2017-01-02

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10.1080/01426397.2016.1243236
Landscape Research
Informa UK Limited

A preliminary investigation into the restorative potential of public aquaria exhibits: a UK student-based study

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KEYWORDS
Human biodiversity; preferences; perceived restorativeness; sub-aquatic environments; aquarium; blue space

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Supplemental data for this article can be accessed here.
[http://dx.doi.org/10.1080/01426397.2016.1243236]

ABSTRACT
Even ‘managed’ natural settings, such as botanical gardens and zoos, can provide restorative experiences. Well-being benefits may also be greater in land/waterscapes with greater biodiversity (eg, species richness). Using two photo studies with student participants, we explored aesthetic and behavioural preferences, affect and the restorative potential of multiple public aquaria exhibits, including variation in biodiversity. Study 1 (*N* = 39) found that aquarium exhibits, in general, scored as highly as natural environments (eg, green space) on all dimensions. Study 2 (*N* = 40) examined whether responses were influenced by exhibit characteristics including: climatic region (tropical/temperate), biological group (vertebrates/invertebrates), species richness (high/low) and abundance of individuals (high/low). Supporting predictions, tropical, vertebrate (fish) and High species richness exhibits were generally rated more positively than temperate/invertebrate/low species richness exhibits. However, some low richness/high abundance exhibits were also rated unexpectedly positively. Findings are discussed within the context of the growing well-being and biodiversity literature.

1. Introduction

1.1. Overview

Chronic stress associated with our demanding modern lives can manifest a variety of emotional, cognitive, behavioural and physical symptoms that can lead to serious health problems including anxiety and depression, raised blood pressure and increased risk of heart disease and stroke. Stress can be devastating for the individual but is also a huge economic problem. In 2014/2015, 9.9 million working days were lost in Great Britain due to work-related stress, depression and anxiety (HSE, 2015). Although medication can alleviate symptoms of stress, studies suggest that exposure to pleasant natural environments, or views of nature, can promote relaxation, alleviate stress and facilitate emotional, physical and cognitive recovery, particularly when compared to built settings (eg, Hartig, Evans, Jamner,

Davis, & Garling, 2003; Ulrich et al., 1991; White, Pahl, Ashbullby, Herbert, & Depledge, 2013; reviews: Bowler, Buyung-Ali, Knight, & Pullin, 2010; Velarde, Fry, & Tveit, 2007). Explanations of why humans are drawn to natural environments and other restorative settings are offered by three main theories: the Attention Restoration Theory (ART); the Psychophysiological Stress Recovery Theory (PSRT); and the Biophilia Hypothesis. Briefly, ART proposes that restorative settings can ease mental fatigue caused by extensive episodes of concentration and focus ('directed attention'—see Kaplan, 1995) and PSRT suggests that as humans evolved in natural environments, they have immediate, instinctive positive emotional responses to nature which affect psychological and physiological measures (Berto, 2014; Ulrich et al., 1991). Lastly, the Biophilia Hypothesis suggests that humans have an innate emotional connection with other living organisms (Wilson, 1993). The two most prominent theories on restoration, ART and PSRT, have different perspectives but agree on two main points: people's environmental preferences are influenced by their need for restoration (van den Berg, Koole, & van der Wulp, 2003) and natural environments tend to be perceived as more restorative than built or artificial settings (Berto, 2014). Many studies, however, classify environments simply as 'natural' or 'urban/built' (Velarde et al., 2007). This fails to represent the variety of landscapes, making it difficult to determine which environmental characteristics have contributed to positive health outcomes (Pearson & Craig, 2014). Furthermore, water appears to be a key element of preferred environments (eg, Korpela, Ylen, Tyrvainen, & Silvennoinen, 2010; Ulrich, 1993); yet, many studies exploring the health benefits of natural environments predominately feature 'green space' (Bowler et al., 2010). Evidence of positive relationships between 'blue space' (waterscapes) and human health does exist but appears to be more a by-product of environmental psychology research rather than systematic research into the effects of blue space on health and wellbeing (Volker & Kistemann, 2011; White et al., 2010). Hence, the current research had two main aims. First, we compared the restorative potential of a blue space setting (public aquaria) with that of more commonly researched environments (eg, green space). Although not a 'natural' environment, aquaria provide important opportunities to view nature, and 'indoor nature exposure' (INE review: McSweeney, Rainham, Johnson, Sherry, & Singleton, 2015) provides psychological and physiological health benefits that may be particularly important in urban spaces. Second, as few studies have investigated how specific environmental elements influence health outcomes, we investigated people's preferences for, affective responses to and the restorative potential of, different types of public aquaria exhibits.

