Title

'Blue' coasts: unravelling the perceived restorativeness of coastal environments and the influence of their components

Authors

Alexander HOOYBERG*[a] (alexander.hooyberg@vliz.be)

Nathalie MICHELS[b,c] (nathalie.michels@ugent.be)

Jens ALLAERT[d,e] (jens.allaert@ugent.be)

Michiel VANDEGEHUCHTE[a] (michielvandegehuchte@gmail.com)

Gert EVERAERT[a] (gert.everaert@vliz.be)

Stefaan DE HENAUW[b] (stefaan.dehenauw@ugent.be)

Henk ROOSE[f] (henk.roose@ugent.be)

Affiliations

[a] Flanders Marine Institute, Ostend, Belgium

[b] Department of Public Health and Primary Care, Ghent University, Ghent, Belgium

[c] Department of Developmental, Personality and Social Psychology, Ghent University, Ghent, Belgium

[d] Department of Head and Skin, Ghent University, University Hospital Ghent, Ghent, Belgium

[e] Department of Psychiatry and Medical Psychology, Ghent University, Ghent, Belgium

[f] Department of Sociology, Ghent University, Ghent, Belgium

Corresponding author

Alexander HOOYBERG: alexander.hooyberg@vliz.be; Flanders Marine Institute – Wandelaarkaai 7, 8400 Ostend, Belgium; +32-(0)59-34 14 97

1 Introduction

Understanding how outdoor environments impact psychological restoration is key for achieving and maintaining good mental health in our society (Filipova et al., 2020). Poor mental health has become increasingly prevalent, and now approximately one out of six people suffer from mental illness in Europe (OECD & European Commission, 2020). To cost-effectively treat and prevent poor mental health, researchers have increasingly investigated how outdoor environments may act as “the ultimate healthcare system” (UNEP, 2019).

Outdoor environments can provide psychological restoration in many ways, but it is still unclear which physical and social components of the environment determine its restorativeness. Exposure to outdoor environments can bring psychological restoration by replenishing cognitive resources (Berman et al., 2012; Grassini et al., 2019; Ladouce et al., 2019; Ohly et al., 2016; Stevenson et al., 2018), inducing a more positive emotional balance (Bratman et al., 2021; Brooks et al., 2017; Browning et al., 2020; Kondo et al., 2020), and/or altering the hormonal and nervous system-related physiology towards less stress (Haluza et al., 2014; Hartig et al., 2014; Mygind et al., 2019). Attention restoration theory predicts that the restorativeness of an environment increases when there is high (soft) fascination, scope/extent, compatibility, and being away, because these features allow a person to be distracted from everyday demands and to replenish depleted directed attention resources (R. Kaplan & Kaplan, 1989; S. Kaplan, 1995). On the other hand, psycho-evolutionary theory explains that humans have evolved to recover quickly from psychological and physiological stress in natural non-threatening and resource-rich environments, and not in urban environments (Ulrich, 1981, 1983; Ulrich et al., 1991). A large body of literature has shown that components that increase or decrease the naturalness (e.g. vegetation, urban park attributes) indeed co-determine the environment’s potential for psychological restoration (Gascon et al., 2015; Georgiou et al., 2021; Jiang et al., 2014, 2015, 2016; Karmanov & Hamel, 2008; Labib et al., 2020; Lindal & Hartig, 2013, 2015; Liu et al., 2022; Neilson et al., 2016, 2017, 2020; Nguyen et al., 2018; Nordh et al., 2009; Mears et al., 2019; Van den Berg et al., 2014; White et al., 2010, 2016). Together with the natural and urban components, the presence of other people may also alter the potential for psychological restoration in an environment (Collado et al., 2017; Maas et al., 2009; Neale et al., 2021; Staats & Hartig, 2004). The few studies that investigated this showed that psychological restoration is likely to be increased in the presence of non-threatening people (e.g. friends or family) without overcrowding, due to increased perceived safety (Ashbullby et al., 2013; Herzog & Rector, 2009; Nordh et al., 2011; Staats & Hartig, 2004). However, there exist many types of environments with different proportions of natural and urban components and people, such as along urbanized coasts. It is still unknown how the psychological restoration varies within such heterogeneous environments, and how each component of the environment contributes to forming the restorative experience (Browning et al., 2021; Hartig et al., 2014; Joye & de Block, 2011; Neilson et al., 2019; Ohly et al., 2016; Stevenson et al., 2018; Velarde et al., 2007).

Previous research has illustrated that coastal areas as a whole are beneficial for human health (XXX, 2020 masked for blind review; Peng & Yamashita, 2016b; Wheeler et al., 2012; White et al., 2013), that there is some level of cross-country variation in Europe (White et al., 2021), that the influence of coastal areas as a whole on psychological restoration and mental health is yet unclear (Gascon et al., 2015, 2017; XXX, 2020 masked for blind review), but that beaches alone definitely promote psychological restoration (Hipp & Ogunseitan, 2011; Jarratt & Gammon, 2016; Peng & Yamashita, 2016a; Wyles et al., 2016), and that two adjacent types of coastal environments can have different impacts on restoration (i.e. urbanized beach vs. coastal city; (Vert et al., 2020). However, the heterogeneity in the restorativeness due to the spatial diversity in the types of coastal environments and their components has not been addressed. For example, at the Belgian coast, more natural environments (e.g. beaches, dunes, salt marshes) are interspersed with more urban ones (e.g. towns, dikes, harbors), and this inter-environment variability may explain why living at the Belgian coast is associated with overall no improvements in psychological health (XXX, 2020 masked for blind review). Moreover, Vert and colleagues (2020) illustrated that walking in a nearby urban beach brought more restoration compared to walking in a nearby coastal city, which further supports the hypothesis that there is inter-environment variation in psychological restoration along coastal areas. Additionally, intra-environment variation may also exist within a coastal environment, especially at beaches. The presence or absence of various anthropogenic amenities, such as beach bars or beach cabins, may cause micro-scale differences in the potential for psychological restoration. Previous studies have inexplicitly supported this notion by describing the varying experiences of visitors depending on the varying natural and urban components and people at beaches (Ashbullby et al., 2013; Chen & Teng, 2016; Maguire et al., 2011; Subiza-Pérez et al., 2020). Thus, both inter- and intra-environment variation in the restorativeness of coastal areas may have resulted in inconsistent findings across studies, but it is still unclear how (de Vries et al., 2021; Gascon et al., 2017; Georgiou et al., 2021; Severin et al., 2021; Vert et al., 2020; White et al., 2010, 2017).

This study’s first aim was to quantify the inter- and intra-environment variation in psychological restoration along the Belgian coast. The second aim was to quantify the influence of naturally varying doses of natural and urban components and people in the environments on the psychological restoration. To do so, ten distinctive coastal environments and five distinctive beach environments were identified along the Belgian coast and represented by pictures, which were to be rated by the study participants on the perceived restorativeness. The picture-ratings were linked to the type of coastal or beach environment, and to the doses of the natural and urban components and people as identified on the pictures.

2 Materials and methods

2.1 Study design

This study's aims were addressed with data from a picture-rating experiment with a within-subject design. The pictures showed ten coastal environments and five beach environments along the Belgian coast, and each participant rated each picture on the perceived restorativeness of the displayed environment in a randomized order. The pictures were also used to quantify the doses of natural and urban components and of people, to be representative for their doses in the real environments. The experiment was designed to answer additional research questions than those addressed in this study, and here we only report those aspects that were relevant to address this study's aims.

Tackling the aims of this study with a picture-rating experiment required to address three methodological challenges. Firstly, pictures only represent the visual part of the actual multi-exposure environment, and the components of the real environment are only being represented by their visual aspects on the pictures (Browning et al., 2021). Secondly, the ratings of the perceived restorativeness only represents how the participant perceived the depicted environments to be restorative, and thus differs from objective measures for psychological restoration (Figure 1Hartig et al., 2014, 1997). Thirdly, the participant's attention and conduct towards the visualized environment may differ between participants and may change throughout the experiment. More specifically, experimentally induced fatigue-effects or other unconscious visual and attentional processes (e.g. concentration, gaze) may alter the actual dose of the exposure and its according effect sizes (Nordh et al., 2010). In turn, this can be influenced by individual or contextual effect modifiers (e.g. mental health; White et al., 2020). These three methodological challenges seem to have hardly been reported in the literature (Browning et al., 2021). Therefore, we present them here in a newly developed diagram (Figure 1). To address these challenges, we thoroughly searched the extant literature to find the best methodological practices. Many good practices have been reported (Hartig et al., 1997, 2014; Jiang et al., 2014, 2015, 2016; Nordh et al., 2009; White et al., 2010), but no standardized guidelines or best methodological practices seemed to be available (Browning et al., 2021). Therefore, we built further on the studies that reported good practices, and tackled the three challenges by assembling a valid picture set, an improved scale for perceived restorativeness, and a good experimental procedure. Recently, this strategy was also suggested by the review of Browning and colleagues (2021).

2.2 Participants

The study participants included 102 healthy 18-to-29-year-old students (Table 1). This sample size was in line with an a priori power analysis based on similar work by Nordh et al. (2009) and White et al. (2010). No exclusion criteria were adopted. The data-collection occurred in two periods from February 21st till March 12th 2020 (labelled as ‘Period 1’) and from September 7th till November 27th 2020 (labeled as ‘Period 2’), due to the restricted government regulations to combat the spread of the COVID-19 virus. The study was conducted in accordance with The Code of Ethics of the World Medical Association for experiments involving humans (Declaration of Helsinki) and was approved by Ghent University’s Medical Ethical Committee.

2.3 Pictures

2.3.1 Picture-set assembly

The participants watched 52 pictures that were photographed along the Belgian coast. The pictures were optimized to maximally represent the real environments and to be standardized relative to each other.

The Belgian coast is 65 km long and has landward dunes and urban developments in the form of municipalities and harbors (Kustportaal; Marine Regions, 2009), and we targeted leisure destinations approximately < 1 km to the shore. We chose the most commonly found environments along the Belgian coast, and those that are most representative for what coastal visitors may encounter during their recreational activities. As such, ten coastal environments were included in this study for the inter-environment comparison: beaches, piers, dunes, salt marshes, green parks, dikes, towns, recreational harbors, docks, and historical sites; and five beach environments for the intra-environment comparison: open beach, in the seawater, on a breakwater, between beach cabins, and in a beach bar.

