aquatic environment to be any environment, natural or urban, containing visible amounts of standing or running water (but not falling rain or settled ice or snow). Although aquatic environments might usually be considered to be ones dominated by water (e.g. seas and lakes) we also include environments where water may be a secondary aspect of the scene (e.g. fountains or streams; cf. Herzog, 1985). This enables the potential dose-response relationships between people's preferences and ratings and the amount of water in a scene to be investigated.

Perhaps the most compelling evidence that people value aquatic environments comes from research into behavioural choices. Luttik (2000), for instance, reviewed house prices across several districts of the Netherlands and concluded that, all else being equal, people were prepared to pay between 8 and 12% more for houses with views of water. Lange and Schaeffer (2001) report similar findings for rooms in two hotels in Zurich. In one, rates for rooms overlooking the lake were roughly 10% higher than those with views to a forest. These data are supported by expenditure on leisure excursions to aquatic environments. In the UK, for instance, there are nearly 250 million visits to the coast and a 180 million to other aquatic environments such as rivers, canals and lakes annually (Natural England, 2009). However, these findings are indicative only because it may be that other features of these environments, e.g. their remoteness or lack of human construction rather than the presence of water *per se*, are driving these effects.

More direct, but also more equivocal, evidence comes from psychological research. First, Herzog (1985) examined preferences for different waterscapes and found that photographs of "swampy areas" were rated significantly less positively than "rivers, ponds and lakes", "mountain waterscapes" and "large bodies of water". Although suggesting variability in response to aquatic environments this study did not, however, examine non-aquatic environments so people's relative preferences between the two could not be assessed. Nevertheless, the study did suggest a possible dose-response element to aquatic environments. Specifically, the highest preference ratings were for "large bodies of water" suggesting preferences might increase as the proportion of water increases.

A second study, by Ulrich et al. (1991), did compare people's reactions to videos of natural scenes either with or without water present (in addition to urban environments). Instead of preference ratings, however, the researchers were interested in the degree to which being exposed to different environments following a stressful situation would help "restore" people's physiological functioning, e.g. blood pressure and skin conductance, to pre-stress levels. Twenty

participants were shown a video of "Nature Vegetation" and 20 of "Water". The water video was described as a: "Setting dominated by trees and a fast moving stream; waves and ripples on stream surface. No people or animals. Constant 63–64 decibel sound from stream". The authors state that they found no significant differences between the Natural Vegetation and Water settings (although no data are presented).

While this suggests that water may not have any particular restorative properties, a number of alternative interpretations are possible. First, the scene was "dominated by trees" making it possibly a green-space scene with some water rather than a "large body of water" with some green (cf. Herzog, 1985). Second, the average level of noise in the water video was higher (though the maximum was the same) and it may be that any positive effects from viewing water were counteracted by negative effects of a more noisy auditory stimulus. Third, there may have been insufficient power to detect differences with only 20 participants per condition. Fourth, only one scene was used making it hard to know whether this was representative of all aquatic environments and whether the effects are generalisable.

A third study, by van den Berg, Koole, and van der Wulp (2003) also directly compared the presence of aquatic elements in natural and urban settings. Participants were presented with videos of walks in Urban and Rural environments that either did or did not contain water. Similar to Ulrich et al. (1991) they found no effect of water on "affective restoration, concentration, beauty or naturalness" (p.141). A closer inspection of the videos reveals a potential explanation: The water in these scenes is a thin, dark brown, unattractive stream or canal. As the authors themselves recognise: "our manipulation may have been too weak to have any impact on participant's preferences or restoration...[thus]... it seems worthwhile to further investigate the independent contribution of water to the occurrence of restorative effects in future studies" (p.145).

1.3. Effect of aquatic environments: indirect evidence

This continuing ambiguity concerning the impact of water on well-being has led some researchers to eliminate it from all scenes (e.g. Herzog, Maguire, & Nebel, 2003). Although this aids interpretation it does not help us understand the role that water plays. More commonly studies have included aquatic stimuli but not systematically (e.g. Berman, Jonides, & Kaplan, 2008; Berto, 2005; Pretty, Peacock, Sellens, & Griffin, 2005). In reviewing these papers our goal is not to be unjustly critical. The original stimuli were constructed for other purposes and within their frame of reference we find the results compelling. Nevertheless, we did find a systematic, though no doubt unintentional, bias towards the inclusion of aquatic scenes in the more positive categories of stimuli. For instance, while Berman et al.'s (2008) set of 50 nature photographs contained 39 with water (78%), not one of their urban ones did. Given that many towns and cities are built, for good historical reasons, near the coast, along rivers or on lakes (Solomon, 2010) and often contain human-made aquatic elements such as ponds or fountains (Nordh, Hartig, Hagerhall, & Fry, 2009) this appears to be a potential oversight.

A similar picture emerges with Berto's (2005) data. Of her 25 Restorative images, 19 (76%) contained water while water was present in only 2 of 25 (8%) Unrestorative scenes. More informative still are Pretty et al.'s (2005) stimuli. These authors developed four categories of image along two dimensions: Rural/Urban crossed with Pleasant/Unpleasant. Participants in each of the four groups were presented with slide shows of 80 images. The number containing water was: Rural Pleasant = 31; Rural Unpleasant = 6; Urban Pleasant = 38; Urban Unpleasant = 6. Thus while 39% of Rural Pleasant and 47% of Urban Pleasant scenes contained water, only 8%

of Rural and Urban Unpleasant ones did. We interpret this as support for the contention that water may play a key role in preferences and potential restorativeness for both Rural and Urban scenes.

Far from being isolated examples these findings reflect an underlying pattern in the literature. Of the 6 landscape posters used by Kweon, Ulrich, Walker, and Tassinary (2008) to reduce anger and stress at work, 5 were of aquatic scenes. In Nanda, Eisen, and Baladandayuthapani's (2008) survey of art preferences among patients and students, aquatic scenes consistently ranked highest. Purcell, Peron, and Berto's (2001) participants ranked "lake" scenes as the most preferable and restorative, if not most familiar, landscape. The highest ranked Forest scenes in Han's (2007) research contained water. The examples in Weinstein, Przybylski, and Ryan (2009) paper are of a "natural" aquatic scene vs. an "urban" one with no water. Felsten (2009) noted that "natural murals, especially those with water, were more restorative" (p.160). Nordh et al. (2009) found that small urban "pocket parks" containing water were rated as more restorative, in terms of "being away" and "fascinating" than those without water. Finally, although not predicted, Karmanov and Hamel (2008) found an urban scene with a large amount of water was generally rated as positively as rural green space.

Moreover, previous data sets were not only less likely to include water in the less positive categories but when it did appear there tended to be less of it. For instance, the largest proportion of water in Berto's (2005) Unrestorative scenes represented around 5% of the image while her Restorative scenes contained up to 50%. Similar proportions are evident in Pretty et al.'s (2005) Pleasant vs. Unpleasant stimuli, and some of Berman et al.'s (2008) Nature scenes contain around 60% water. We interpret these findings to suggest that there may be a dose-response effect with restorativeness increasing in proportion to the amount of water present in the scenes. The basic idea builds on Tennesen and Cimprich's (1995) study which categorised views from student dorms as either, All Nature, Mostly Nature, Mostly Built or All Built.