1.2. Restorative potential of alternative settings

The presence of water and living things links aquaria to all three theories mentioned, especially ART which proposes that four key components define a restorative setting (Kaplan, 1995): fascination (holds one's attention effortlessly); being away (physically or psychologically removed from everyday routines); extent (coherently connected and offering sufficient scope for exploration); and compatibility (in keeping with an individual's needs). Although frequently encountered in nature, these components may also be found in other, alternative environments such as museums (eg, Kaplan, Bardwell, & Slakter, 1993) and zoos (Pals, Steg, Siero, & van der Zee, 2009). While these settings contain varying amounts of nature, from significant (eg, botanical gardens—Bennett & Swasey, 1996) to very little (eg, museums— Packer, 2008), they nevertheless all provide restorative experiences,

some of which are deemed as restorative as natural environments (Packer & Bond, 2010). Even studies that have not explicitly referred to ART but have instead explored the motivations and derived benefits of visiting such settings have also found them to be potentially restorative (Ballantyne, Packer, & Hughes, 2008; Falk, Heimlich, & Bronnenkant, 2008; Packer & Ballantyne, 2002).
Identifying the environmental cues and clues that lead to improved health and well-being in these settings may be especially important for those who rarely go outside or who have limited access to natural environments (Depledge, Stone, & Bird, 2011). For these people, opportunities to engage with nature in 'managed' environments, or to bring nature indoors, may be particularly helpful.

1.3. Environment subcategories and well-being

Determining the specific landscape characteristics that promote positive health outcomes has been largely overlooked; yet, even environments of the same 'type' can vary markedly. They may include different quantities of natural (eg, plants, water and/or rocks) and built (eg, roads and/or buildings) features, and represent different geographic regions. Each individual feature may affect psychological and physiological responses that, ultimately, may influence environmental preferences (Balling & Falk, 1982) and perceived restorativeness (van den Berg et al., 2003). Landscapes containing water, for instance, are particularly appealing (White et al., 2010); yet, water movement and quality can affect people's responses (Herzog, 1985; Nasar & Lin, 2003). Tenngart Ivarsson and Hagerhall (2008) compared the restorativeness of two healing gardens and found significant differences between them, even though both were perceived as restorative.
However, biological diversity (biodiversity) is one landscape attribute that is attracting interest and, increasingly, studies are examining the relationship between biodiversity, and human health and well-being. For instance, Luck, Davidson, Boxall, and Smallbone (2011) found that personal and neighbourhood well-being was positively associated with species richness and abundance of birds, and vegetation cover and density. Other studies have found that psychological well-being measures (eg, cognitive restoration) tended to be more positive in urban or semi-urban parks that contained greater actual, or perceived, species richness (Dallimer et al., 2012; Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007). It is worth mentioning that the term 'diversity' has been used in several, conceptually different ways in ecological literature, making communicating about diversity quite problematic and confusing (Tuomisto,2010). It is also apparent that the relationship between health and biodiversity is not always clear or consistent. People vary in their ability to judge species richness and well-being outcomes can vary depending on taxonomic group and respondents' demographics. A review by Lovell, Wheeler, Higgins, Irvine, and Depledge (2014) identified positive relationships between biodiverse natural environments, and health and well-being outcomes in 10 of the 16 studies. Nevertheless, they recommended that further research be undertaken as relationships were frequently inconclusive. A preference for greater species richness has also been noted in other areas of research. Lindemann- Matthies and Bose (2007) asked visitors to a botanical garden to create their ideal patch of 'meadow' using real or imaginary plants. The visitors designed structurally diverse, species-rich meadows and stated that diversity was their main assemblage criterion. Lindemann-Matthies, Junge, and Matthies (2010) found that people's appreciation of experimental arrays and natural meadows increased with

true species richness, although their ability to judge species richness was often poor. Although not well-being related, these studies highlight that landscape features can influence people's environmental preferences and, ultimately, may affect the potential for an environment to provide restoration.

1.4. Preferences for, and the restorative potential of, marine life

Studies exploring people's preferences for underwater marine life usually stem from an interest in marine conservation, rather than human health. As conservation efforts are frequently motivated by people's aesthetic preferences, particularly for charismatic megafauna, human preferences may influence whether a particular species, or group of animals, is valued and protected (Stokes, 2007).