A large number of pictures were taken in the environments on June 7th, June 8th, and June 17th 2019 (N = 838), from which a selection was made later. The photography was done by the lead author of this study, who had explored most of the leisure destinations along the Belgian coast in his private life prior to the start of this study. The pictures were taken at multiple locations within the identified environments and in the most likely directions of view, while ensuring that the amount of natural and urban components and people on the pictures were representative for their amounts that are commonly found in the real environments throughout the year. Thus, we did not exclude people but avoided taking pictures during peak-tourism. Similarly as in previous studies, we took all pictures during calm and sunny weather conditions (Jiang et al., 2014 and White et al., 2010). Additionally, since several technical attributes of the pictures could impact the viewers' experience and the pictures' representativeness for the real environment, such as picture sharpness, zoom, and perspective (Yarbus, 1967), the pictures were taken with the appropriate camera settings and shooting practices (Supplementary Material Section 1.2).

The pictures that were shown to the participants and were relevant for addressing this study's aims included 52 of the most representative pictures from the large initial set. The strategy was to eliminate the scenes that contained the least elements or situations that would raise questions among the participants or draw their attention undesirably. In the end, we made sure that each environment was represented by at least two pictures (Table 2). Notably, one picture of a salt marsh needed to be retrieved from the web, and disturbing elements on two-pictures were edited out. All the pictures were further edited to improve the realism of the lightness and darkness (e.g. details visible in the shadows) and to homogenize color tone, saturation, and contrast across the pictures. Editing was done in Adobe Lightroom (Adobe, 2020a) and Adobe Photoshop (Adobe, 2020b), after which all pictures were exported in jpeg-format with a full-HD 1920 x 1080 resolution to be imported in E-Prime 3.0 (Psychology Software Tools Inc., 2016) for visualization during the experimental procedure and in Tobii Pro Lab (Tobii Pro AB, 2014) for analyses of the pictures' components.

2.3.2 Dose of natural and urban components and people

To calculate the dose of natural and urban components and people on each picture, we adopted a pixel-based density calculation. This procedure was similar to the tree density calculations in panoramic exposures by Jiang et al. (2014, 2015, 2016), which were highly appraised by the review of nature simulations by Browning et al. (2021). In this study, each part of each picture that was easily identifiable and distinguishable from other parts of the picture was delineated by manually drawing a polygon around it. We meant to include each pixel to exactly one polygon, so that there was no overlap or unassigned pixels at the borders of the polygons (see Figure 2 for an example). Then, the relative cover of each polygon was calculated as the number of pixels belonging to that polygon divided by the total number of pixels in the picture. As such, the relative cover of a polygon is the result of both the component's size (i.e. bigger things take up more of the picture) and distance to the camera (the further away, the smaller it is on the picture). Consequently, the relative cover of the component that is delineated by one or more polygons can be interpreted as its 'dose'. Subsequently, all the polygons were hierarchically classified according to 52 classes based on the type of component they enclosed (Figure 3). At the highest level, the hierarchy distinguished 'natural' components, 'urban' components, and 'people'. Natural and urban components further harbored 'lower-level constituents'. For example, 'natural' components harbored 'water', which in turn harbored 'freshwater' and 'saltwater'. For each class in the hierarchy, the relative cover of all the polygons referring to that class at that level and at underlying levels was summed for further analyses. As such, each picture has a percentage of dose (= the summed relative cover) for each type of component in the hierarchy. In each picture, the center area with a coverage of 0.094% (circle) was not considered, because this served other aims than those addressed in this study. The polygons were drawn and classified with Tobii Pro Lab's built-in functions (Tobii Pro AB, 2014), and their relative cover was calculated with the triangle method implemented by the function *polyarea* of the *geometry* package (Habel et al., 2019) in R (R Core Team, 2018).

Figure 4 shows that each coastal environment was distinct for the types and proportions of natural and urban components and people (full details available in Supplementary Material Section 1.3). All pictures used in this study and their calculated doses of natural and urban components and people and their lower-level constituents are openly available from (XXX, 2022 masked for blind review).

2.4 The picture-rating experiment

The picture-rating experiment consisted of online pre-appointment phase and an appointment at the computer lab. The pre-appointment phase aimed to inform the participants about the practicalities and goal of the study (i.e. to assess perceived restorativeness of the coast by a picture-rating experiment), and to take a first background questionnaire with their digital informed consent. The participants were also instructed not to be under the influence of alcohol, caffeine, or tranquilizing substances on the day of their appointment, and to rest for 10 minutes in the waiting room before their appointment. Upon entry in the computer lab, the participants were briefed and asked for their informed consent before being habituated to the lab. During habituation, they filled in a second questionnaire about their state mental health. Then, the pictures were shown and rated by the participants on a computer. This started with a short on-screen text that gave the following instructions in the participants' native language Dutch. "*Imagine that you have experienced a mentally exhausting period, and that you have come to the Belgian coast to relax. Imagine that you are at the place where each of the following pictures were taken."* This was similar as was done in previous research (Nordh et al., 2009; White et al., 2010). After two trial pictures, which were the same for every participant, the participants were exposed to the pictures in random order. Each picture was shown for eight seconds, after which there was an unlimited period for participants to rate it. To ensure that the participants' focus was on the center of the screen before the next picture was shown, an eye-tracking-controlled centered fixation cross was displayed before each picture was shown (the eye-tracker was calibrated with 9 fixations points during the habituation to the lab). The fixation cross was shown for 850 milliseconds and an additional minimum 150 milliseconds during which the participant had to lock focus on the cross. To avoid mental exhaustion during the course of the experiment, a two-minute recovery period was included after half the pictures were rated. A grey screen with text instructed the participants to rest comfortably. After all the pictures were rated, the participants were debriefed and compensated financially (€15) for their efforts. The computer-based procedure was programmed in E-Prime 3.0 (Psychology Software Tools Inc., 2016) and Tobii Pro Lab (Tobii Pro AB, 2014) with E-Prime Extensions for Tobii Pro 3.2 (Psychology Software Tools Inc., 2019). Instructions were shown on a Tobii Pro Spectrum 23.8-inch screen with a full-HD 1920 x 1080 resolution.

2.5 Perceived restorativeness

The perceived restorativeness of each picture was assessed by using an adapted version of the perceived restorativeness scale (PRS; Hartig et al., 1997). The PRS has shown to have a good generalizability and sensitivity compared to other self-report scales for the restorativeness of an environment (Han, 2018). Our version consisted of five-items (Table 3), and previous studies have also used shorter versions compared to the original 11-item PRS for their more convenient use in repeated assessments (Berto, 2005; Han, 2018; Nordh et al., 2009; White et al., 2010). First, the participants were instructed to imagine being in need of restoration and having come to the environment on the picture to relax (Table 3). Then, the first item of the adapted PRS referred to the overall 'perceived likelihood of restoration', similarly as the PRS-1 used in Nordh et al. (2009). This item taps into the possibility for actually experiencing restoration, both emotionally (i.e. relaxing) and cognitively (i.e. regaining mental strength and energy) (Hartig, 2011). The remaining four items drew on attention restoration theory and were derived from earlier studies' short versions of the PRS (Berto, 2005; Han, 2018; Nordh et al., 2009; White et al., 2010). Since there was still some ambiguity in the items reported by the previous literature, we rephrased the items to refer more directly to attention restoration theory's core constructs: being away, fascination, coherence, and compatibility (Table 3). As such, the adapted PRS in this study refers to both the perceived likelihood of restoration in a scenario where the participant would require restoration, as well as to the participants' perceived judgement of environmental characteristics that in theory would foster actual restoration ('perceived restorativeness' or 'environmental quality' or 'restorative potential' (Hartig, 2011). So, both are relying on retrospective and prospective imaginations (Hartig, 2011). Each item was scored on an 11-point Likert scale, which was labelled at 0 with 'totally disagree', at 5 with 'neutral', and at 10 with 'totally agree'. All items were translated to the participants' native language Dutch. The scores from all five items were treated as continuous and averaged to a total score that was used for the analyses (Cronbach's alpha = 0.90, Cronbach's alpha of individual items is available in Supplementary Material Section 1.4). The total score was sufficiently normally distributed for this study's purposes (skewness = -0.20, kurtosis = 2.55, histogram and QQ-plot available in Supplementary Material Section 1.4). We refer to this score of our adapted PRS throughout the study simply as 'PRS'.

2.6 Covariates

The analyses controlled for 33 potential covariates related to the individuals' demography, lifestyle, health, and residential surroundings, which have been shown to be influential in the rating of an environment for its restorativeness. The 33 potential covariates were age, gender, socio-economic status, BMI, physical activity, diet, dog ownership, smoking status, associating the Belgian coast with obligations, number of visits to the Belgian coast in the past three months, number of visits to the Belgian coast in the past year, number of visits to the Belgian coast per year as a kid, residential coastal proximity, satisfaction to residential coastal proximity, near-home urbanization, near-home access to green spaces, near-home access to blue spaces, near-home air quality, near-home noise levels, nature relatedness, coastal relatedness, sleep quality, stress in the past month, burnout score, rumination, sense of coherence, state stress, picture order, period of sampling, momentary outside temperature, momentary outside precipitation, momentary outside wind, and momentary outside humidity.

For the reasons for inclusion based on current literature, their measurement, and the Cronbach's alpha scores of the covariates assessed as questionnaires, we refer to Supplementary Material Section 1.1.

2.7 Statistical analyses

Statistical differences and relations between the perceived restorativeness and environments and their components were inferred with general linear mixed models due to their robustness and ability to account for experimentally-induced grouping factors or random effects (Gałecki & Burzykowski, 2013). The inter-environment variation in perceived restorativeness was investigated via a regression-based general linear mixed model (GLMM) with the ten coastal environments as main categorical predictor, PRS as outcome, and with random intercepts for participants and pictures ($N_{participants}$ = 102, $N_{pictures}$ = 52, $N_{observations}$ = 5304). In this model, the pictures of the five intra-beach environments were embedded under 'beach'.

The intra-environment variation in perceived restorativeness within beaches was investigated via a similar GLMM. In this model, the five beach environments were the main categorical predictor, with PRS as outcome, and with random intercepts for participants and pictures ($N_{participants}$ = 102, $N_{pictures}$ = 10, $N_{observations}$ = 1020).

For including the covariates in each model for the inter- or intra-environment variation in PRS, we used an automated forward model selection procedure based on the Akaike Information Criterion (AIC). Lower AIC values indicate better model fit accounted for model complexity (Sakamoto et al., 1986; Zuur et al., 2009), so we searched for the optimal set of covariates with the lowest AIC. To do so, we tested in an iterative way whether and how the AIC changed when adding a covariate in the model. In each iteration, only that covariate that reduced the AIC the most was retained. The end of this iterative process was achieved when the AIC had reached its minimum and none of the remaining potential covariates decreased the AIC. As such, the model only included covariates that were actually relevant.