1.4. Current research and hypotheses

Clearly, the idea that water may have restorative potential is not original (e.g. see Kaplan & Kaplan, 1995). Nonetheless, it seems that many studies have unintentionally supported, and in many cases not even recognised, this possibility. The central aim of the current research was to therefore explore this issue more systematically. We had three main objectives. First, and most importantly, we wanted to systematically examine whether the presence of water in both natural and built environments would have a positive impact on a range of preference and rating indicators. Second, by controlling the proportion of water in a scene we wanted to explore potential dose-response relationships: e.g. do reactions to scenes become more positive as the proportion of water increases? Third, we wanted to revisit the Green/Built relationship but submit this to more rigorous testing by excluding water from both environments. These objectives were addressed in two studies.

Measures of preference in Study 1 were attractiveness (e.g. Herzog, 1985) and willingness to visit the scene (an approach-avoidance measure, Ulrich, 1983), and in Study 2 willingness to pay (WTP) for a hypothetical hotel room with the specific view (Lange & Schaeffer, 2001). In terms of other ratings, in Study 1 we measured affective valence and arousal (De Kort, Meijnders, Sponselee, & Ijsselstein, 2006) and in Study 2 perceived restorativeness (Study 2; Berto, 2005; Hartig, Korpela, Evans, & Gärling, 1997).

1.4.1. Hypothesis 1: Green vs. built environments

Earlier research demonstrated that Built environments containing Green space are rated more positively than those without. Extending this logic we hypothesised that as the proportion of

visible Green space increases, so the rated positivity of the scene will also increase. This will manifest itself in stronger preferences for (attractiveness/willingness to visit/pay) and more positive ratings of (valence/arousal/perceived restorativeness) environments with more vs. less green space.

1.4.2. Hypothesis 2: Aquatic elements of natural environments

Our review above suggests that natural scenes containing water are more likely to be viewed positively. Extending this logic, we hypothesise that as the proportion of Aquatic space visible in natural scenes increases, so preferences and ratings will also increase.

1.4.3. Hypothesis 3: Aquatic elements of built environments

If the first two hypotheses are correct then adding water to Built environments should also increase positivity towards them. Moreover, as the proportion of Aquatic space visible in Built scenes increases, so preferences and ratings should also increase.

1.4.4. Hypothesis 4: Aquatic vs. green in built environments

Finally, if Hypotheses 1–3 are supported then including water in Built environments should result in greater positivity ratings than adding Green space. Specifically, we hypothesised that preferences and ratings of Built scenes containing Aquatic elements will be more positive than those containing Green elements.

2. Study 1

2.1. Preparatory work: development of photo sets

We began by identifying three archetypal environments: "Aquatic" including water and associated aspects (e.g. rocky shore, sandy beach); "Green" including fields, forests, parkland; and "Built" including buildings and constructions (e.g. walls, roads). We then collated images that either reflected a single environment (e.g. "Green-Only") or a combination of two (e.g. "Green-Aquatic"). The ratio of these elements in mixed environments was crucial. Following the "rule-of-thirds" in photography (Krages, 2005) all scenes were selected to feature approximately 2/3rds of one environment and 1/3rd of the other (excluding sky). So, for instance, an "Aquatic-Built" environment would be one where roughly 2/3rds of the scene would contain aquatic elements and 1/3rd human-made construction. A "Built-Aquatic" scene would feature both aspects but in the opposite ratio.

This resulted in 9 core environments: Aquatic-Only; Aquatic-Green; Aquatic-Built; Green-Only; Green-Aquatic; Green-Built; Built-Only; Built-Aquatic; and Built-Green. Fig. 1 provides examples. Fig. 1a, d and g represent Aquatic-Only, Green-Only and Built-Only respectively (i.e. 3/3rds, or all, – excluding sky). Other images such as Fig. 1b had a "primary proportion" ($\approx 2/3$ rds) Aquatic and a "secondary proportion" ($\approx 1/3$ rd) Green (i.e. Aquatic-Green). The reverse case, Fig. 1e has a primary proportion ($\approx 2/3$ rds) Green and secondary proportion ($\approx 1/3$ rd) Aquatic (i.e. Green-Aquatic). Given the nature of real scenes these proportions are approximate only.

In addition our review of the literature also suggested that image content (e.g. presence of people, animals, etc) was not always standardised. For instance, some studies included people in urban but not nature scenes (Hartig & Staats, 2006; Staats & Hartig, 2004; Ulrich et al., 1991). A resulting preference for natural environments might therefore be due to a preference for a lack of people rather than for green space *per se*. Other studies have avoided this issue by only including scenes without people, animals etc. (Felsten, 2009; Han, 2007; Herzog et al., 2003). However, to the extent that this does not reflect actual experiences, it is difficult to interpret these findings with respect to people's everyday encounters with such environments. Thus, although our central aim was to examine the



Fig. 1. Example scenes: A) Aquatic Only; B) Aquatic-Green; C) Aquatic-Only + Object; D) Green-Only; E) Green-Aquatic; F) Green-Only + People; G) Built-Only; H) Built-Aquatic; I) Built-Green + Animals.

effects of water, we nevertheless thought it important to standardise image content, making sure that a) all environments featured examples of commonly occurring contents and b) the frequency of these elements was standardised as much as possible across environments. Specifically, our review identified 4 commonly occurring content types: People, Animals, Objects (e.g. cars, boats, cranes) and scenes with none of these, i.e. Scene Only. Fig. 1c, f and i provide examples containing Objects (boat), People and Animals respectively. We had no specific hypotheses regarding the impact of image content.

Combined, this produced a total number of 36 different photo-categories (3 Primary Proportion: Aquatic/Green/Built $\times$ 3 Secondary Proportion: Aquatic/Green/Built $\times$ 4 Content: Scene Only/People/Animals/Objects). To bolster reliability we included at least two, and up to eight, images within each category. Core categories (e.g. Aquatic-Only) were over-sampled, reflecting previous research. This produced a set of 120 images in Total (Table 1). Following Han (2007) our aim was, as much as possible, to include images that were of “good photographic quality and ... taken at approximate eye-level” (p534). The majority of images were of the local region (South West England) although some were

of continental cities and landscapes. Finally, we only included images taken under clement weather conditions. Although this limits generalisation the combinatorial explosion associated with different climatic conditions proved prohibitive in the current research. We were able to supply around 100 images from various sources. The remaining images were taken by one of the authors (AS) in order to complete the full set. In practice, it proved difficult to find Object scenes without people, especially in Aquatic environments (e.g. sailors on boats) so this category of image Content is not quite as “clean” as the others.

2.2. Method

2.2.1. Participants

Participants were recruited via the School of Psychology's paid participant pool at the University of Plymouth, UK which offers £3 per 1/2 h of participation. This pool contains students, university staff and members of the public. Details of all pool studies are advertised on a specific web-site and participants contact researchers to agree a time for testing. Using this method we recruited 40 Ps, 28 females, M age = 28.5 yrs (range 18–63).

Table 1
Number of photos in each category.