Polak and Shashar (2013) investigated divers' willingness to pay for changes in fish and coral qualities over an artificial reef, and found that divers were most willing to pay for conservation efforts that increased the overall level of biodiversity (total richness and abundance of fish and coral species), and least likely to pay for increases in fish abundance only. Uyarra, Watkinson, and Cote (2009) found that species richness and number of fish schools contributed most to the enjoyment of coral reefs. Research examining preferences for different natural environments (including underwater scenes) found that 70% of participants who had previously snorkelled or SCUBA dived preferred to do so in warm, tropical

seas; only 6% preferred these activities in cooler, more temperate waters (White, Cracknell, Corcoran, Jenkinson, & Depledge, 2014).

The studies reviewed by Lovell et al. (2014) almost exclusively related to terrestrial environments: only one study (Curtin, 2009) investigated people's psychological responses to marine life. Curtin found that participants' thoughts and feelings on a whale-watching trip frequently resonated with the Biophilia Hypothesis and ART, as participants expressed awe and wonder for nature's beauty and design, found the excursions lifted their spirits, facilitated contemplation and a time to 'stand and stare' and elicited feelings of deep joy and happiness. Curtin proposed that these responses suggest that these excursions could be healing and restorative. Although illuminating, Curtin's study was on genuine outdoor marine life experiences and the question remains how indoor nature experiences may compare.

1.5. Restorative potential of aquaria

Although we know relatively little about preferences for natural sub-aquatic environments (White et al., 2014), we have a better understanding of preferences for indoor underwater settings. Many people keep home aquaria because they find them calming and helpful in reducing levels of stress and anxiety (Kidd & Kidd, 1999). Potentially, this also explains their frequent inclusion in health care settings. The belief that watching fish is calming and relaxing is supported by several studies that have shown beneficial physiological (decreased heart rate and/or blood pressure, eg, DeSchriver & Riddick, 1990; Wells, 2005) or psychological responses (greater relaxation, reduced anxiety, eg, Katcher, Segal, & Beck, 1984) to watching live fish in small tanks, or video footage of aquarium fish, when compared to control conditions.

Public aquaria also provide opportunities to view nature and spend time in close proximity to living things, and evidence suggests that these experiences can be restorative. Work comparing motivations to visit museum-type environments found that visitors to an aquarium were more likely to be motivated by restoration than visitors to either a museum or art gallery (Packer & Ballantyne, 2002). Certainly, public aquaria fit the four components central to ART: they contain many different animals that easily capture one's attention (fascination); they are physically located away from a person's everyday life (being away); there are different exhibits and displays to explore (extent); and somewhere a person has chosen to visit (compatibility). One study investigating the psychological and physiological responses of viewing a large aquarium exhibit, during a three-stage restocking event, observed measurable reductions in heart rate and blood pressure, and found that the greatest improvements in mood occurred when the exhibit was fully stocked (Cracknell, White, Pahl, Nichols, & Depledge, 2015). However, being a field study, restocking could not be controlled and species richness and abundance were confounded, making it difficult to establish how either characteristic affected well-being outcomes.

Public aquaria usually display a variety of large and small, tropical and temperate exhibits. Exhibits may house a single interesting specimen (eg, Giant Pacific Octopus, *Enteroctopus dofleini*); a mixed community (eg, representating a coral reef); or feature large numbers of the same species (eg, Northern anchovies, *Engraulis mordax*). Some exhibits feature 'charismatic' species (eg, seahorses, *Hippocampus*

spp.—Jefferson, Bailey, Laffoley, Richards, & Attrill, 2014), whereas other exhibits may contain anecdotally
less appealing animals such as crabs ('invertebrates'—see Kellert, 1993; Woods, 2000). First author
observations of aquarium visitors suggest that people have preferences for certain exhibit types and that
different exhibits elicit different emotional responses (eg, awe, calm and/or excitement). Establishing
which exhibit characteristics prompt which response is important. As over 700 million people visit
public aquaria annually (Gusset & Dick, 2011), the potential for these indoor nature experiences to help
alleviate stress and anxiety may be quite significant.