To quantify how each component's dose in our hierarchy influenced the PRS, we constructed separate GLMM's that each had the dose of the component of interest as main continuous predictor, PRS as outcome, and random intercepts for participants and pictures ($N_{participants}$ = 102, $N_{pictures}$ = 52, $N_{observations}$ = 5304). The covariates in each of these models were taken from the model that assessed the inter-environment variation in perceived restorativeness, because this allowed for the interpretations to be comparable between the models.

Significance of the differences in the PRS between the ten coastal environments and five beach environments was assessed by Tukey-corrected p-values of the estimated marginal means at $\alpha = 0.05$. Significance of the effects of the components' doses on the PRS was assessed at $\alpha = 0.05$ with Benjamini-Hochberg correction to control for false discovery rate (Benjamini & Hochberg, 1995). Model assumptions were a normal distribution of the residuals and independency of observations relative to the random effects. These assumptions were checked by visually inspecting the modelled residuals over the fitted values, and by assessing whether the random variance was lower than the residual variance. All analyses were performed in R (R Core Team, 2018), and GLMMs were developed with the *lme4* package (Bates et al., 2015).

3 Results

3.1 Inter-environment variation in the perceived restoration

The first analysis compared the PRS-scores of ten coastal environments representative for the Belgian coast via a general linear mixed model. Most importantly, Figure 5 shows that the estimated marginal means of PRS-scores for the ten coastal environments differ gradually, with more natural environments scoring higher. More specifically, the PRS rating of the environments was in decreasing order: salt marshes, dunes, beaches, green parks, piers, historical sites, dikes, docks, recreational harbors, and towns (Figure 5). Salt marshes had the highest PRS (i.e. 8.54/10), and towns the lowest (i.e. 5.46/10). So, the perceived restoration of the 10 coastal environments differed up to 30%, was neutral to positive, and seemed to associate with the environments' 'naturalness'. The model that compared these ten coastal environments explained 33.4% (marginal R^2) of the variation in the PRS scores of the 52 included pictures, of which 6.1% was attributed to the inclusion of covariates. The model controlled for the residential perception of air quality ($p < 0.001$), stress in the past month ($p = 0.003$), smoking status ($p = 0.020$), having a work-relationship with the coast ($p = 0.026$), and gender ($p = 0.066$). Detailed reports on the final model formulation, tested assumptions, variances, ANOVA estimates, and pairwise differences, for models with and without covariates, can be found in Supplementary Material Section 2.1.

3.2 Intra-environment variation in the perceived restoration

The second analysis looked at whether different types of environments within the beach were associated with different PRS-scores via a second general linear mixed model. Figure 6 shows that the PRS-scores of five different beach environments differed up to approximately 20%. More specifically, pictures taken on breakwaters scored better than those taken between beach cabins and those taken in beach bars. No differences were found between the PRS-scores of pictures taken from in the seawater and those taken at open beaches. The model that compared these five beach environments explained 34.1% (marginal R^2) of the variation in the PRS scores of the 10 included pictures, of which 14.9% was attributed to the inclusion of covariates. These results are controlled for the participants' gender ($p < 0.001$), coastal relatedness ($p = 0.002$), burnout score ($p = 0.008$), diet ($p = 0.012$), smoking status ($p = 0.006$), residential green access ($p = 0.033$), and residential air quality perception ($p = 0.006$). Detailed reports on the final model formulation, tested assumptions, variances, ANOVA estimates, and pairwise differences for models with and without covariates can be found in Supplementary Material Section 2.2.

3.3 Influence of natural and urban components and people on PRS

The third set of analyses explored which natural, urban, and/or social components on the pictures were positively and negatively associated with the PRS-scores. Table 4 shows that, at the highest level, the PRS-scores were highly associated with the dose of natural components (positive effect, $\beta = 3.175 \pm 0.304$, $p < 0.001$, $R^2 = 0.300$) and urban components (negative effect, $\beta = -3.263 \pm 0.308$, $p < 0.001$, $R^2 = 0.302$). This 'naturalness'-effect also held for the lower-level constituents, although with smaller magnitudes of effect sizes and explained variation (Table 4). Specifically, significant associations were positive for mostly natural lower-level constituents, namely for vegetation (in general and for dune vegetation), seawater on the beach (not water in general), sky, natural underground (in general and for sandy underground), and breakwaters. Negative associations were always with urban lower level components, namely buildings (in general and for shops and unspecified buildings), anthropogenic disturbances (in general and for vehicles), urban undergrounds (in general and hard undergrounds other than streets), distant landscapes (in general and for recreational harbors), and unclassified urban components. There was a negative trend that showed that an increasing dose of people tended to be associated with strong adverse effects on the PRS ($\beta = -19.684 \pm 9.593$, $p = 0.105$, $R^2 = 0.088$). However, it seemed that people and some low-level components resulted in unrealistic model estimates, most likely because they were low in prevalence and had low ranges in their doses (i.e. β-estimates above 10 for people, flower box, brackish water, seawater on beach, marine debris, wildlife, litter, vehicle, bench, shops, buoy, play and sports, professional equipment, coastal defense, pier, big harbor, construction, bin, unclassified urban). All the associations were controlled for the same covariates as the model for the inter-environment comparison. For each modelled association, the corresponding linear regression graphs and more details of the model output estimates are available in Supplementary Material Section 2.3.

4 Discussion

4.1 Main results

This study investigated the inter- and intra-environment variation in the perceived restorativeness along the Belgian coast, and the influence of the environment's natural and urban components and people.

In the first part of this study, we compared the perceived restorativeness of ten coastal environments and five beach environments representative for the Belgian coast. Previous research either regarded coastal areas as a whole or focused on only some coastal environments (e.g. White et al., 2021), such as urbanized beaches or coastal towns (e.g. Vert et al., 2020), and it was yet unclear how various types of coastal environments benefit health differently (XXX, 2020 masked for blind review). This study provides evidence that more natural coastal environments, including beaches, salt marshes, and dunes, scored consistently and up to 30% higher on the perceived restorativeness than the neutrally scoring urban environments, including towns, harbors, dykes (Figure 5; Figure 6). We found similar results on a "micro-level" at the beach, where being on a breakwater was associated with higher perceived restorativeness compared to being in a beach bar or between beach cabins (being at the open beach or in the seawater scored moderately good). Thus, this study reveals that the magnitude of perceived restorativeness in coastal areas is positive to neutral, highly location-specific, and related to the environments' 'naturalness'.

The adapted perceived restorativeness scale (PRS) used in this study referred to both the perceived restorativeness (or restorative quality/potential) of the environment based on attention restoration theory as to the perceived likelihood of emotional restoration (Han, 2018; Hartig et al., 1997; see also Methods section 2.4). More specifically, four of the five constructs in our adapted perceived restorativeness scale referred to feelings of fascination, being away, coherence, and compatibility. According to the attention restoration theory, environments that score higher on these constructs can more easily restore directed attention resources, which are needed to cope with everyday challenges and demands (Hartig et al., 1997; R. Kaplan & Kaplan, 1989; S. Kaplan, 1995). The fifth construct in our scale asked for the likelihood of relaxation and mental restoration in the specific environment. Hypothesized is that such emotional restoration (e.g. stress-reduction) originates from early humans' adaptive responses to natural environments (Ulrich, 1981, 1983; Ulrich et al., 1991). In that respect, the natural coastal environments in this study would have been rated better because these environments would be higher in prospect and lower in refuge (Appleton, 1977), remind more of early human's savannah habitats (Orians, 1980; Orians & Heerwagen, 1992), and act more on biophilia (Wilson, 1984) than urban environments would. All scores were highly consistent with the scores of the other four constructs, and it is hypothesized that all rely on retrospective perceptions about the past experiences with the coastal environments that are prospected to a future hypothetical scenario where one would be in the environment and in need of restoration (Hartig, 2011).

The results of this study stem from a female-dominated student population (83% female, 18-24-year-old) that was largely residing in inland regions. Previous studies have shown that people with a different age, gender, and residential proximity, among other personal characteristics, may perceive the restorativeness of various environments in different ways (White et al., 2010; Neilson et al., 2016, 2017; Nguyen et al., 2018), potentially due to the differences in perceived levels of safety (Jiang et al., 2017), prerequisites for restoration such as being away (Hartig et al., 1997), and previous experiences and desired activities, including mobility (Elliott et al., 2018). Such sociological drivers may explain why this study finds that students rate urban coastal environments as neutral and not as positive, while these urban coastal environments still seem to be very popular and highly valued by elderly coastal residents and tourists. In any case, from the literature it seems that the perceived restorativeness being higher for more natural (coastal) environments is a population-wide phenomenon (see introduction).

In the second part of this study, we confirmed and refined the influence of the environments' 'naturalness' by revealing that the perceived restorativeness was positively associated with the doses of natural components on the pictures, and negatively with the doses of urban components. Remarkably, the dose of natural and urban components and their embedded lower-level constituents accounted for 30% of the total variation in the perceived restorativeness. This was almost equal to the 33.4% of the variation that was explained by the inter-environment differences in the first part of this study (both percentages include the 6.1% variation explained by the covariates). As such, our findings not only confirm the effect of naturalness on restoration such as found in previous literature (e.g. Gascon et al., 2015; Jiang et al., 2016; Karmanov & Hamel, 2008; Labib et al., 2020; Lindal & Hartig, 2015; Liu et al., 2022; Neilson et al., 2017; Nguyen et al., 2018; Nordh et al., 2009; White et al., 2010), but also highlight the relative importance of this naturalness-effect respective to other aspects of the (coastal) environment (e.g. social).

Despite that the people on the pictures in our study only explained a limited amount of variation (i.e. about 9% including the variation explained by the covariates), and their doses were generally too low (i.e. 0-7%) for conclusions to be made , they have potentially contributed to substantially lower scores for restorativeness. In general, depending on the amount and type of people, the restorativeness of an environment may range from highly positive when the presence of people from similar social classes increase opportunities for strengthening social cohesion and social aspects of wellbeing (Ashbullby et al., 2013;

Maguire et al., 2011; Oh et al., 2010), to highly negative when there is overcrowding and decreased feelings of safety (Ashbullby et al., 2013; Herzog & Rector, 2009; Nordh et al., 2011; Staats & Hartig, 2004). Since these patterns may be especially relevant in coastal areas (e.g. mass summer tourism vs. desertedness in winter), we should note that the dose-effect of people in coastal areas is probably context and time dependent, and the underlying sociological pathways are worthy for further investigation.