Primary prop. ($\approx 2/3$ rd)	Aquatic			Green			Built			Total
Secondary prop. ($\approx 1/3$ rd)	Aquatic	Green	Built	Aquatic	Green	Built	Aquatic	Green	Built	
Scene only	8	4	4	4	8	4	4	4	8	48
+Animal/s	4	2	2	2	4	2	2	2	4	24
+Person/s	4	2	2	2	4	2	2	2	4	24
+Object/s	4	2	2	2	4	2	2	2	4	24
Total	20	10	10	10	20	10	10	10	20	120

2.2.2. Procedure

On arriving at the testing labs participants were briefed about the study's general nature and informed of the confidentiality of their answers and their right to withdraw in accordance with the university's ethical requirements. If happy to continue they were seated in front of a standard PC at approximately 60 cm from a flat-screen monitor (42 cm × 27 cm) with the centre at eye-level. Participants began by reading an introductory passage which told them that they were going to rate a series of photos on four dimensions. They then conducted three practice trials. For all experimental stimuli, the photographic image constituted roughly 75% of the screen. The background was black. Questions appeared below the image in sequence one at a time. Only after a response was made to the first question was it replaced with the second one. The practice trials contained an Aquatic, Green and Built scene not included in the final set of 120. Responses were given on the keyboard and directly recorded by the computer.

Following the practice trials, participants began the main study. Proceeding at their own pace participants then rated all 120 photos on four dimensions. Trials were divided into three blocks of 40 with the opportunity to "take a short break" between blocks. The images in each block were counterbalanced for proportion and content, with image order within blocks randomised for each participant. After the final rating, participants answered three background questions before being debriefed, thanked and paid.

2.2.3. Measures

The 4 questions for each photograph were designed to measure preferences and affective reactions to the images. The preference questions reflected aesthetic ("How attractive do you find this scene?") and behavioural ("How willing would you be to visit this scene?") preferences. Responses were on scales from Not at all (1) to Extremely (10). The emotion items were designed to tap into the two dimensions of the affect circumplex, i.e. valence and arousal (Russell, 1980), as recommended by De Kort et al. (2006, p.317). Ps were asked: "How does this photo make you feel?" with two response scales, Very Sad (1) to Very Happy (10) (henceforth *affect*), and Calm (1) to Excited (10) (i.e. arousal). Finally, participants were asked about their familiarity with environments in the *Past* ("Where did you grow up?") and the *Present* ("Where do you live now?") and their general *Living Preferences* ("Where would you like to live?"). Categorical responses in each case were: Mostly marine (water); mostly green (countryside); or mostly urban.

2.3. Results

2.3.1. Preliminary analysis

Responses to the three final questions concerning environmental familiarity and preferences suggested that only a minority either grew up (18%) or claimed they were currently living (3%) in a mostly marine environment. Nevertheless, 50% said that they would prefer to live in such an environment (cf. Purcell et al., 2001).

The overall means and standard deviations (in parentheses) for the four dependent variables were as follows: Attractiveness, $M = 6.04$ (1.06); willingness to visit, $M = 6.04$ (1.22); affect, $M = 5.87$ (.89); arousal, $M = 4.79$ (1.01). Given that the mid-point of the scales was 5.5, participants generally found the places in the photographs attractive, were willing to visit them and affective reactions were mildly positive. This might reflect the fact that all photos were taken under clement weather conditions. Arousal was below the mid-point, suggesting that overall the images were more calming than exciting. All correlations were positive and significant. The correlation between the two preference items was $r = .91$, $p < .001$, and as a result we collapsed these two variables for use in

all future analysis, referring simply to "Preferences". The correlation between preferences and affect was also strong $r = .75$, $p < .001$. This supports earlier work suggesting a link between preferences and affective responses: People, not surprisingly, prefer places that make them feel good.

The correlations with arousal were much weaker $rs < .39$, $ps < .05$. Moreover, during de-briefing, a number of participants reported finding this item hard to respond to because they couldn't decide whether some environments were calming or exciting since they appeared to offer both possibilities. Due to this ambiguity we felt we could not assume the robustness of this item and excluded it from further analysis. Study 2 attempts to provide a more robust measure of a similar concept, i.e. perceived restorativeness.

To explore the general relationship between image content, preferences and affect we carried out two one-way repeated measures ANOVAs, one for preferences and one for affect, comparing Scene Only, Animals, People and Objects. Planned contrasts were used to compare the typical image used in prior research, i.e. Scene Only, with the other three categories. Descriptive data are presented in the first four rows of Table 2. There was a large main effect of Content for both preferences ($F(3,117) = 34.22$, $p < .001$, $\eta^2 = .47$) and affect ($F(3,117) = 33.64$, $p < .001$, $\eta^2 = .46$). Planned comparisons suggested that compared to Scene-Only views, images containing People had significantly higher preference ($M_{\text{diff}} = .34$, $p = .015$) and affect ($M_{\text{diff}} = .32$, $p < .001$) ratings, while images including Objects had the reverse effect: Preference, $M_{\text{diff}} = -.39$, $p < .001$; affect, $M_{\text{diff}} = -.29$, $p < .001$. Images containing Animals were also associated with more positive affect ($M_{\text{diff}} = .43$, $p < .001$) than Scene Only but only marginally higher preferences ($M_{\text{diff}} = .15$, $p = .062$).

2.3.2. Main analysis

We explored Hypotheses 1–3 using a series of one-way repeated measures ANOVAs comparing four different environments (Table 2). In all cases environments were entered in

Table 2

Preferences, affective valence, willingness to pay and perceived restorativeness for different environments.

	Study 1		Study 2	
	Preferences	Affect	Willingness to pay	Restorativeness
	M (SD)	M (SD)	M (SD)	M (SD)
<i>Content</i>				
Scene only	5.95 (1.07)	5.76 (.82)	61.13 (6.27)	6.31 (.91)
Animals	6.10 (1.21)	6.19 ^a (1.16)	60.89 (5.09)	6.34 (.88)
People	6.29 ^a (1.09)	6.08 ^a (.83)	63.09 ^a (6.03)	6.72 ^a (.83)
Objects	5.56 ^a (1.15)	5.47 ^a (.90)	56.67 ^a (7.16)	5.73 ^a (1.25)
<i>Hypothesis 1: built vs. green</i>				
Built-only	3.66 (1.10)	4.44 (1.02)	47.96 (4.84)	3.84 (1.12)
Built-green	4.89 ^b (1.18)	4.95 ^b (1.06)	54.67 ^b (7.98)	4.88 ^b (1.52)
Green-built	5.50 ^b (1.58)	5.42 ^b (1.03)	55.73 (7.00)	5.77 ^b (1.27)
Green-only	5.83 ^b (1.54)	5.88 ^b (1.24)	60.81 ^b (7.43)	6.94 ^b (1.23)
<i>Hypothesis 2: green vs. aquatic</i>				
Green-only	5.83 (1.54)	5.88 (1.24)	60.81 (7.43)	6.94 (1.23)
Green-aquatic	7.05 ^b (1.39)	6.63 ^b (1.28)	69.42 ^b (7.39)	8.01 ^b (.90)
Aquatic-green	7.68 ^b (1.09)	7.19 ^b (1.03)	72.85 ^b (6.96)	8.28 ^b (.85)
Aquatic-only	7.40 ^b (1.26)	6.90 ^b (1.18)	71.75 (6.42)	8.01 ^b (.94)
<i>Hypothesis 3: built vs. aquatic</i>				
Built-only	3.66 (1.10)	4.44 (1.02)	47.96 (4.84)	3.84 (1.12)
Built-aquatic	5.96 ^b (1.16)	5.70 ^b (.97)	57.79 ^b (7.94)	5.52 ^b (1.17)
Aquatic-built	5.99 (1.33)	5.77 (1.08)	59.74 (9.19)	6.29 ^b (1.25)
Aquatic-only	7.40 ^b (1.26)	6.90 ^b (1.18)	71.75 ^b (6.42)	8.01 ^b (.94)