1.6. Current research and hypotheses

Although viewing marine life, in real or managed environments, provides potentially restorative
experiences, it appears that neither of these areas has been studied extensively. Hence, founded on
theoretical frameworks exploring people's preferences for different types of landscapes (eg, Purcell,
Peron, & Berto, 2001; Ulrich et al., 1991) and animals (eg, Kellert, 1993; Woods, 2000), and the perceived
restorativeness of different settings (eg, Berto, 2005; Hartig, Korpela, Evans, & Garling, 1997), the
current research had two main aims. First, using the commonly employed method of asking people
to rate photographs, Study 1 investigated preferences for, affective responses to and the perceived
restorativeness of human-made sub-aquatic scenes (aquarium exhibits) compared to three natural
environments and one built environment. As White et al. (2014) found that natural underwater scenes
were as preferred as green space, we hypothesised that aquarium exhibits would be at least as preferred
and potentially restorative as natural underwater environments and green space, and would be rated
more highly than built. Second, as natural landscapes differ in their characteristics (water, land and/or
wildlife) and may elicit different preferences and restorative experiences, Study 2 explored responses
to different exhibit types, subcategorised by climatic region, biological 'group', species richness and
abundance of individuals. Based on previous studies, we hypothesised that preferences and perceived
restorativeness would be greater for tropical exhibits, vertebrates, and exhibits containing higher
abundance and species richness.

2. Study 1

2.1. Method

2.1.1. Development of photo set

We developed a set of 50 colour photographs, 10 each of five landscape types (Figure 1): ‘Built’ (eg, buildings and/or roads); ‘Green’ (eg, fields and/or woodland); ‘Aquatic’ (water and associated aspects, eg, sandy beach); ‘Natural sub-aquatic’ (underwater scenes, eg, seabed); and ‘Human-made sub-aquatic’ (ie, aquarium exhibits). Images of the first four environments were of pleasant scenes in climatically temperate regions. The fifth category contained 10 images of ‘typical’ aquarium exhibits and, as such, contained both tropical and temperate exhibits.

Figure 1. Example scenes of different land and waterscapes (Study 1).

2.1.2. Participants

Participants (*N* = 39) were UK university students who participated for course credit (29 females, *M* age = 19.5 years, range 18–25 years). Sixteen of the participants (41%) had previously snorkelled, SCUBA dived or free dived.

2.1.3. Procedure

The procedure followed White et al. (2014). Each participant viewed all photos in a fully repeated measures design. On entering the testing laboratory, participants were informed about the general nature of the study, the confidentiality of their answers and their right to withdraw in accordance with the university’s ethical requirements. If willing to proceed, they were seated in front of a standard PC, approximately 60 cm from a flat-screen monitor. Participants began by reading an explanatory passage which told them that they were going to rate a series of photographs on four dimensions. The questions appeared below the image in sequence, one at a time. A response to each question was required before being replaced with the next question. Participants completed three practice trials before proceeding with the main study, at their own pace. Photo order was randomised for each participant. Following the final image rating, participants answered two additional questions (see Supplementary Material) before being debriefed and thanked.

2.1.4. Measures

Adapted from White et al. (2010; see also Herzog, 1985), the preference questions reflected aesthetic (‘How pleasant do you rate this scene?’) and behavioural (‘How willing would you be to hang this picture in your room?’) preferences. Responses were on a scale of ‘Not at all (1)’ to ‘Extremely (10)’. Affective reactions to the image were measured by asking ‘How does this photo make you feel?’ from ‘Very Sad

(1)' to 'Very Happy (10)' (see de Kort, Meijnders, Sponselee, & Ijsselsteijn, 2006). Perceived restorativeness was measured using a single item adapted from Felsten (2009): 'Overall, to what extent do you think that this scene would be excellent for restoring your ability to concentrate or work effectively on a demanding project?' with responses from 'Not at all (1)' to 'Extremely (10)'. Finally, participants were asked 'To what extent do you find watching fish relaxing?' (1–10 scale) and 'Have you (either now or in the past) snorkelled, free dived or SCUBA dived?' (Yes/No response).

2.2. Results and discussion

We calculated the mean of all responses to the 10 images of each land/waterscape type and used these means to examine the results for each dependent variable using a series of one-way repeated measures analysis of variance (ANOVAs). Screening of boxplots revealed one statistical outlier (> Mean plus/minus 3x SDs) for one of the 20 key variables. As removal of this outlier did not significantly alter statistical results, the participant was retained. To examine normality, data were checked for skew and kurtosis. There was no kurtosis but 4 out of the 20 variables were subject to either a slight positive or negative skew (all ≤ 2.6). Transformation of these data did not significantly alter our findings, so the original data were retained.