Our statistical analyses on the doses of the hierarchically classified lower-level natural and urban constituents revealed how much the restorativeness varied with every type of component found on our pictures, including some well-discussed (e.g. vegetation, water) and lesser-discussed components (e.g. skies). Since this study used realistic pictures and not ones with manipulated components, it is important to consider three naturally-occurring dependency-effects before interpreting the reported dose-response effects. Firstly, since the space in an environment or on a picture is limited, an increase in the dose of one component automatically results in a smaller dose of the other components. Consequently, the effects associated with an increased dose of a specific component may actually reflect the effects from the decreased doses of other components. Secondly, the measured response to a particular component may not reflect the effect of the actual component per se, but rather the response to the component's characteristics, such as its color, fractal pattern, or complexity (Franěk et al., 2019; Joye et al., 2016; Kaplan et al., 1972; Michels et al., 2021). Thirdly, on our non-manipulated pictures the component of interest may frequently co-occur with other components, whose effects may obscure the effect of the component of interest. Considering these dependency effects, in the next paragraph we provide an overview of the natural and urban components of which their increasing doses significantly impacted the perceived restorativeness, and what we can draw from our results with respect for the findings from the literature.

The dose-response effects of our lower-level natural components generally agree with what was found in the literature. Firstly, our results confirm a positive dose-effect of vegetation, which has also been extensively described previously (Jiang et al., 2014, 2015, 2016; Labib et al., 2020; Nguyen et al., 2018; Nordh et al., 2009; Mears et al., 2019; Ulrich et al., 1991; White et al., 2010). In our study, dependency-effects with other components are deemed to be negligible, because the vegetation cover took more than 10% of the picture on 14 pictures from diverse environments and ranged from 0% to over 80% on these pictures. In contrast, we did not find a dose-effect of water. White et al. (2010) proposed the existence of such a dose-effect of water, and a large amount of observational studies showed that the (amount of) visible (sea-)water in blue spaces improves health outcomes (Charlier & Chaineux, 2009; Cracknell, 2019; Dempsey et al., 2018; Garrett et al., 2019; Nutsford et al., 2016; Peng & Yamashita, 2016b; Völker & Kistemann, 2011; Völker et al., 2016). However, this study and previous follow-up experiments of White and colleagues' study (2010) with manipulated picture components could not replicate the dose-effect of water (Neilson et al., 2016, 2017; Nguyen et al., 2018). Therefore, it has been argued that either there is spatial variation in the dose-effect of water (e.g. cross-country, inland vs. coastal, among types of environments, drinkable vs. non-drinkable), or that the effects are dependent on the population and/or context (e.g. cultural or demographic differences, during visits vs. from the residence; Nguyen et al., 2018; Ulrich et al., 1991; White et al., 2020). Since we did not observe a higher perceived restorativeness of docks and recreational harbors compared to towns and dikes without water, the dose-effect of water seems to be practically absent along the Belgian coast. A lesser-known, but interesting, dose-effect found in this study is that of the sky (in its totality, not of blue skies or clouds separately). Sky visibility was positively associated with restorativeness and explained up to 6% of the variation. The literature about the psychological experiences in response to skies is scarce, but Masoudinejad and Hartig (2020) also found that skies in experimentally controlled cityscapes increased restoration likelihood judgments, similarly as environments with higher levels of prospect and refuge, sense of spaciousness, and safety (Lindal & Hartig, 2013; Stamps, 2005). In both the study of Masoudinejad and Hartig (2020) and our study, dependency-effects between sky visibility and building height seem especially prominent, which limits our ability to deduce whether the effect comes from decreased building height or increased sky visibility. A last dose-effect of natural components found in this study was a positive association between sandy undergrounds and the restorativeness. To our knowledge, no direct investigations for the effects of sandy undergrounds have been performed. However, seeing more sand in realistic environments would automatically result in a larger extent and spaciousness, which benefits restoration (R. Kaplan & Kaplan, 1989). Interestingly, sand as a particular type of underground can also make the coastal experience more unique by being integral to many coastal activities (e.g. walking, play and sports; Ashbullby et al., 2013; Elliott et al., 2018).

In contrast to the dose-effects of natural components, urban components' dose-response effects were usually negative. Significant decreases in the perceived restorativeness were associated with an increased dose of buildings, vehicles, hardened undergrounds, and distant urban landscapes. To our knowledge, no previous study has directly investigated the dose-effects of such components on the perceived restorativeness, except for the study of Masoudinejad and Hartig (2020) that tested for the ratio building/sky visibility from a window, of which the interpretation is troubled by the before-mentioned dependency-effects. Noteworthy is that the magnitude of restoration may also change with building architecture (Lindal & Hartig, 2013), levels of upkeep (including the presence of litter; Van Hecke et al., 2018; Wyles et al., 2016), and traffic-related disturbances (von Lindern et al., 2016). The urban environments in our study were usually well-maintained, so this may have caused the overall scores for these urban environments to be only neutral and not detrimental. In any case, most coastal urban environments also seem to associate with a more holiday-like appearance and more opportunities for leisure compared to the average inland urban environments, and this may have further protected them against being rated worse by the participants.

4.2 Limitations and strengths

This study's holistic approach and innovative methods coincide with some noteworthy limitations. Firstly, focusing on Belgian coastal environments has made the results of this study difficult to compare with most of the previous studies' comparisons of green, blue, and urban spaces and with types of coastal environments that are not found in Belgium, such as rocky shores (White et al., 2010; Wyles et al., 2014). Nevertheless, many of the Belgian coastal environments are similar to those in many other urbanized and touristic coastal areas (e.g. beaches, towns, dikes). Secondly, the female-dominated students recruited in this study differed in traits, motivations, and behaviors from the typical Belgian population and Belgian coastal visitors, which may have resulted in student-specific and largely female-specific scores for the perceived restoration (Browning et al., 2021). Thirdly, the use of a picture-rating experiment inherently associates with some methodological challenges with regard to the representativeness of the pictures for the real environments, the validity of the perceived restorativeness ratings for the actually occurred restoration, and the influences of attentional processes driven by experimental, individual, and contextual factors while observing those pictures (Browning et al., 2021; Hartig et al., 2014, 1997; White et al., 2020). However, a particular strength of this study is that these challenges were highlighted in a newly developed diagram (Figure 1), and were tackled by assembling a well-standardized picture-set, adopting a valid experimental procedure with a well-performing adapted perceived restorativeness scale, and controlling for many participant-related covariates. In any case, pictures would not be less likely to result in altered effects than more immersive simulations

(Browning et al., 2021; Velarde et al., 2007), and subjective measures are often a good reflection of objectively experienced restoration (Subiza-Pérez et al., 2020). Lastly, the components were only investigated linearly, and not by other curvatures (e.g. power-line as in Jiang et al., 2015), which may have simplified the results unjustly. This study's aims were to be exhaustive rather than focused, which resulted in new insights about important dependency-effects, and in the unveiling of many impactful and non-impactful natural, urban, and social components.

4.3 Avenues for future research

Understanding how outdoor environments impact psychological restoration is a prerequisite for sustainable spatial design and the development of novel therapeutic practices in the cost-effective treatment and prevention of poor mental health (UNEP, 2019). This study has captured the inter- and intra-environment variation in perceived restorativeness and the influence of natural and urban components and people, but while doing so focused purely on visual exposures and the perceived restoration thereof. Therefore, future research is necessary if restorative (coastal) outdoor environments are to become clinically applicable. More specifically, additional insights should be gathered about how multi-sensorial and immersive experiences (e.g. virtual or real) impact on psycho-physiological measures of restoration (e.g. cognitive task performance or psycho-physiological measurements), and how the effects may differ among populations with a different demographic and socio-economic background and state mental health (Browning et al., 2021; Wooller et al., 2016). Additionally, spatiotemporal risk factors should be identified, including those related to climate and weather (e.g. time of the year), crowding, and litter (Hipp & Ogunseitan, 2011; White et al., 2014; Wyles et al., 2016). Architectural designs already incorporate many preferred natural and urban components (e.g. street greenery), but it seems that more research is necessary to reveal their actual psychological benefits (e.g. Bell et al., 2020; van den Bogerd et al., 2021). While addressing these knowledge gaps, current theoretical frameworks should remain to be updated and tested in ecologically valid scenarios (Collado et al., 2017; Hartig et al., 2014; Stevenson et al., 2018). Lastly, the short-term and long-term clinical and societal benefits of exposure to different coastal environments should be quantified in economic value and their cost effectiveness should be outweighed with respect to other treatments for mental health (Papathanasopoulou et al., 2016). If exposure to restorative coastal environments would prove to be cost-effective, then sharing literacy about the coast's therapeutic value with the health sector, public, and tourism sector may provide beneficial ripple-effects through society (Roberts et al., 2021; Sandifer et al., 2021).

5 Conclusion

This study aimed to quantify the inter-environment and intra-environment variation in the perceived restorativeness along the Belgian coast and to quantify the influence of natural and urban components and people on the restorativeness. To do so, 52 pictures of ten coastal environments and five beach environments representative for the Belgian coast were rated on an adapted perceived restorativeness scale by 102 students, and methodological challenges for the validity of this picture-rating experiment were identified and tackled. The data was analyzed by a series of general linear mixed models that controlled for individual and study-design related factors. The results demonstrated that more natural coastal environments were rated up to 30% more positive than the neutrally scoring urban coastal environments. This naturalness-effect largely coincided with positive dose-response effects of vegetation, sky visibility, and sandy undergrounds (not water), and negative dose-response effects of buildings, vehicles, hardened undergrounds, and distant urban landscapes. The effect of people remains uncertain, but interesting for future research since this study saw a potentially large impact of people on the restorativeness. Taken together, the results of this study confirm and greatly refine previous perspectives about coasts' high restorative potential (XXX, 2020 masked for blind review), and avenues for future research are proposed for cost-effectively preventing and treating poor mental health.

6 Supplementary information

Supplementary data associated with this article can be found in the online version.

7 Role of the funding source

The funding source was not involved in this study.