Note: Planned contrasts used to test: a = Significantly different from Scene Only ($p < .05$); b = Significantly different from preceding mean ($p < .05$). See text for details on scale anchors.

accordance with predictions such that the first environment entered was the one we expected would receive the least positive rating (e.g. Built-Only) and so on up to the most positive (e.g. Aquatic-Only). Planned repeated contrasts were then used to compare the means between adjacently ranked environments. This enabled us to test whether ratings were, for instance, significantly higher for environments with some green space vs. none and a lot of green spaces vs. some. Preferences and affect were analysed separately.

2.3.2.1. Hypothesis 1: Green vs. built environments. Did increasing the amount of green space in a scene result in more favourable ratings? The main effects were highly significant for both preferences, $F(3,117) = 53.63$, $p < .001$, $\eta^2 = .58$, and affect, $F(3,117) = 36.77$, $p < .001$, $\eta^2 = .49$. As predicted, as the amount of Green space increased so did ratings. Planned repeated contrasts found that, compared to Built-Only scenes, Built-Green environments were both more preferred ($M_{\text{diff}} = 1.23$, $p < .001$) and associated with more positive affect ($M_{\text{diff}} = .51$, $p < .001$). Consistent with earlier research, adding at least some Green space improved reactions to Built environments. In terms of a dose-response relationship, more Green space (Green-Built) was better than some Green space (Built-Green): Preferences, $M_{\text{diff}} = .61$, $p < .001$; affect, $M_{\text{diff}} = .47$, $p < .001$. Eliminating Built aspects entirely (Green-Only) produced yet greater improvements on Green-Built: Preferences, $M_{\text{diff}} = .33$, $p = .007$; affect, $M_{\text{diff}} = .46$, $p < .001$. Thus there appeared to be a dose-response relationship between the amount of Green space in a scene and the positivity of people's preferences and affective responses.

2.3.2.2. Hypothesis 2: Aquatic elements of natural environments. Did adding and increasing the amount of water in natural scenes result in more favourable ratings? Again, there were highly significant effects of environment on both preferences, $F(3,117) = 70.63$, $p < .001$, $\eta^2 = .64$, and affect, $F(3,117) = 36.42$, $p < .001$, $\eta^2 = .48$. As predicted, as the proportion of Aquatic space in natural environments increased so ratings also increased. The relationship was not, however, straightforward. Adding some water to green scenes (i.e. Green-Aquatic vs. Green-Only) resulted in significantly higher preferences ($M_{\text{diff}} = 1.22$, $p < .001$) and affect ($M_{\text{diff}} = .75$, $p < .001$). Moreover, further increasing the proportion of water (i.e. Aquatic-Green vs. Green-Aquatic) had similar effects: Preferences ($M_{\text{diff}} = .63$, $p < .001$), affect ($M_{\text{diff}} = .56$, $p < .001$). Making natural environments wholly aquatic (i.e. Aquatic-Only), however, resulted in significantly lower ratings of both preferences ($M_{\text{diff}} = -.28$, $p = .007$) and affect ($M_{\text{diff}} = -.29$, $p = .006$) than for Aquatic-Green environments. People preferred and experienced more positive emotions when they looked at a largely aquatic scene with elements of flora than scenes that consisted entirely of water and water related features.

2.3.2.3. Hypothesis 3: Aquatic elements of built environments. Did increasing the amount of water in Built environments result in more favourable ratings? Again, there were highly significant main effects for both preferences, $F(3,117) = 172.32$, $p < .001$, $\eta^2 = .82$, and affect, $F(3,117) = 80.25$, $p < .001$, $\eta^2 = .67$. Adding some water to built environments, i.e. Built-Aquatic vs. Built-Only, increased ratings of both preferences ($M_{\text{diff}} = 2.30$, $p < .001$) and affect ($M_{\text{diff}} = 1.26$, $p < .001$). However, unlike either of the previous analyses there were no significant differences between Built-Aquatic and Aquatic-Built environments for either preferences ($M_{\text{diff}} = .03$, $p = .85$) or affect ($M_{\text{diff}} = .07$, $p = .54$). Aquatic-Only environments, however, did receive significantly higher preference ($M_{\text{diff}} = 1.41$, $p < .001$) and affect ($M_{\text{diff}} = 1.13$, $p < .001$) ratings than Aquatic-Built environments. In short, there appeared to be a step

function between reactions to water and built environments. Adding some water was positive but increasing the proportion had no further effect.

2.3.2.4. Hypothesis 4: Aquatic vs. green in built environments. Are Built environments containing water rated more positively than those with Green space? To test this we examined Built environments using two 2(Other aspect: Green/Aquatic) $\times$ 2(Proportion Built: Primary/Secondary) repeated measures ANOVAs, one for preferences and one for affect. Supporting Hypothesis 4 there was a significant main effect of Other Aspect for both preferences $F(1,39) = 56.14$, $p < .001$, $\eta^2 = .29$ and affect $F(1,39) = 31.42$, $p < .001$, $\eta^2 = .22$. Built environments with Aquatic vs. Green features were associated with more positive preferences ($M_{\text{diff}} = .77$, $p < .001$) and affect ($M_{\text{diff}} = .55$, $p < .001$).

There were also main effects of Proportion Built echoing findings above that people prefer a greater proportion of natural elements in a scene $F(1,39) = 8.81$, $p = .005$, $\eta^2 = .05$ and experience more positive affect $F(1,39) = 12.11$, $p = .001$, $\eta^2 = .05$. Finally, there were also significant interactions between Other aspect and Proportion: preferences $F(1,39) = 8.90$, $p = .005$, $\eta^2 = .05$, affect $F(1,39) = 4.70$, $p = .036$, $\eta^2 = .03$. Because the proportion (1/3rd vs. 2/3rds) of Green Space in Built environments was important (Hypothesis 1) but the proportion of Aquatic space was not (Hypothesis 3) this interaction is a product of a larger difference between Green vs. Aquatic when they are the secondary vs. primary element.

Preference ratings for all 9 environments, ordered from the least to the most preferred, are presented in Fig. 2. The pattern reflects the above analyses but the similarity between Green-Only and Built-Aquatic environments ($M_{\text{diff}} = -.14$, $p = .44$) is now more apparent. Built environments with water were preferred as much as natural environments without water. A similar pattern emerges for affect (no figure), where again there was no difference between Green-Only and Built-Aquatic ($M_{\text{diff}} = -.18$, $p = .23$).