Table 1. Means (*M*) and standard deviations (SD) for aesthetic preference, willingness to display, affective valence and perceived restorativeness for different environments.

Environment type	Attractiveness *M* (SD)	Willingness to display *M* (SD)	Affect *M* (SD)	Restorativeness *M* (SD)
Built	3.18a (1.37)	2.23a (1.10)	3.58a (1.29)	2.45a (1.06)
Natural subaquatic	6.19b (1.80)	4.94b (2.05)	5.78b (1.62)	4.83b (1.98)
Green	6.53b (1.28)	4.67b (1.70)	6.21b (1.32)	5.17b (1.68)
Man-made sub-aquatic (aquarium)	7.64c (1.30)	6.40c (1.92)	7.02c (1.45)	5.88c (1.92)
Aquatic	7.89c (1.27)	6.61c (1.99)	7.35c (1.49)	6.48d (1.85)

Notes: Column means with different superscripts are significantly different (a-b: $p < .001$; b-c: $p < .01$; c-d: $p < .05$). All scales from 1 to 10.

The means for each environment were entered in order (lowest to highest means) enabling repeated contrasts to compare the significance between adjacently ranked environments (Table 1). The main

effect of environment type was significant for all four aspects: aesthetic preference, $F(4, 152) = 142.87$, $p < .001$; willingness to display, $F(4, 152) = 91.13$, $p < .001$; affect, $F(4, 152) = 94.87$, $p < .001$; and perceived restorativeness, $F(4, 152) = 86.12$, $p < .001$. As anticipated, the built environment was the least preferred environment and scored significantly lower on all four dimensions (all p values < .001) than images of natural environments (sub-aquatic, green and aquatic) and managed nature (aquarium exhibits). There were no significant differences between ratings for natural underwater environments and green space on all four dimensions (all ps > .05) but these environments were significantly less preferred than aquatic and aquarium waterscapes (all ps < .01). Aquatic and aquarium scenes were the most preferred environments. There were no significant differences between these waterscapes for aesthetics, behavioural choice or affect (all ps > .05), although the aquatic images were perceived as more restorative ($p = .016$).

To explore whether familiarity with sub-aquatic environments affected participants' responses, we examined the differences in environment ratings between divers and non-divers. One-way ANOVAs revealed no statistically significant differences between the two groups for any of the environments, on any of the four dimensions, suggesting that familiarity with sub-aquatic environments was unimportant in this study. Both divers ($M = 8.19$, SD = 1.56) and non-divers ($M = 7.48$, SD = 2.19) found watching fish relaxing but a one-way ANOVA revealed no significant differences.

In summary, and in support of our anticipated findings, aquarium images were rated more highly than built, green space and natural sub-aquatic images, and similar to aquatic scenes (an overall mean for all four dimensions was calculated, giving an overall 'preference' rating for each environment— Cronbach's $\alpha = .934$: Figure 2). Although aquarium images were significantly more preferred than natural sub-aquatic images, this may be the result of the more 'exotic' nature of the aquarium images.

As mentioned, in order to gain an impression of people's reactions to the range of typical aquarium exhibits, tropical images were also included. Potentially, if only images of temperate marine animals had been included in the aquarium category, there may have been little, if any, difference between these two environment types. Therefore, in order to establish whether characteristics of an exhibit

Figure 2. Environment ordered from least to most preferred (Study 1).

(eg, tropical vs. temperate) influenced well-being outcomes, our second study investigated responses
to a range of exhibit types.

3. Study 2

3.1. Method

3.1.1. Development of photo set

We developed a set of 40 photographs representing different exhibit types typically found in public
aquaria (Figure 3). Exhibit images were subcategorised based on climatic region (temperate/tropical
water), biological group (vertebrates/invertebrates), species richness (high/low) and abundance of
individuals (high/low). Thirty images of vertebrates (all fish species) and 10 images of invertebrates
were selected. As far as possible, subcategories were balanced for charismatic and less charismatic
species. From a shortlist, six aquarium biologists known to the first author rated and selected five
images most representative of each subcategory (example subcategory: Tropical—Low species richness/
High abundance). Photographs were sourced from the first author's personal collection, photographs
from colleagues and Internet sites (eg, Flickr). Hundreds of photographs were obtained but most were
discarded due to poor quality or unsuitable content. This was especially true of the temperate, High
species richness/High abundance category, which appeared particularly underrepresented.