8 References

XXX, 2020 masked for blind review

XXX, 2022 masked for blind review

1. Adobe. (2020a). *Lightroom 4.3 [Computer software]* (4.3). Adobe.
2. Adobe. (2020b). *Photoshop 22.5 [Computer software]* (22.5). Adobe.
3. Appleton, J. (1977). The Experience of Landscape. *Annals of the Association of American Geographers*, *67*(1), 149–151. https://www.jstor.org/stable/2562247
4. Ashbullby, K. J., Pahl, S., Webley, P., & White, M. P. (2013). The beach as a setting for families' health promotion: A qualitative study with parents and children living in coastal regions in Southwest England. *Health & Place*, *23*, 138–147. https://doi.org/10.1016/j.healthplace.2013.06.005
5. Bates, D., Mächler, M., Bolker, B. M., & Walker, S. C. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01
6. Bell, S., Mishra, H. S., Elliott, L. R., Shellock, R., Vassiljev, P., Porter, M., Sydenham, Z., & White, M. P. (2020). Urban Blue Acupuncture: A Protocol for Evaluating a Complex Landscape Design Intervention to Improve Health and Wellbeing in a Coastal Community. *Sustainability*, *12*(10), 4084. https://doi.org/10.3390/su12104084
7. Benjamini, Y., & Hochberg, Y. (1995). Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. Journal of the Royal Statistical Society, 57(1), 289–300. https://doi.org/http://dx.doi.org/10.2307/2346101
8. Berman, M. G., Kross, E., Krpan, K. M., Askren, M. K., Burson, A., Deldin, P. J., Kaplan, S., Sherdell, L., Gotlib, I. H., & Jonides, J. (2012). Interacting with nature improves cognition and affect for individuals with depression. *Journal of Affective Disorders*, *140*(3), 300–305. https://doi.org/10.1016/j.jad.2012.03.012
9. Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology*, *25*(3), 249–259. https://doi.org/10.1016/j.jenvp.2005.07.001
10. Bratman, G. N., Olvera-Alvarez, H. A., & Gross, J. J. (2021). The affective benefits of nature exposure. *Social and Personality Psychology Compass*, *December 2020*, 1–22. https://doi.org/10.1111/spc3.12630
11. Brooks, A. M., Ottley, K. M., Arbuthnott, K. D., & Sevigny, P. (2017). Nature-related mood effects: Season and type of nature contact. *Journal of Environmental Psychology*, *54*, 91–102. https://doi.org/10.1016/j.jenvp.2017.10.004
12. Browning, M. H. E. M., Saeidi-Rizi, F., McAnirlin, O., Yoon, H., & Pei, Y. (2021). The Role of Methodological Choices in the Effects of Experimental Exposure to Simulated Natural Landscapes on Human Health and Cognitive Performance: A Systematic Review. *Environment and Behavior*, *53*(7), 687–731. https://doi.org/10.1177/0013916520906481
13. Browning, M. H. E. M., Shipley, N., McAnirlin, O., Becker, D., Yu, C. P., Hartig, T.,

& Dzhambov, A. M. (2020). An Actual Natural Setting Improves Mood Better Than Its Virtual Counterpart: A Meta-Analysis of Experimental Data. In *Frontiers in Psychology* (Vol. 11, Issue September, pp. 1–12). https://doi.org/10.3389/fpsyg.2020.02200

14. Charlier, R. H., & Chaineux, M.-C. P. (2009). The healing sea: A sustainable coastal ocean resource: thalassotherapy. *Journal of Coastal Research*, *254*, 838–856. https://doi.org/10.2112/08A-0008.1
15. Chen, C. L., & Teng, N. (2016). Management priorities and carrying capacity at a high-use beach from tourists' perspectives: A way towards sustainable beach tourism. *Marine Policy*, *74*(September), 213–219. https://doi.org/10.1016/j.marpol.2016.09.030
16. Collado, S., Staats, H., Corraliza, J. A., & Hartig, T. (2017). Restorative Environments and Health. In G. Fleury-Bahi, E. Pol, & O. Navarro (Eds.), *Handbook of Environmental Psychology and Quality of Life Research* (pp. 127–148). Springer International Publishing. https://doi.org/10.1007/978-3-319-31416-7_7
17. Cracknell, D. (2019). *By the Sea: The therapeutic benefits of being in, on and by the water*. Aster.
18. de Vries, S., Nieuwenhuizen, W., Farjon, H., van Hinsberg, A., & Dirkx, J. (2021). In which natural environments are people happiest? Large-scale experience sampling in the Netherlands. *Landscape and Urban Planning*, *205*(October 2020), 103972. https://doi.org/10.1016/j.landurbplan.2020.103972
19. Dempsey, S., Devine, M. T., Gillespie, T., Lyons, S., & Nolan, A. (2018). Coastal blue space and depression in older adults. *Health and Place*, *54*(September), 110–117. https://doi.org/10.1016/j.healthplace.2018.09.002
20. Ehring, T., Raes, F., Weidacker, K., & Emmelkamp, P. M. G. (2012). Validation of the dutch version of the perseverative thinking questionnaire (PTQ-NL). *European Journal of Psychological Assessment*, *28*(2), 102–108. https://doi.org/10.1027/1015-5759/a000097
21. Elliott, L. R., White, M. P., Grellier, J., Rees, S. E., Waters, R. D., & Fleming, L. E. (2018). Recreational visits to marine and coastal environments in England: Where, what, who, why, and when? *Marine Policy*, *97*(February), 305–314. https://doi.org/10.1016/j.marpol.2018.03.013
22. Filipova, T., Kopsieker, L., Gerritsen, E., Bodin, E., Brzezinski, B., & Ramirez-Rubio, O. (2020). *Mental health and the environment: How European policies can better reflect the impact of environmental degradation on people's mental health and well-being*. *December*, 1–81. https://ieep.eu/uploads/articles/attachments/2bfb2051-b305-4338-9770-ae8071320b1a/Mental health and the environment.pdf?v=63775265428
23. Franěk, M., Petružálek, J., & Šefara, D. (2019). Eye movements in viewing urban images and natural images in diverse vegetation periods. *Urban Forestry & Urban Greening*, *46*(October), 126477. https://doi.org/10.1016/j.ufug.2019.126477
24. Gałecki, A., & Burzykowski, T. (2013). *Linear Mixed-Effects Models Using R*. Springer New York. https://doi.org/10.1007/978-1-4614-3900-4
25. Garrett, J. K., White, M. P., Huang, J., Ng, S., Hui, Z., Leung, C., Tse, L. A., Fung,

F., Elliott, L. R., Depledge, M. H., & Wong, M. C. S. (2019). Urban blue space and health and wellbeing in Hong Kong: Results from a survey of older adults. *Health and Place*, *55*(November), 100–110. https://doi.org/10.1016/j.healthplace.2018.11.003

26. Gascon, M., Mas, M. T., Martínez, D., Dadvand, P., Forns, J., Plasència, A., & Nieuwenhuijsen, M. J. (2015). Mental health benefits of long-term exposure to residential green and blue spaces: A systematic review. *International Journal of Environmental Research and Public Health*, *12*(4), 4354–4379. https://doi.org/10.3390/ijerph120404354

27. Gascon, M., Zijlema, W., Vert, C., White, M. P., & Nieuwenhuijsen, M. J. (2017). Outdoor blue spaces, human health and well-being: A systematic review of quantitative studies. *International Journal of Hygiene and Environmental Health*, *220*(8), 1207–1221. https://doi.org/10.1016/j.ijheh.2017.08.004

28. Georgiou, M., Morison, G., Smith, N., Tieges, Z., & Chastin, S. (2021). Mechanisms of impact of blue spaces on human health: A systematic literature review and meta-analysis. *International Journal of Environmental Research and Public Health*, *18*(5), 1–41. https://doi.org/10.3390/ijerph18052486

29. Grassini, S., Revonsuo, A., Castellotti, S., Petrizzo, I., Benedetti, V., & Koivisto, M. (2019). Processing of natural scenery is associated with lower attentional and cognitive load compared with urban ones. *Journal of Environmental Psychology*, *62*(April 2018), 1–11. https://doi.org/10.1016/j.jenvp.2019.01.007

30. Habel, K., Grasman, R., Gramacy, R. B., Mozharovskyi, P., & Sterratt, D. C. (2019). *geometry: Mesh Generation and Surface Tessellation* (R package version 0.4.5). https://cran.r-project.org/package=geometry

31. Haluza, D., Schönbauer, R., & Cervinka, R. (2014). Green perspectives for public health: A narrative review on the physiological effects of experiencing outdoor nature. *International Journal of Environmental Research and Public Health*, *11*(5), 5445–5461. https://doi.org/10.3390/ijerph110505445

32. Hartig, T. (2011). Issues in Restorative Environments Research: Matters of Measurement. In B. Fernández-Ramírez, C. Hidalgo-Villodres, C. M. Salvador-Ferrer, & M. J. Martos Méndez (Eds.), *Psicología ambiental 2011: Entre los estudios urbanos y el análisis de la sostenibilidad [Environmental psychology 2011: between urban studies and the analysis of sustainability]. (Proceedings of the 11th Biennial Conference on Environmental Psychology).* (pp. 1–20).
33. Han, K. T. (2018). A review of self-report scales on restoration and/or restorativeness in the natural environment. *Journal of Leisure Research*, *49*(3–5), 151–176. https://doi.org/10.1080/00222216.2018.1505159
34. Hartig, T., Korpela, K., Evans, G. W., & Gärling, T. (1997). A measure of restorative quality in environments. *Scandinavian Housing and Planning Research*, *14*(4), 175–194. https://doi.org/10.1080/02815739708730435

35. Hartig, T., Mitchell, R., de Vries, S., & Frumkin, H. (2014). Nature and Health. *Annual Review of Public Health*, *35*(1), 207–228. https://doi.org/10.1146/annurev-publhealth-032013-182443

36. Herzog, T. R., & Rector, A. E. (2009). Perceived danger and judged likelihood of restoration. *Environment and Behavior*, *41*(3), 387–401. https://doi.org/10.1177/0013916508315351

37. Hipp, J. A., & Ogunseitan, O. A. (2011). Effect of environmental conditions on perceived psychological restorativeness of coastal parks. *Journal of Environmental Psychology*, *31*(4), 421–429. https://doi.org/10.1016/j.jenvp.2011.08.008

38. Jarratt, D., & Gammon, S. (2016). 'We had the most wonderful times': Seaside nostalgia at a British resort. *Tourism Recreation Research*, *41*(2), 123–133. https://doi.org/10.1080/02508281.2016.1147213

39. Jellesma, F. C., Meerum Terwogt, M., & Rieffe, C. (2006). De Nederlandstalige Sense of Coherence vragenlijst voor kinderen. *Gedrag En Gezondheid*, *34*, 18–26.