2.4. Discussion

Results were highly encouraging for our central thesis: Images of Natural and Built environments with water were preferred and associated with more positive affect than those without water. That these effects emerged from a large and systematically controlled stimuli set provides robustness. Nevertheless, given the novelty of the findings it is necessary to examine generalisability across measures. Consequently, Study 2 uses willingness to pay (WTP) as a measure of preference and perceived restorativeness. The former is important because it links our work more closely to standard economic approaches. The latter is used in response to the limitations we encountered with the arousal dimension.

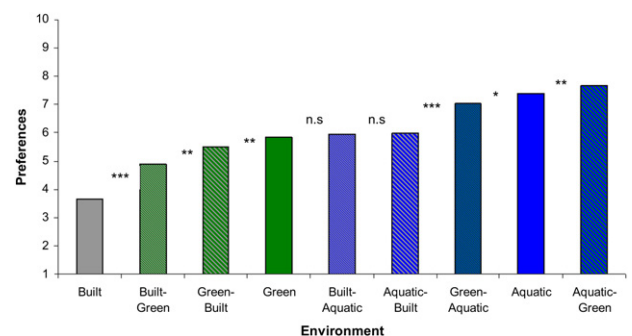


Fig. 2. Environments ranked from least to most Preferred. Note: The significance of differences between adjacent environments (using planned repeated contrasts) is shown between them: *** $p < .001$, ** $p < .01$, * $p < .05$, n.s. not significant.

3. Study 2

3.1. Introduction

Earlier we noted that people are prepared to pay more for a house/room with an aquatic view (Lange & Schaeffer, 2001; Luttik, 2000). However, we know very little about the views included in these earlier studies in terms of relative environmental proportions and contents. Consequently the dose-response analysis we are interested in has not been examined using such “revealed-preferences” (i.e. actual behaviour). Developing the kind of systematic stimuli set used in Study 1 in real accommodation contexts is, moreover, unfeasible since it would be extremely difficult to find 120 hotel rooms that are identical in all respects except for their view deconstructed along several dimensions.

Study 2 therefore adopts an alternative measure of preferences that is widely used in economic assessments of hard to value contexts (e.g. Loomes, 2006). Specifically, rather than observing what people are prepared to pay we ask them to indicate their willingness to pay (WTP) for hypothetical rooms with specific views. An advantage of this “stated-preference” approach is that hypothetical rooms can be made identical in all other respects. A disadvantage is that WTP, even for hypothetical judgments, is subject to a range of biases (Dolan & White, 2007). However, since we use a repeated measures design such differences should apply equally to all environments, reducing the problem compared to between subject designs.

The degree to which natural environments are more “restorative” than urban ones has been a central concern of research in this area. Despite debate about exactly what restoration entails (Kaplan, 1995; Ulrich et al., 1991), broadly speaking it is the idea that everyday experiences can deplete our physiological, cognitive and emotional resources. Such depletion emerges in various ways. For instance it can appear in a range of stress-related bio-markers, poorer performance on cognitive tasks, and negative changes in mood (for review, see van den Berg, 2006). An environment is said to be restorative if there is evidence that exposure to it can reduce or reverse these effects, effectively “restoring” the person to the more positive state, in which they were previously.

The “gold-standard” of research in this area monitors actual physical/cognitive/mental restoration (e.g. Berman et al., 2008; Berto, 2005; De Kort et al., 2006; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Pretty et al., 2005; Ulrich et al., 1991). An alternative line of research has examined people’s perceptions of the potential restorativeness of different environments (Berto, 2005; Felsten, 2009; Hartig & Staats, 2006; Purcell et al., 2001). As above, since it was unfeasible to monitor actual restoration with respect to all 120 of our images the current study adopts this latter approach and asks people to what extent they perceive the different scenes to indicate potentially restorative properties. Specifically, we used Berto’s (2005) short (5 item) version of Hartig et al. (1997) Perceived Restorativeness Scale (PRS). Advantages include the few number of items, high internal reliability and concordance with objective measures of cognitive restoration (Berto, 2005).

Our hypotheses were essentially the same as Study 1. Thus we predicted higher WTP and greater perceived restorativeness for Green than Built environments (Hypothesis 1), for Aquatic than Green natural environments (Hypothesis 2), for Built environments with vs. without water (Hypothesis 3) and for Built environments with Aquatic than Green features (Hypothesis 4).

3.2. Method

3.2.1. Participants

40 participants who had not taken part in Study 1 were again recruited via the School of Psychology’s Paid Participant pool for

a 1/2 h study. There were 29 females, Mean age = 23.5 yrs (range 18–56).

3.2.2. Procedure

The procedure was similar to Study 1 with some changes. Most significantly there were now 6, instead of 4 questions per image. In order to keep the study under 1/2 h it was necessary to divide the photoset in half and present 20 participants with one set of 60 images and the other 20 with the remaining 60. Because there were at least two images from each category, counterbalancing across the two sets was possible. As with Study 1, there were three blocks but this time containing 20 images in randomised order. Despite the increase in questions, halving the photoset greatly reduced potential fatigue within each block compared to Study 1. The introductory passage was also slightly different to accommodate the different question format. After the final rating, participants answered the same three background questions as in Study 1 and were again debriefed, thanked and paid.

3.2.3. Measures

Participants began by reading the following passage: “We are interested in people’s perceptions of various outdoor scenes. You will be shown a series of 60 photographs and asked six questions about each. The first five will ask questions such as how relaxing and fascinating you find the place in the photograph. The final question asks you to imagine staying in a hotel room with the scene as the view from your bedroom window. You are asked to image that the room where you are staying is in a 2–3 star hotel where single rooms range in price from £40 per night to £85 per night. The rooms are identical (all en-suite, same furniture, same size etc) with the exception of the view from the window. What we want to know is how much you would be willing to pay for the rooms with different views.” This price range genuinely reflected that of 2–3 Star hotel rooms in the local area at the time.

The short-version of the Perceived Restorativeness Scale (PRS, Berto, 2005) included the following items: a) That is a place which is away from everyday demands and where I would be able to relax and think about what interests me (*being-away*); b) That place is fascinating; it is large enough for me to discover and be curious about things (*fascination*); c) That is a place where the activities and the items are ordered and organised (*coherence*); d) That is a place which is very large, with no restrictions to movements; it is a world of its own (*scope*); e) In that place, it is easy to orient and move around so that I could do what I like (*compatibility*). All responses were on scales from 1 (Not at all) to 10 (Very Much).

The willingness to pay (WTP) judgment was simply “How much would you be willing to pay for a room with this view?”. The low anchor was £40 with each subsequent point representing a £5 increase. We thus had 9 further increments up to £85 per night.

3.3. Results

3.3.1. Preliminary analysis

Environmental familiarity and preferences again suggested that only a minority either grew up (18%) or claimed they were currently living (2%) in a mostly marine environment, while 68% stated that they would prefer to live in such an environment. Reliability analysis on the short-version PRS suggested that it was reliable ($\alpha = .84$). Echoing the original work on this scale, however, the “coherence” measure did not correlate with the other four items (r s from $-.14$ to $-.23$). As the original authors noted, coherence seems to form a separate factor while “the PRS can parsimoniously combine the three a priori being away, fascination, and compatibility items into a General Restorativeness subscale” (Hartig et al., 1997, p191).