3.1.2. Participants

Participants (*N* = 40) were students at a UK university who participated for course credit (27 females,
M age = 20.8 years, 18–35 years). Eighteen participants (45%) had snorkelling, SCUBA or free diving
experience.

Figure 3. Example scenes of different aquaria exhibits (Study 2).

3.1.3. Procedure and measures

The procedure and measures were identical to Study 1: participants rated photographs on four
dimensions, and were asked about prior diving experience and how relaxing they found watching fish.

3.2. Results and discussion

We again calculated the overall mean from responses to each exhibit type (Table 2) and examined the
results for each dependent variable using a series of one-way repeated measures ANOVAs. Screening
of boxplots revealed no statistical outliers. There was no kurtosis and all 32 key variables were normally

distributed, except one that was subject to a slight positive skew (2.19). Data were transformed but did
not significantly alter our findings; therefore, the original data were retained for analyses.

Table 2. Means (*M*) and standard deviations (SD) for aesthetic preference, willingness to display, affective valence and perceived
restorativeness for different exhibit types.

Note: All scales from 1 to 10.

Environment (exhibit) content		Dimensions				
Group	Region (No. of images)	Species richness	Abundance	Attractiveness	Willingness to display	Affect	Restorativeness
		M (SD)	*M* (SD)	*M* (SD)	*M* (SD)	
Invertebrate	Temperate (5)	Low	Low	3.82 (2.06)	2.67 (1.81)	4.06 (1.64)	3.27 (1.81)
Invertebrate	Tropical (5)	Low	Low	5.44 (1.72)	4.05 (2.08)	5.12 (1.45)	4.34 (1.70)
Vertebrate	Temperate (5)	Low	Low	4.93 (1.67)	3.38 (1.93)	4.88 (1.48)	4.05 (1.69)
Vertebrate	Tropical (5)	Low	Low	5.83 (1.38)	4.33 (2.05)	5.72 (1.07)	4.60 (1.44)
Vertebrate	Temperate (5)	Low	High	6.10 (1.34)	4.31 (1.80)	5.58 (.99)	4.60 (1.56)
Vertebrate	Tropical (5)	Low	High	6.94 (1.07)	5.38 (1.80)	6.29 (1.00)	5.22 (1.64)
Vertebrate	Temperate (5)	High	High	4.80 (1.29)	3.31 (1.47)	4.63 (1.20)	3.90 (1.44)
Vertebrate	Tropical (5)	High	High	7.67 (0.98)	6.05 (1.78)	6.92 (1.21)	5.62 (1.91)

Figure 4. Preference ratings for attractiveness, willingness to display, affect and perceived restorativeness as a function of climatic
region and biological group (Study 2).

First, we conducted a two (region: temperate; tropical) by two (biological group: invertebrates;
vertebrates) repeated measures ANOVA on the Low abundance/Low species richness category (Figure 4).

We found a significant effect of region: images of tropical species were consistently more preferred than
those of temperate species on all four dimensions (Attractiveness: $F(139) = 80.30$, $p < .001$; Willingness
to display: $F(139) = 64.24$, $p < .001$; Affect: $F(139) = 92.93$, $p < .001$; Perceived restorativeness: $F(139) =$
51.49, $p < .001$). We also found a significant effect of group, with vertebrates being significantly more
preferred than invertebrates (Attractiveness: $F(139) = 29.76$, $p < .001$; Willingness to display: $F(139)$
$= 13.57$, $p = .001$; Affect: $F(139) = 30.81$, $p < .001$; Perceived restorativeness: $F(139)$ $= 23.47$, $p < .001$).