40. Jiang, B., Chang, C. Y., & Sullivan, W. C. (2014). A dose of nature: Tree cover, stress reduction, and gender differences. *Landscape and Urban Planning*, *132*, 26–36. https://doi.org/10.1016/j.landurbplan.2014.08.005

41. Jiang, B., Larsen, L., Deal, B., & Sullivan, W. C. (2015). A dose-response curve describing the relationship between tree cover density and landscape preference. *Landscape and Urban Planning*, *139*, 16–25. https://doi.org/10.1016/j.landurbplan.2015.02.018

42. Jiang, B., Li, D., Larsen, L., & Sullivan, W. C. (2016). A Dose-Response Curve Describing the Relationship Between Urban Tree Cover Density and Self-Reported Stress Recovery. *Environment and Behavior*, *48*(4), 607–629. https://doi.org/10.1177/0013916514552321

43. Jiang, B., Mak, C. N. S., Larsen, L., & Zhong, H. (2017). Minimizing the gender difference in perceived safety: Comparing the effects of urban back alley interventions. *Journal of Environmental Psychology*, *51*, 117–131. https://doi.org/10.1016/j.jenvp.2017.03.012

44. Joye, Y., & de Block, A. (2011). "Nature and I are two": A critical examination of the biophilia hypothesis. *Environmental Values*, *20*(2), 189–215. https://doi.org/10.3197/096327111X12997574391724

45. Joye, Y., Steg, L., Ünal, A. B., & Pals, R. (2016). When complex is easy on the mind: Internal repetition of visual information in complex objects is a source of perceptual fluency. *Journal of Experimental Psychology: Human Perception and Performance*, *42*(1), 103–114. https://doi.org/10.1037/xhp0000105

46. Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*. Cambridge University Press. https://doi.org/10.1037/030621

47. Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Environmental Psychology1*, *15*, 169–182. https://doi.org/10.1016/j.repc.2011.09.012

48. Kaplan, S., Kaplan, R., & Wendt, J. S. (1972). Rated preference and complexity for natural and urban visual material. *Perception & Psychophysics*, *12*(4), 354–356. https://doi.org/10.3758/BF03207221

49. Karmanov, D., & Hamel, R. (2008). Assessing the restorative potential of contemporary urban environment(s): Beyond the nature versus urban dichotomy. *Landscape and Urban Planning*, *86*(2), 115–125. https://doi.org/10.1016/j.landurbplan.2008.01.004

50. Kondo, M. C., Triguero-Mas, M., Donaire-Gonzalez, D., Seto, E., Valentín, A., Hurst,

G., Carrasco-Turigas, G., Masterson, D., Ambròs, A., Ellis, N., Swart, W., Davis, N., Maas, J., Jerrett, M., Gidlow, C. J., & Nieuwenhuijsen, M. J. (2020). Momentary mood response to natural outdoor environments in four European cities. *Environment International*, *134*(September 2019), 105237. https://doi.org/10.1016/j.envint.2019.105237

51. Kustportaal. (n.d.). *The Belgian coast*. Retrieved December 17, 2021, from https://www.kustportaal.be/en/belgian-coast

52. Labib, S. M., Lindley, S., & Huck, J. J. (2020). Spatial dimensions of the influence of urban green-blue spaces on human health: A systematic review. *Environmental Research*, *180*(October 2019), 108869. https://doi.org/10.1016/j.envres.2019.108869

53. Ladouce, S., Donaldson, D. I., Dudchenko, P. A., & Ietswaart, M. (2019). Mobile EEG identifies the re-allocation of attention during real-world activity. *Scientific Reports*, *9*(1), 15851. https://doi.org/10.1038/s41598-019-51996-y

54. Lindal, P. J., & Hartig, T. (2013). Architectural variation, building height, and the restorative quality of urban residential streetscapes. *Journal of Environmental Psychology*, *33*, 26–36. https://doi.org/10.1016/j.jenvp.2012.09.003

55. Lindal, P. J., & Hartig, T. (2015). Effects of urban street vegetation on judgments of restoration likelihood. *Urban Forestry and Urban Greening*, *14*(2), 200–209. https://doi.org/10.1016/j.ufug.2015.02.001

56. Luyckx, K., Goossens, E., Apers, S., Rassart, J., Klimstra, T., Dezutter, J., & Moons, P. (2012). The 13-Item Sense of Coherence Scale in Dutch-Speaking Adolescents and Young Adults: Structural Validity, Age Trends, and Chronic Disease. *Psychologica Belgica*, *52*(4), 351. https://doi.org/10.5334/pb-52-4-368

57. Maas, J., van Dillen, S. M. E., Verheij, R. A., & Groenewegen, P. P. (2009). Social contacts as a possible mechanism behind the relation between green space and health. *Health and Place*, *15*(2), 586–595. https://doi.org/10.1016/j.healthplace.2008.09.006

58. Maguire, G. S., Miller, K. K., Weston, M. A., & Young, K. (2011). Being beside the seaside: Beach use and preferences among coastal residents of south-eastern Australia. *Ocean and Coastal Management*, *54*(10), 781–788. https://doi.org/10.1016/j.ocecoaman.2011.07.012

59. Marine Regions. (2009). *Belgian Coast - http://marineregions.org/mrgid/2550*. http://marineregions.org/mrgid/2550

60. Masoudinejad, S., & Hartig, T. (2020). Window View to the Sky as a Restorative Resource for Residents in Densely Populated Cities. *Environment and Behavior*, *52*(4), 401–436. https://doi.org/10.1177/0013916518807274

61. Michels, N., De Witte, F., Di Bisceglie, E., Seynhaeve, M., & Vandebuerie, T. (2021). Green nature effect on stress response and stress eating in the lab: Color versus environmental content. *Environmental Research*, *193*(September 2020), 110589. https://doi.org/10.1016/j.envres.2020.110589

62. Mygind, L., Kjeldsted, E., Hartmeyer, R., Mygind, E., Stevenson, M. P., Quintana, D. S., & Bentsen, P. (2019). Effects of Public Green Space on Acute Psychophysiological Stress Response: A Systematic Review and Meta-Analysis of the Experimental and Quasi-Experimental Evidence. *Environment and Behavior*, 001391651987337. https://doi.org/10.1177/0013916519873376

63. Neale, C., Lopez, S., & Roe, J. (2021). Psychological restoration and the effect of people in nature and urban scenes: A laboratory experiment. *Sustainability (Switzerland)*, *13*(11). https://doi.org/10.3390/su13116464

64. Neilson, B. N., Craig, C. M., Curiel, R. Y., & Klein, M. I. (2020). Restoring Attentional Resources With Nature: A Replication Study of Berto's (2005) Paradigm Including Commentary From Dr. Rita Berto. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *2005*, 001872082090928. https://doi.org/10.1177/0018720820909287

65. Neilson, B. N., Craig, C. M., Travis, A. T., & Klein, M. I. (2019). A review of the limitations of Attention Restoration Theory and the importance of its future research for the improvement of well-being in urban living. *A Review of the Limitations of Attention Restoration Theory and the Importance of Its Future Research for the Improvement of Well-Being in Urban Living*, *11*, 59–67. https://doi.org/10.13135/2384-8677/3323

66. Neilson, B. N., Klein, M., Briones, E., & Craig, C. (2016). The importance of water is in question: Aquatic nature images do not have significantly higher restorativeness ratings than green nature images. *Proceedings of the Human Factors and Ergonomics Society*, *2010*, 446–449. https://doi.org/10.1177/1541931213601101

67. Neilson, B. N., Nguyen, T., Bukowski, A., & Klein, M. (2017). Are all types of natural environments created equal? A comparison of different elements in nature for improving restoration in work environments. *Proceedings of the Human Factors and Ergonomics Society*, *2017-Octob*(2010), 1247–1251. https://doi.org/10.1177/1541931213601793

68. Nguyen, T., Neilson, B. N., & Klein, M. I. (2018). Greenery versus aquatic: Cognitive restoration of different components of nature for improvement in environmental design. *Proceedings of the Human Factors and Ergonomics Society*, *1*, 373–377. https://doi.org/10.1177/1541931218621086

69. Nisbet, E. K., & Zelenski, J. M. (2013). The NR-6: A new brief measure of nature relatedness. *Frontiers in Psychology*, *4*(NOV), 1–11. https://doi.org/10.3389/fpsyg.2013.00813

70. Nordh, H., Alalouch, C., & Hartig, T. (2011). Assessing restorative components of small urban parks using conjoint methodology. *Urban Forestry and Urban Greening*, *10*(2), 95–103. https://doi.org/10.1016/j.ufug.2010.12.003

71. Nordh, H., Hagerhall, C. M., & Holmqvist, K. (2010). Exploring view pattern and analysing pupil size as a measure of restorative qualities in park photos. *Acta Horticulturae*, *881*(2003), 767–772. https://doi.org/10.17660/ActaHortic.2010.881.126

72. Nordh, H., Hartig, T., Hagerhall, C. M., & Fry, G. (2009). Components of small urban parks that predict the possibility for restoration. *Urban Forestry and Urban Greening*, *8*(4), 225–235. https://doi.org/10.1016/j.ufug.2009.06.003

73. Nutsford, D., Pearson, A. L., Kingham, S., & Reitsma, F. (2016). Residential exposure to visible blue space (but not green space) associated with lower psychological distress in a capital city. *Health and Place*, *39*, 70–78. https://doi.org/10.1016/j.healthplace.2016.03.002

74. Labib, S. M., Lindley, S., & Huck, J. J. (2020). Spatial dimensions of the influence of urban green-blue spaces on human health: A systematic review. *Environmental Research*, *180*(October 2019), 108869. https://doi.org/10.1016/j.envres.2019.108869
75. OECD, & European Commission. (2020). Health at a Glance: Europe 2020. State of health in the EU cycle. In *Health at a Glance 2007*. https://doi.org/10.1787/82129230-en

76. Oh, C.-O., Draper, J., & Dixon, A. W. (2010). Comparing resident and tourist preferences for public beach access and related amenities. *Ocean & Coastal Management*, *53*(5–6), 245–251. https://doi.org/10.1016/j.ocecoaman.2010.04.007

77. Ohly, H., White, M. P., Wheeler, B. W., Bethel, A., Ukoumunne, O. C., Nikolaou, V., & Garside, R. (2016). Attention Restoration Theory: A systematic review of the attention restoration potential of exposure to natural environments. *Journal of Toxicology and Environmental Health - Part B: Critical Reviews*, *19*(7), 305–343. https://doi.org/10.1080/10937404.2016.1196155

78. Orians, G. H. (1980). Habitat selection: general theory and applications to human behavior. In J. Lockard (Ed.), *The evolution of human social behavior* (1st ed., pp. 49–66). Elsevier.

79. Orians, G. H., & Heerwagen, J. H. (1992). Evolved responses to landscapes. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: evolutionary psychology and the generation of culture* (pp. 555–579). Oxford University Press.