Accordingly we removed the coherence item from our scale resulting in an increase in reliability ($\alpha = .98$; see also Felsten, 2009).

A comparison of the two groups of participants suggested that the first group were shown a slightly more positive set of 60 photographs. Specifically, they were willing to pay slightly more than the second group ($M_{\text{diff}} = 3.35$, $p = .047$) and perceived their 60 images as marginally more restorative ($M_{\text{diff}} = .45$, $p = .087$). These (small) differences support our contention that the broadest possible range of stimuli should be used to avoid misrepresenting an environmental category by selecting especially pleasant or unpleasant exemplars. As allocation of photos and participants to groups was random and of no theoretical interest, we collapse responses to environments across groups in all further analyses. The overall mean for WTP was $M = £61.19$ ($SD = 5.37$) and for restorativeness was $M = 6.39$ ($SD = .82$). The two measures were moderately positively correlated $r(40) = .34$, $p = .03$. People were willing to pay more for a hotel room with a restorative view.

To explore image content we carried out two one-way repeated measures ANOVAs, comparing Scene Only, Animals, People and Objects (Table 2). There were large main effects of Content for both WTP $F(3,117) = 27.34$, $p < .001$, $\eta^2 = .41$ and restorativeness, $F(3,117) = 26.56$, $p < .001$, $\eta^2 = .41$. Compared to Scenes Only, participants were willing to pay significantly more for views featuring People ($M_{\text{diff}} = 1.96$, $p < .001$), significantly less for views containing Objects ($M_{\text{diff}} = -4.46$, $p < .001$) and were indifferent with respect to Animals ($M_{\text{diff}} = -.24$, $p = .74$). A similar picture emerged for restorativeness. Compared to Scene-Only views, people found those containing People significantly more restorative ($M_{\text{diff}} = .41$, $p < .001$), those containing Objects significantly less restorative ($M_{\text{diff}} = -.58$, $p < .001$) and were again indifferent regarding Animals ($M_{\text{diff}} = .03$, $p = .74$).

3.3.2. Main analysis

Again we used one-way repeated measures ANOVAs with repeated contrasts to examine the effect of environments on WTP and perceived restorativeness (Table 2).

3.3.2.1. Hypothesis 1: Green vs. built environments. There were highly significant main effects of environment for both WTP, $F(3,117) = 38.44$, $p < .001$, $\eta^2 = .50$, and restorativeness $F(3,117) = 88.06$, $p < .001$, $\eta^2 = .69$. As predicted, as the amount of Green space increased so did ratings. More specifically, people were willing to pay £6.71 more per night, for an identical hotel room with a view of some (Built-Green) vs. no (Built-Only) Green space ($M_{\text{diff}} = 6.71$, $p < .001$). Similarly, Built-Green scenes were perceived as significantly more restorative than Built-Only ($M_{\text{diff}} = 1.04$, $p < .001$). In terms of dose-response predictions, restorativeness was, as with Study 1, significantly higher for Green-Built than Built-Green scenes ($M_{\text{diff}} = .89$, $p < .001$). However, people were not willing to pay significantly more for these views ($M_{\text{diff}} = 1.06$, $p = .50$). Nevertheless, Green-Only environments were rated significantly more positively than Green-Built environments in terms of both WTP ($M_{\text{diff}} = 5.08$, $p < .001$) and restorativeness ($M_{\text{diff}} = 1.17$, $p < .001$). Overall people were prepared to pay nearly £13 per night more to stay in a room with a fully Green, compared to a fully Built view.

3.3.2.2. Hypothesis 2: Aquatic elements of natural environments. Again, there were highly significant effects of including Aquatic elements in natural environments on both WTP $F(3,117) = 62.92$, $p < .001$, $\eta^2 = .62$, and restorativeness, $F(3,117) = 31.83$, $p < .001$, $\eta^2 = .45$. The dose-response relationship found in Study 1 was replicated. Specifically, adding some water to green scenes (i.e. Green-Aquatic vs. Green-Only) resulted in significantly higher WTP ($M_{\text{diff}} = 8.61$, $p < .001$) and restorativeness

($M_{\text{diff}} = 1.07$, $p < .001$). Moreover, further increasing the proportion of water (i.e. Aquatic-Green vs. Green-Aquatic) had similar effects on both WTP ($M_{\text{diff}} = 3.43$, $p = .001$) and restorativeness ($M_{\text{diff}} = .27$, $p = .036$). Similar to Study 1, making natural environments wholly aquatic

(i.e. Aquatic-Only), however, resulted in lower WTP ($M_{\text{diff}} = -1.10$, $p = .16$) and restorativeness ($M_{\text{diff}} = -.27$, $p = .016$) though only the latter decrease was significant. Overall, people were willing to pay around £12 per night more to stay in a room with an Aquatic-Green than a Green-Only view.

3.3.2.3. Hypothesis 3: Aquatic elements of built environments. Again, adding Aquatic aspects to Built environments had significant main effects for both WTP, $F(3,117) = 165.19$, $p < .001$, $\eta^2 = .81$ and restorativeness, $F(3,117) = 171.61$, $p < .001$, $\eta^2 = .82$. Adding some water, Built-Aquatic vs. Built-Only, significantly increased WTP ($M_{\text{diff}} = 9.83$, $p < .001$) and restorativeness ($M_{\text{diff}} = 1.68$, $p < .001$). However, increasing the proportion of water in a built environment (Aquatic-Built vs. Built-Aquatic) did not significantly increase WTP ($M_{\text{diff}} = 1.95$, $p = .10$). Nevertheless, and contrary to preferences, affect and WTP, people did report such scenes as more restorative ($M_{\text{diff}} = .77$, $p = .001$). Aquatic-Only environments, once again, were viewed more positively than Aquatic-Built environments, with significantly higher WTP ($M_{\text{diff}} = 12.01$, $p < .001$) and restorativeness ($M_{\text{diff}} = 1.72$, $p < .001$). In overall terms people were prepared to pay nearly £24 per night more to stay in a room with a fully Aquatic, compared to a fully Built view.

3.3.2.4. Hypothesis 4: Aquatic vs. green in built environments. As with Study 1 we tested this using two 2(Other aspect: Green/Aquatic) $\times$ 2(Proportion Built: Primary/Secondary) repeated measures ANOVAs, one for WTP and one for restorativeness. Supporting Hypothesis 4 there was a significant main effect of Other aspect for both WTP $F(1,39) = 14.39$, $p = .001$, $\eta^2 = .10$ and restorativeness $F(1,39) = 14.35$, $p < .001$, $\eta^2 = .10$. Built environments with Aquatic vs. Green features were associated with higher WTP ($M_{\text{diff}} = £3.54$) and restorativeness ($M_{\text{diff}} = .58$). This time, however, while there was a main effect of proportion of Built for restorativeness $F(1,39) = 21.81$, $p < .000$, $\eta^2 = .18$, this was not significant for WTP $F(1,39) = 2.32$, $p = .136$, $\eta^2 = .02$. Neither of the interactions was significant $F_s < .27$, $p_s > .60$.