We noted a significant interaction for three of the four dimensions (Attractiveness: $F(139) = 12.02$,

p = .001; Willingness to display: *F*(130) = 4.80, *p* = .035; Perceived restorativeness: *F*(139) = 6.45, *p* = . 015),
suggesting that the content of temperate exhibits (ie, vertebrates vs. invertebrates present) was more
important than for tropical exhibits.
Second, we conducted a series of two (region: temperate; tropical) by three (biota level: Low
species richness/Low abundance; Low species richness/High abundance; High species richness/High
abundance) repeated measures ANOVAs on the four dependent variables (Figure 5). Tropical exhibits
were again rated significantly higher than temperate exhibits (all *p*s < .001). We also found a significant
effect of biota level (all *p*s < .01). Repeated measures contrasts revealed that the Low species richness/
High abundance condition was rated significantly higher than the Low species richness/Low abundance
condition (*p*s < .01). Comparison of the High species richness/High abundance and Low species richness/
High abundance conditions found that the High species richness/High abundance category was only
rated statistically higher for attractiveness (*F*(139) = 6.49, *p* = .015). Intriguingly, paired *t*-tests revealed
that although ratings for the tropical High species richness/High abundance exhibits were consistently
and significantly greater than the tropical Low species richness/High abundance ratings (all *p*s < .01),
the opposite was true for the temperate images: the Low species richness/High abundance images
were preferred to the High species richness/High abundance images (all *p*s < .001).
Figure 5. Preference ratings for attractiveness, willingness to display, affect and perceived restorativeness as a function of climatic
region and biota level (Study 2).

Divers and non-divers rated the High abundance categories similarly, but divers rated the Low
abundance categories significantly higher than non-divers, especially regarding how the image made
them feel (all *p*s < .05). Again, we found no significant differences between diver and non-diver ratings
for how relaxing they found watching fish (overall *M* = 7.50, SD 1.47).
Generally, our hypotheses were supported: participants preferred tropical exhibits to temperate
exhibits, higher rather than lower numbers of individuals and vertebrates (fish) to invertebrates.
Intriguingly, and contrary to our original hypothesis, High species richness was only rated more highly
for the tropical exhibits: temperate exhibit images scored more highly when species richness was low.

4. General discussion

4.1. Summary of main findings

We found support for our hypothesis in Study 1: aquarium exhibit images were at least as preferred and potentially restorative as natural underwater environments and green space. Furthermore, aquarium images were rated similar to the most highly rated environment in this study—aquatic (blue space) environments. Generally, our hypotheses for Study 2 were also supported: when viewing images of different exhibit types, participants tended to prefer tropical exhibits, higher abundance and vertebrates.

However, one finding appeared contrary to our predictions. Although, as hypothesised, the tropical High species richness/High abundance category was rated significantly higher than both Low species richness categories (and was the most highly rated of all exhibit categories), the same could not be said of the temperate equivalent. This category rated surprisingly low and appears at odds with overall findings.

We offer a number of possible explanations for these results. First, we believe that the relatively poor ratings for this category partly reflect the paucity of good-quality images with which to represent this category at its best. Despite a seemingly inexhaustible quantity of images, most were unusable (eg, blurred fish and/or camera flash). Furthermore, photographs of some exhibit categories featured more heavily than others: colourful coral reef tanks, charismatic species (eg, clownfish, *Amphiprion spp*.), dynamic schooling fish and exhibits housing large, impressive animals (eg, whale sharks, *Rhincodon typus*) were particularly well represented. However, although we found many good-quality images of large mixed species (our High species richness/High abundance category) tropical exhibits, comparable photos of temperate exhibits were scarce. Although the overall lack of images available may reflect people's behavioural preferences (ie, perhaps taking fewer photographs of exhibits they do not particularly like), it is more likely that the lack of suitable images reflects poor image quality. Aquarium exhibits are designed to replicate natural habitats and while tropical species are often brightly coloured and well illuminated in clear water, in temperate regions, where light intensity is lower, species tend to be less obviously colourful and often more cryptic. Photographing temperate species in these more dimly lit environments is more challenging (especially as public aquaria often prohibit flash photography) and poor-quality images can result.

Second, when the temperate High abundance categories (High vs. Low species richness) were compared, the Low species richness exhibits were more significantly more preferred. One possible explanation may be the presence of some images of schooling fish in the temperate Low species richness/High abundance photographs. These ‘bait ball’ images were visually striking and perhaps people find the inferred movement fascinating, despite the uniform appearance of the fish. Dallimer et al. (2012) also noted that ‘it is equally possible that the abundance of a given taxonomic group is more important or noticeable than the number of different species’ (p. 51). Indeed, finding that greater species richness may not always be the preferred assemblage is intriguing. It is, therefore, conceivable that different fish assemblages may provide different health outcomes that could be ‘tailored’ depending on purpose and circumstance (eg, calming vs. energising experiences).