80. Papathanasopoulou, E., White, M. P., Hattam, C., Lannin, A., Harvey, A., & Spencer, A. (2016). Valuing the health benefits of physical activities in the marine environment and their importance for marine spatial planning. *Marine Policy*, *63*, 144–152. https://doi.org/10.1016/j.marpol.2015.10.009

81. Peng, C., & Yamashita, K. (2016a). An Empirical Study on the Effects of the Beach on Mood and Mental Health in Japan. *Journal of Coastal Zone Management*, *18*(4). https://doi.org/10.4172/2473-3350.1000412

82. Peng, C., & Yamashita, K. (2016b). Effects of the Coastal Environment on Well-being. *Journal of Coastal Zone Management*, *19*(2). https://doi.org/10.4172/2473-3350.1000421

83. Psychology Software Tools Inc. (2016). *E-Prime 3.0 [Computer software]*. https://support.pstnet.com/

84. Psychology Software Tools Inc. (2019). *E-Prime Extensions for Tobii Pro 3.2 [Computer software]*. https://support.pstnet.com/

85. R Core Team. (2018). *R: A language and environment for statistical computing [Computer software]*. R Foundation for Statistical Computing (Vienna, Austria). https://www.r-project.org/

86. Roberts, B. R., White, M. P., Davison, S. M. C., McMeel, O., Eatock, C., Kellett, P., Calewaert, J. B., & Fleming, L. E. (2021). Public preferences for policy intervention to protect public health from maritime activities: A 14 European country study. *Global Environmental Change*, *71*(February), 102397. https://doi.org/10.1016/j.gloenvcha.2021.102397

87. Sakamoto, Y., Ishiguro, M., & Kitagawa, G. (1986). *Akaike information criterion*

statistics. KTK Scientific Publishers ; D. Reidel ; Sold and distributed in the U.S.A. and Canada by Kluwer Academic Publishers.

88. Sandifer, P. A., Keener, P., Scott, G. I., & Porter, D. E. (2021). Oceans and Human Health and the New Blue Economy. In *Preparing a Workforce for the New Blue Economy*. Elsevier Inc. https://doi.org/10.1016/b978-0-12-821431-2.00057-3

89. Schaufeli, W., De Witte, H., & Desart, S. (2019). *Work-related version of the BAT*.

90. Severin, M. I., Vandegehuchte, M. B., Hooyberg, A., Buysse, A., Raes, F., & Everaert, G. (2021). Influence of the Belgian Coast on Well-Being During the COVID-19 Pandemic. *Psychologica Belgica*, *61*(1), 284–295. https://doi.org/10.5334/pb.1050

91. Staats, H., & Hartig, T. (2004). Alone or with a friend: A social context for psychological restoration and environmental preferences. *Journal of Environmental Psychology*, *24*(2), 199–211. https://doi.org/10.1016/j.jenvp.2003.12.005

92. Stamps, A. E. (2005). Visual permeability, locomotive permeability, safety, and enclosure. In *Environment and Behavior* (Vol. 37, Issue 5). https://doi.org/10.1177/0013916505276741

93. Stevenson, M. P., Schilhab, T., & Bentsen, P. (2018). Attention Restoration Theory II: a systematic review to clarify attention processes affected by exposure to natural environments. *Journal of Toxicology and Environmental Health - Part B: Critical Reviews*, *21*(4), 227–268. https://doi.org/10.1080/10937404.2018.1505571

94. Subiza-Pérez, M., Vozmediano, L., & San Juan, C. (2020). Green and blue settings as providers of mental health ecosystem services: Comparing urban beaches and parks and building a predictive model of psychological restoration. *Landscape and Urban Planning*, *204*(August), 103926. https://doi.org/10.1016/j.landurbplan.2020.103926

95. Tobii Pro AB. (2014). *Tobii Pro Lab 1.130 [Computer software]* (1.130). Tobii Pro AB.

96. Ulrich, R. S. (1981). Natural versus urban scenes: some psychophysiological effects. *Environment and Behavior*, *13*(5), 523–556. https://doi.org/10.1177/0013916581135001

97. Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman & J. Wohlwill (Eds.), *Human behavior and environment* (Issue 6, pp. 85–125). New York: Plenum. https://doi.org/10.1007/978-1-4613-3539-9

98. Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Environmental Psychology*, *11*, 201–230.

99. UNEP. (2019). *Caring for the environment helps to care for your mental health*. https://www.unep.org/news-and-stories/story/caring-environment-helps-care-your-mental-health

100. Van den Berg, A. E., Jorgensen, A., & Wilson, E. R. (2014). Evaluating restoration in urban green spaces: Does setting type make a difference? *Landscape and Urban Planning*, *127*, 173–181. https://doi.org/10.1016/j.landurbplan.2014.04.012

101. van den Bogerd, N., Elliott, L. R., White, M. P., Mishra, H. S., Bell, S., Porter, M., Sydenham, Z., Garrett, J. K., & Fleming, L. E. (2021). Urban blue space renovation and local resident and visitor well-being: A case study from Plymouth, UK. *Landscape and Urban Planning*, *215*(July). https://doi.org/10.1016/j.landurbplan.2021.104232

102. van der Ploeg, J. (2013). *Stress bij kinderen (Stress in children)*. Bohn Stafleu van Loghum. https://doi.org/10.1007/978-90-368-0419-6

103. Van Hecke, L., Ghekiere, A., Van Cauwenberg, J., Veitch, J., De Bourdeaudhuij, I., Van Dyck, D., Clarys, P., Van De Weghe, N., & Deforche, B. (2018). Park characteristics preferred for adolescent park visitation and physical activity: A choice-based conjoint analysis using manipulated photographs. *Landscape and Urban Planning*, *178*(July 2017), 144–155. https://doi.org/10.1016/j.landurbplan.2018.05.017

104. Velarde, M. D., Fry, G., & Tveit, M. (2007). Health effects of viewing landscapes - Landscape types in environmental psychology. *Urban Forestry and Urban Greening*, *6*(4), 199–212. https://doi.org/10.1016/j.ufug.2007.07.001

105. Vert, C., Gascon, M., Ranzani, O., Márquez, S., Triguero-Mas, M., Carrasco-Turigas, G., Arjona, L., Koch, S., Llopis, M., Donaire-Gonzalez, D., Elliott, L. R., & Nieuwenhuijsen, M. (2020). Physical and mental health effects of repeated short walks in a blue space environment: A randomised crossover study. *Environmental Research*, *188*(June), 109812. https://doi.org/10.1016/j.envres.2020.109812

106. Völker, S., & Kistemann, T. (2011). The impact of blue space on human health and well-being - Salutogenetic health effects of inland surface waters: A review. *International Journal of Hygiene and Environmental Health*, *214*(6), 449–460. https://doi.org/10.1016/j.ijheh.2011.05.001

107. Völker, S., Matros, J., & Claßen, T. (2016). Determining urban open spaces for health-related appropriations: a qualitative analysis on the significance of blue space. *Environmental Earth Sciences*, *75*(13). https://doi.org/10.1007/s12665-016-5839-3

108. von Lindern, E., Hartig, T., & Lercher, P. (2016). Traffic-related exposures, constrained restoration, and health in the residential context. *Health and Place*, *39*, 92–100. https://doi.org/10.1016/j.healthplace.2015.12.003

109. Wheeler, B. W., White, M. P., Stahl-Timmins, W., & Depledge, M. H. (2012). Does living by the coast improve health and wellbeing. *Health and Place*, *18*(5), 1198–1201. https://doi.org/10.1016/j.healthplace.2012.06.015

110. White, M. P., Alcock, I., Wheeler, B. W., & Depledge, M. H. (2013). Coastal proximity, health and well-being: Results from a longitudinal panel survey. *Health and Place*, *23*, 97–103. https://doi.org/10.1016/j.healthplace.2013.05.006

111. White, M. P., Cracknell, D., Corcoran, A., Jenkinson, G., & Depledge, M. H. (2014). Do preferences for waterscapes persist in inclement weather and extend to sub-aquatic scenes? *Landscape Research*, *39*(4), 339–358. https://doi.org/10.1080/01426397.2012.759919

112. White, M. P., Elliott, L. R., Gascon, M., Roberts, B., & Fleming, L. E. (2020). Blue space, health and well-being: A narrative overview and synthesis of potential benefits. *Environmental Research*, *191*(September), 110169.

https://doi.org/10.1016/j.envres.2020.110169

113. White, M. P., Elliott, L. R., Grellier, J., Economou, T., Bell, S., Bratman, G. N., Cirach, M., Gascon, M., Lima, M. L., Lõhmus, M., Nieuwenhuijsen, M., Ojala, A., Roiko, A., Schultz, P. W., van den Bosch, M., & Fleming, L. E. (2021). Associations between green/blue spaces and mental health across 18 countries. *Scientific Reports*, *11*(1), 1–12. https://doi.org/10.1038/s41598-021-87675-0

114. White, M. P., Pahl, S., Wheeler, B. W., Depledge, M. H., & Fleming, L. E. (2017). Natural environments and subjective wellbeing: Different types of exposure are associated with different aspects of wellbeing. *Health and Place*, *45*(July 2016), 77–84. https://doi.org/10.1016/j.healthplace.2017.03.008

115. White, M. P., Pahl, S., Wheeler, B. W., Fleming, L. E. F., & Depledge, M. H. (2016). The "Blue Gym": What can blue space do for you and what can you do for blue space? *Journal of the Marine Biological Association of the United Kingdom*, *96*(1), 5–12. https://doi.org/10.1017/S0025315415002209

116. White, M. P., Smith, A., Humphryes, K., Pahl, S., Snelling, D., & Depledge, M. (2010). Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes. *Journal of Environmental Psychology*, *30*(4), 482–493. https://doi.org/10.1016/j.jenvp.2010.04.004

117. Wilson, E. O. (1984). *Biophilia*. Harvard University Press.

118. Wooller, J. J., Barton, J., Gladwell, V. F., & Micklewright, D. (2016). Occlusion of sight, sound and smell during Green Exercise influences mood, perceived exertion and heart rate. *International Journal of Environmental Health Research*, *26*(3), 267–280. https://doi.org/10.1080/09603123.2015.1109068

119. Wyles, K. J., Pahl, S., Thomas, K., & Thompson, R. C. (2016). Factors That Can Undermine the Psychological Benefits of Coastal Environments: Exploring the Effect of Tidal State, Presence, and Type of Litter. *Environment and Behavior*, *48*(9), 1095–1126. https://doi.org/10.1177/0013916515592177

120. Wyles, K. J., Pahl, S., & Thompson, R. C. (2014). Perceived risks and benefits of recreational visits to the marine environment: Integrating impacts on the environment and impacts on the visitor. *Ocean and Coastal Management*, *88*, 53–63. https://doi.org/10.1016/j.ocecoaman.2013.10.005

121. Yarbus, A. L. (1967). *Eye Movements and Vision*. Springer US. https://doi.org/10.1007/978-1-4899-5379-7

122. Zuur, A. F., Ieno, E. N., Walker, N. J., Saveliev, A. A., & Smith, G. M. (2009). *Mixed effects models and extensions in ecology with R*. Springer.