Finally, the rankings of the different environments were very similar to Study 1. Nevertheless, while people were indifferent between Green-Only and Aquatic-Built hotel room views, $M_{\text{diff}} = £1.07$, $t(39) = .90$, $p = .373$, their WTP was reduced for rooms with Built-Aquatic views, $M_{\text{diff}} = -£3.02$, $t(39) = 2.36$, $p = .024$. Moreover, Green-Only views were perceived as significantly more restorative than either Built-Aquatic $M_{\text{diff}} = 1.42$, $t(39) = 6.30$, $p < .001$ or Aquatic-Built, $M_{\text{diff}} = .65$, $t(39) = 3.01$, $p = .005$.

3.4. Brief discussion

Broadly speaking these results replicate Study 1. In line with the earlier literature and Hypothesis 1, people were willing to pay more for hotel rooms with views of Green nature than Built environments and they reported finding these scenes more restorative. Moreover, as the proportion of Green space in the scene increased ratings of both preferences (WTP) and perceived restorativeness also increased. Supporting Hypothesis 2, people were also willing to pay more for rooms with views of nature containing water and found these views more restorative. As with Study 1, Aquatic-Only scenes were rated lower than Aquatic-Green scenes, though only significantly so for restorativeness, suggesting that the interface between land and water may be particularly valued.

Hypotheses 3 and 4 suggest that Built environments containing water were again generally preferred and engendered more positive reactions than Built environments containing Green space. However, in overall terms the perceived restorativeness of Green-Only space was, in contrast to Study 1, significantly higher than either form of Built environment containing water. One interpretation is that the restorativeness measure is more sensitive than the other three because it is a combination of four items. Further research is needed to tease out the cause of these small differences but the general picture is clear: There was little difference between natural Green space and Built environments with water.

4. General discussion

Our review of the literature comparing people's reactions to different environments suggested an unintentional bias with water featuring more often, and in larger quantities, in natural than built environments. Since water may be a positive environmental feature, which for historical reasons is a central aspect of many towns and cities, this may have been a potentially important oversight. We therefore collated a large set of scenes ($N = 120$) that systematically controlled for the presence of water in both natural and built environments. Our central thesis was that both natural and built scenes containing water would, all else equal, have a more positive impact on a range of preference and rating judgments than those without water. We also speculated that there may be a positive association between ratings and the proportion of water in a scene, approximating a dose-response relationship.

4.1. Summary of findings

We began by examining the relationship between natural and built environments where no water was visible. Replicating earlier work, preferences (i.e. perceived attractiveness, willingness to visit the scene and willingness to pay for the view) and ratings (i.e. affective reactions and perceived restorativeness), were more positive for natural than built environments. This suggests that preferences for natural environments found earlier were not simply due to the greater presence of water in these scenes. Nevertheless, preferences and ratings were more positive towards both natural and built scenes containing water indicating that previous research may have over-estimated the differences.

By varying the proportion of Aquatic, Green and Built environments in the scenes we also found several dose-response relationships (Tennessen & Cimprich, 1995). Reactions to non-aquatic environments became more positive as the amount of Green space increased. Similarly, natural environments containing large amounts of water ($\approx 2/3$ ds) were rated more positively than those with less water ($\approx 1/3$ ds). However, scenes containing only water were rated less positively than ones with $2/3$ ds water and $1/3$ rd Green, on all measures except WTP. This finding suggests that the optimal environment may be the interface between land and large bodies of water (Herzog, 1985), which may make evolutionary sense given physiological adaptations to both terrestrial and aquatic habitats (Morgan, 1997).

The dose-response relationship between Aquatic and Built environments was different. Although Built scenes containing some water were rated more positively than those without, the extra benefits of a greater proportion of water were minimal. Consequently, the extent of aquatic features in a built environment may be less important than their mere presence. Importantly, responses to Built environments containing water were just as positive as those to purely natural Green space on three of our four measures. These findings add an important qualification to the previous

literature by suggesting that some Built environments may be just as positive as entirely natural Green space.

This finding echoes results by Karmanov and Hamel (2008) who found that a video of Amsterdam's Eastern Docklands (Urban) was as mood enhancing among exam-stressed students as a video of rural Amstelland. Importantly, they note that "the presence of water, which is a special feature of the urban environment of our study, may be partly responsible for its restorative effects" (p.122). Moreover, Carrus, Scopelliti, Bonaiuto, and Romoli (2008) suggest that images of urban Rome are highly aesthetically appealing. As Rome is famous for its many aquatic features and fountains it would be interesting to analyse the proportion of water in the beautiful historical places in their work.

Finally, although we had no specific hypothesis regarding image content, images containing People were, overall, rated more positively than ones without. This may offer support for the notion that the presence of others can aid restoration (Staats & Hartig, 2004) as long as they are non-threatening (Herzog & Rector, 2008). These results also suggest that earlier studies which included people in urban but not natural settings (e.g. Hartig & Staats, 2006; Staats & Hartig, 2004; Ulrich et al., 1991) may have underestimated the relative positivity of natural environments by only including people in urban scenes. Future research may want to explore scene content even more systematically than we were able to do here by expanding the number of examples in specific categories.

4.2. Why might aquatic environments be good for well-being?

The breadth, in terms of different measures, and strength, in terms of effect sizes, of our findings are encouraging. In particular the similarity of reactions to Green-Only and Built-Aquatic environments is perhaps surprising given the near unanimous finding in previous research regarding the superiority of natural vs. urban settings (although see Karmanov & Hamel, 2008). The obvious question to ask is why aquatic environments should be so beneficial? Unfortunately the present research is largely descriptive and we require further research to address this question. Although it may be true that preferences for aquatic environments have been selected for in our evolutionary history (e.g. Morgan, 1997) this speculation can not be tested directly. However, it may be productive to examine the mechanisms through which the presence of water may trigger higher preferences, affect and restorativeness ratings. Three lines of enquiry may offer insight.

First, it may be that certain visual properties of aquatic environments that are attractive and potentially restorative. For instance, water reflects light in interesting ways and it may be that certain lines and patterns of light are more restorative than others (Fernandez & Wilkins, 2008). The water in van den Berg et al.'s (2003) stimuli, for instance, was of a dull hue and hardly reflected light (at least in the pictures in the paper) and this may account for their null effect of water. Our images of water, by contrast, may have offered a greater range of interesting and potentially restorative light patterns and reflections. Clearly, more work is needed to test this possibility.

Second, aquatic environments may be associated with more restorative sounds (e.g. breaking waves). Bird (2007), for instance, quotes a respondent who claims she visits a local river because she finds its sound relaxing. While one of the benefits of using videos and field studies is that sounds can accompany images (Diette, Lechtzin, Haponik, Devrotes, & Rubin, 2003) we know of no research that has systematically decomposed the potential restorativeness of different, and particularly aquatic, sounds. A possible criticism is that sounds were not present in the current research and thus could not account for the reactions to aquatic environments reported here. Research suggests however that activation in

the secondary auditory cortex can occur without any external auditory stimuli (Bunzeck, Wuestenberg, Lutz, Heinze, & Jancke, 2005). Thus people may be imagining the sounds of waves breaking on the beach when viewing a picture and this may contribute to more positive ratings.