4.2. Limitations and future work

The two photo studies provided an effective method of exploring people’s preferences for multiple human-made and natural settings, and aquarium exhibit characteristics. Nevertheless, studies seeking to establish whether simulated environments can sufficiently represent real environments (eg, Kjellgren & Buhrkall, 2010) often find simulated nature can provide health benefits but that real nature enhances benefits further. Huang (2009) investigated the use of visual surrogates to represent waterscapes by comparing participants’ psychological responses to slides and video footage, to their responses in the real environment. Huang found slides were only able to sufficiently represent the still physical features in the waterscape (eg, built objects) and video footage was better than slides for conveying the dynamic aspects of a scene (eg, water flow). As environmental simulations aim to maintain the landscape feature being investigated (Huang, 2009), photographs may not be the best way to represent environments containing water (see also Nasar & Lin, 2003) or highly mobile species. Although ‘real nature’ appears to provide the ‘optimum’ benefits, video footage may improve applicability and validity by providing a more realistic representation of exhibits than photographs in settings where exposure to real aquaria is not feasible.

Due to the number of photographs being evaluated in each study, it was decided to use one item

per construct. Although this is a common approach when there are numerous settings to evaluate (eg, Felsten, 2009; White et al., 2010), we recognise that this reduces the sensitivity with which we are tapping into the underlying constructs. Thus, in future work that uses smaller stimuli sets, and therefore places fewer burdens on participants, researchers may want to use established multi-item scales (eg, Perceived Restorativeness Scale—Hartig et al., 1997) to ensure greater robustness in concept measurement.

Another potential limitation of this work was the use of students as there is much debate on whether student participants are generalisable to the wider population. Nevertheless, given that two of the three main theories on restorative environments (Biophilia and PSRT) propose an evolutionary basis for humans' responses to the natural world, we believe that this may be less of an issue in our work than in other areas of research (eg, consumer research—Peterson, 2001). Further work, however, could explore whether non-students exhibit similar preferences, although the observational aspect of Cracknell et al.'s (2015) research in a real aquarium (Study 1a) suggests that they do. Specifically, observation of paying visitors' preferences (measured by dwell time) was exactly in line with the current work: visitors spent longer looking at the tank when biodiversity levels were higher. Our findings relating to species richness were only partially supported: only the tropical High species richness category was significantly more preferred to Low species richness categories. We suggest, therefore, that further studies are required in order to establish other factors that may be influencing diversity preferences.

Although people visit public aquaria for many reasons (eg, entertainment; learning experiences—Wyles et al., 2013), making it difficult to tease apart the different benefits of a visit, a small percentage of visitors ('spiritual pilgrims'—Falk et al., 2008) are primarily driven by the desire for restorative and/or contemplative experiences. For these visitors, and for more general applications in health care, therapeutic or workplace settings, it is important to establish which species, and combinations of species, offer the best health outcomes and under what circumstances: assemblages found to create a calming and stress-reducing environment may be very different from those that provide uplifting and stimulating experiences.

4.3. Conclusions

Overall, these findings contribute to a greater understanding of the restorative potential of public aquaria and, by proxy, natural underwater settings, both areas of research that have received relatively little attention. We suggest that, for some people, aquaria may be potentially as restorative as some natural settings, and may therefore offer valuable opportunities for easy and regular access to a restorative environment. As well as being beneficial for those with little or no access to natural environments, more broadly, this extends to the wider population, who are exposed to increasingly

stressful and urbanised lives. However, although our findings suggest that people clearly find some exhibit characteristics preferable and potentially more restorative than others, we are not suggesting that aquaria are only filled with just animals that people 'like best'. Less aesthetically pleasing animals are still ecologically important and demonstrate the diversity of the marine environment. Instead, we believe that it is important to understand people's responses to different exhibit characteristics as certain animals or behaviours may prove particularly relaxing, uplifting or stimulating to watch. Although this has implications for aquarium planning (eg, different types of exhibit may facilitate the uptake of key conservation messages), this information may be more beneficial when trying to establish the 'optimum' exhibit for other environments, such as a stressful workplace and therapeutic/health care setting.

Acknowledgements

We would like to thank Abigail Corcoran and Melanie Gruendel for help with data collection, Kayleigh Wyles for help with statistical analyses and Lynne James for help with programming.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This research was conducted as part of the first author's PhD, funded by National Aquarium Limited (NAL). The authors confirm that NAL played no part in the study design, data collection or analysis.

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