Finally, for aquatic environments the term “immersion” is more than just a metaphor. The potential to bathe and swim in water allows a very different interaction with the natural environment than can be achieved on land (Rew, 2008). Research using flotation tanks, for instance, has found that immersion in water can lead to significant reductions in physiological and psychological indicators of stress (Forgays & Belinson, 1986; Suedfeld, Ballard, & Murphy, 1983), and it may be that viewing calm aquatic scenes encourages people to recall or mentally simulate positive aspects of physical immersion. Clearly, all three suggestions are highly speculative at this stage but they may serve as useful starting points for improving our understanding of why aquatic environments were rated so positively.

4.3. Limitations & further future research

The present research had a number of limitations which suggest avenues for future research. First, the aquatic environments in the present study were generally ones found to be relatively positive in earlier research (Herzog, 1985). Consequently, systematic manipulation of types of aquatic environment, including less preferred ones such as swamps would be an important next step. Another limitation was our restriction to clement weather conditions. There is a darker side to water such as flooding and storms (e.g. Miceli, Sotgiu, & Settanni, 2008) and we are not suggesting that aquatic environments will always be preferred any more than earlier researchers would claim that earthquakes and landslides in natural terrestrial environments would be. Given the environmental changes predicted for the relatively near future (e.g. IPCC, 2007) it may be important to monitor changes in people's perceptions of aquatic environments especially in areas vulnerable to flooding.

We are also aware that although the majority of participants said they were not living near the marine environment they were nonetheless all living in a coastal town, and reactions to aquatic scenes, due to familiarity, may be systematically different from people living far from the sea. Given that our literature review suggested similar reactions by participants living in the middle of continental America (Berman et al., 2008) we believe this is unlikely. Moreover, adaptation processes may mean that our effects provide relatively conservative estimates and ratings of aquatic environments may be even greater for more landlocked people. Clearly, though, more representative samples are required in future.

Our examination of dose-response used a relatively simplistic method of varying the proportions of different environmental elements. A more sophisticated alternative is discussed by Nordh et al. (2009). Specifically, images of parks were divided into 588 squares and those covered by more than 50% of a particular type of environment (e.g. grass, concrete) were measured, providing a more sensitive measure of image content. Unfortunately, the only feature not analysed this way was water which was dummy coded as being either present or absent. Given the results from the present studies future research into dose-response relationships of water (and other environments) might benefit from Nordh et al.'s (2008) finer grained approach.

This is related to the possibility, raised by a reviewer of an earlier version of this manuscript, that our attempt to systematically control the presence of water in both natural and built settings may not reflect the ecological co-variance of these environments. That is, it may be that natural environments that have been preserved from urban expansion are precisely those which, either due to

public preferences or practical limitations on building, are more likely to be aquatic. By contrast urban expansion has occurred in those areas where it is relatively easy to build and where the public raises fewer objections resulting in few natural water features in urban environments. As a result future research might want to establish the naturally occurring co-variance between environmental types. Nevertheless, urban planners can still provide “non-natural” water features in urban areas. One of the photos used in the present research, for instance, featured a pigeon bathing in an urban fountain. This image was ranked 27th overall in terms of attractiveness (out of 120) and 3rd out of 40 predominantly urban scenes. Even if water is less prevalent in urban settings, this does not mean it couldn't be added and, if properly maintained, help improve people's ratings of urban environments.

Our focus on self-report ratings also leaves open the question of whether our findings extend to objective measures of restoration such as improvements in physiological indicators of stress. Previous concordance between self-report and objective indices (e.g. Ulrich et al., 1991; Berto, 2005) suggests they might, but this needs testing. Exploring a different question Fredrickson and Levinson (1998), for instance, found that cardiovascular recovery (i.e. return to baseline following a fearful film) was twice as fast while watching a 100 s long audio-visual presentation of “waves breaking on a beach” than a control film (watching a pile of sticks). Nevertheless, a similar rate of recovery was also associated with viewing a “puppy playing with a flower” suggesting that further work is needed in terms of direct comparisons of actual restoration associated with different environments.

We were also limited, due to the number and type of scenes we presented, to a controlled laboratory setting. A next step will be to examine people's reactions to more realistic aquatic environments via video recordings (e.g. Fredrickson & Levinson, 1998; Karmanov & Hamel, 2008) or field studies (e.g. Hartig et al., 2003). Kjellgren and Buhrkall (in press), for instance, used a repeated-measures design to compare the experiences of 18 chronically stressed participants to either direct experiences or simulated experiences (slideshow in the lab) of the same park. They found experiences were associated with psychological (e.g. self-reported stress) and physiological (e.g. pulse rate) restoration but that the direct experience was associated with greater feelings of immersion. Supporting our general thesis, a small lake was a central feature of both the real and simulated versions of these restorative experiences.

A further consequence of our laboratory approach was that exposure to the scenes was essentially passive. An alternative is to examine the potential synergistic effects of exercise in different environments (e.g. Hartig et al., 2003; Pretty et al., 2005). A program of work beginning to examine this issue for aquatic environments is the “Blue Gym” (Depledge & Bird, 2009). The initiative builds on an earlier one known as the “Green Gym” which encourages people in the UK to undertake volunteering activities in natural ‘Green Space’ (Pretty, Griffin, Sellens, & Pretty, 2003). In a similar vein the Blue Gym aims to encourage exercise in and around aquatic environments or ‘Blue Space’ (www.bluegym.org.uk). If the present findings extend to active interactions with aquatic environments it may offer important policy implications in terms of how best to improve a population's health and well-being (Maller, Townsend, Pryor, Brown, & St Leger, 2006).

A final issue concerns how we can use any benefits resulting from exposure to aquatic environments to enhance pro-environmental behaviours (cf. Hartig, Kaiser, & Bowler, 2001). In a recent study, visitors to the UK's National Marine Aquarium were monitored for changes in their “marine mindset” (Wyles, Pahl, White, Morris, & Snelling, submitted for publication). Results suggested the visit led to more positive attitudes towards fish sustainability and more negative attitudes towards marine pollution with

particular enhancements in conditions where visitors were provided with additional information. For example, visits including information about sustainable fishing resulted in fewer visitors choosing a non-sustainable fish in a later simulated menu task (25% vs. 56%). We believe that greater understanding of people's affinity with aquatic environments could help us develop the sort of interventions necessary to encourage urgently needed pro-environmental attitudes and behaviours with respect to marine and other aquatic environments.

5. Conclusion

Despite the fact that water covers more than two-thirds of our planet, systematic investigation of relationships with aquatic environments, or Blue Space, has been neglected. The current findings suggest this is an important oversight because these environments were associated with higher preferences and more positive subjective reactions than both natural and built settings without water. Although replication of our findings using different techniques and exploration of the underlying mechanisms is still required, the size of the effects across four different measures of well-being was encouraging. If robust, our observations have a number of potential implications. Urban planners, employers, mental and physical health professionals and educationalists may, for instance, want to consider the value of adding aquatic features to built environments, or arranging visits to natural aquatic environments, to promote the mental well-being of citizens, employees, patients and pupils.

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