List of Tables

1. Table 1: Participants' characteristics table. Summary of all participant-related covariates, indicated for categorical variables as the number (N) of participants in each factor level, or for continuous variables as the mean (M) with standard deviation (SD). Detailed reasoning and implementation of scoring methods are available in Supplementary Material Section 1.1.
   Abbreviations and references to scales: BMI = Body Mass Index; METs = Metabolic Equivalents; NR = Nature Relatedness (Nisbet & Zelenski, 2013); SOC = Sense of Coherence (Jellesma et al., 2006; Luyckx et al., 2012); PSS = Perceived Stress Scale (van der Ploeg, 2013); BAT = Burnout Assessment Tool (Schaufeli et al., 2019); PTQ-t = Perseverance Thinking Questionnaire – trait version (Ehring et al., 2012).

2. Table 2: Tabulated number of pictures per environment and per comparison (inter- or intra-environment). The corresponding pictures can be retrieved from (XXX, 2022 masked for blind review).

3. Table 3: Description of the instructions and questions of the adapted perceived restoration scale (PRS) that was used in this study as main outcome variable.

4. Table 4: General linear mixed model output and correlations of the relationships between the picture components and the Perceived Restorativeness Scale (PRS). Each line indicates the output from a separate model.
   Abbreviations: β = model estimate, SE = Standard Error, df = degrees of freedom, BH = Benjamini-Hochberg, R^2 = explained variation, r = Pearson correlation.
   * Covariates accounted for approximately 6.1% of the explained variation, this variation is still included in the R^2marginal values.

Individual Tables

Participants' characteristics (factor levels) [units]	**N per factor level, or M (SD)**
Age (18-20y, 21-23y, 24-29y)	41, 39, 22
Gender (male, female)	17, 85
Socio-economic status (very good, good, neutral-or-bad)	5, 55, 42
Smoking status (non-smoker, (former) smoker)	96, 6
Diet (normal-or-special diets, no meat)	85, 17
BMI [kg/m²]	21.93 (3.11)
Physical activity [METs/min]	1972.8 (1686.96)
Associating the Belgian coast with obligations (yes, no)	7, 95
Number of visits to the Belgian coast in the past three months [#]	2.41 (5.38)
Number of visits to the Belgian coast in the past year [#]	8.46 (24.94)
Number of visits to the Belgian coast per year as a kid (never, 1-4 x/y, 5-8 x/y, 9-12 x/y, 12-24 x/y, >24 x/y)	7, 49, 15, 11, 9, 11
Dog ownership (yes, no)	22, 80
Near-home urbanization (rural, semi-urban, urban)	38, 49, 15
Near-home access to green spaces (none, few, moderate, a lot)	2, 12, 39, 49
Near-home access to blue spaces (none, few, moderate, a lot)	26, 38, 28, 10
Near-home air quality [rated 0-10]	6.35 (2.3)
Near-home noise levels [rated 0-10]	3.48 (2.39)
Residential coastal proximity (>50km, >20-50km, >5-20km, >1-5km, 0-1km)	74, 18, 5, 3, 2
Satisfaction to residential coastal proximity (good, wants more, wants less)	53, 49, 0
Nature relatedness – 6-item NR scale [1-6]	3.21 (0.82)
Coastal relatedness – 6-item NR scale adapted for coasts [1-6]	2.6 (0.84)
Sense of coherence – 13-item SOC scale [1-5]	2.54 (0.52)
Stress in the past month – 10-item PSS scale [0-4]	1.56 (0.53)
Burnout score – 33-item BAT scale [1-5]	2.27 (0.51)
Rumination – 60-item PTQ-t scale [0-60]	23.48 (11.49)
Sleep quality (never, 1 x/week or less, 2-3 x/week, >4 x/week)	18, 47, 27, 10
State stress [0-10]	2.96 (1.77)
Period of sampling (Period 1, Period 2)	21, 81

Table 1: Participants' characteristics table. Summary of all participant-related covariates, indicated for categorical variables as the number (N) of participants in each factor level, or for continuous variables as the mean (M) with standard deviation (SD). Detailed reasoning and implementation of scoring methods are available in Supplementary Material Section 1.1. Abbreviations and references to scales: BMI = Body Mass Index; METs = Metabolic Equivalents; NR = Nature Relatedness (Nisbet & Zelenski, 2013)*; SOC = Sense of Coherence (Jellesma et al., 2006; Luyckx et al., 2012); PSS = Perceived Stress Scale (van der Ploeg, 2013); BAT = Burnout Assessment Tool (Schaufeli et al., 2019); PTQ-t = Perseverance Thinking Questionnaire – trait version (Ehring et al., 2012).*

		Environments	**$N_{pictures}$**
		Trials	2
Coastal environments (inter-environment comparison)	Beach environments (intra-environment comparison)	Beach/Open beach	6
		In the seawater	2
		On a wave breaker	2
		In a beach bar	2
		Between beach cabins	2
		Dikes	6
		Towns	6
		Recreational harbors	6
		Piers	6
		Dunes	4
		Docks	4
		Salt marshes	2
		Green parks	2
		Historical places	2

Table 2: Tabulated number of pictures per environment and per comparison (inter- or intra-environment). The corresponding pictures can be retrieved from (XXX, 2022 masked for blind review).

Instructions of the PRS (English translation from Dutch presentation)
"Imagine that you are going through a mentally exhausting period. To relax, you have come to the Belgian coast. During your coastal visit, you are at the place where this picture has been taken. Indicate how strong you agree with the following sentences."

Item	**Question**
Likelihood of restoration	Here I can relax and regain mental strength and energy.
Being away	Here I am away from obligations.
Fascination	This place seems fascinating.
Coherence	This place seems chaotic.
Compatibility	This place suits with who I am.

Table 3: Description of the instructions and questions of the adapted perceived restoration scale (PRS) that was used in this study as main outcome variable.

	Model estimates						
Component	β	SE	df	t-value	p-value (adjusted BH)	R^2 (marginal)	r
Natural	3.175	0.304	50	10.439	< 0.001	0.300	0.493
Vegetation	2.001	0.693	50	2.885	0.020	0.110	0.225
Landplant	0.101	0.971	50	0.104	0.935	0.061	0.009
Dune vegetation	3.882	1.080	50	3.595	0.004	0.132	0.270
Salt marsh vegetation	5.467	2.462	50	2.221	0.078	0.092	0.178
Flower box	-377.407	226.985	50	-1.663	0.207	0.079	-0.136
Water	2.302	1.549	50	1.486	0.255	0.076	0.122
Brackish water	33.271	15.372	50	2.164	0.085	0.091	0.174
Seawater	1.953	1.548	50	1.262	0.338	0.072	0.105
Still water	-0.377	2.154	50	-0.175	0.896	0.061	-0.015
Waves	4.146	2.360	50	1.757	0.188	0.081	0.143
Seawater on the beach	50.084	15.629	50	3.204	0.010	0.120	0.246
Sky	3.344	1.020	50	3.277	0.008	0.122	0.250
Blue sky	0.470	1.533	50	0.307	0.840	0.062	0.026
Delineated cumulus	3.392	1.477	50	2.296	0.069	0.094	0.184
Non-delineated cumulus	3.350	1.956	50	1.713	0.197	0.080	0.140
Stratus and cirrus	0.362	1.309	50	0.277	0.847	0.062	0.023
Natural underground	3.108	0.809	50	3.840	0.002	0.140	0.284
Sand underground	3.492	0.831	50	4.203	< 0.001	0.152	0.304
Grass underground	-9.280	7.168	50	-1.295	0.334	0.072	-0.107
Marine debris	15.099	12.079	50	1.250	0.338	0.071	0.104
Wildlife	929.756	1050.400	50	0.885	0.530	0.066	0.074
Urban	-3.263	0.308	50	-10.587	< 0.001	0.302	-0.495
Building	-4.670	1.019	50	-4.584	< 0.001	0.164	-0.324
Shops	-13.929	5.014	50	-2.778	0.025	0.107	-0.218
Unspecified building	-5.615	1.192	50	-4.709	< 0.001	0.168	-0.330
Tower	7.557	12.492	50	0.605	0.691	0.063	0.051
Anthropogenic disturbance	-185.315	55.713	50	-3.326	0.008	0.124	-0.253
Vehicle	-344.178	83.039	50	-4.145	< 0.001	0.150	-0.301
Litter	-212.280	200.540	50	-1.059	0.427	0.069	-0.088
Bench	-40.805	78.583	50	-0.519	0.747	0.063	-0.044

Coastal object	0.760	1.617	50	0.470	0.754	0.063	0.039
Beach bar infrastructure	-0.182	2.655	50	-0.069	0.946	0.061	-0.006
Beach cabin	-0.637	2.999	50	-0.212	0.883	0.061	-0.018
Buoy	2519.649	1599.077	50	1.576	0.230	0.077	0.129
Historical object	-1.463	3.374	50	-0.434	0.768	0.062	-0.036
Play and sports objects	46.881	139.678	50	0.336	0.833	0.062	0.028
Single boat	-5.832	5.406	50	-1.079	0.427	0.069	-0.090
Breakwater	8.585	3.413	50	2.515	0.042	0.100	0.199
Coastal defense	12.467	16.544	50	0.754	0.618	0.065	0.063
Professional equipment	64.272	97.250	50	0.661	0.678	0.064	0.055
Urban underground	-4.729	0.711	50	-6.651	< 0.001	0.224	-0.408
Street	-4.681	2.837	50	-1.650	0.207	0.079	-0.135
Hard underground	-4.313	0.778	50	-5.542	< 0.001	0.193	-0.367
Distant landscape	-4.431	1.623	50	-2.730	0.027	0.106	-0.214
Pier	-31.888	52.674	50	-0.605	0.691	0.063	-0.051
Recreational harbor	-4.367	1.620	50	-2.696	0.028	0.105	-0.212
Big harbor	194.221	393.615	50	0.493	0.751	0.063	0.041
Bin	-20.065	19.087	50	-1.051	0.427	0.068	-0.087
Balustrade	-4.747	3.288	50	-1.444	0.265	0.075	-0.119
Constructions	-128.835	86.897	50	-1.483	0.255	0.076	-0.122
Unclassified urban	-10.991	3.492	50	-3.147	0.011	0.118	-0.242
People	-19.684	9.593	50	-2.052	0.105	0.088	-0.166

Table 4: General linear mixed model output and correlations of the relationships between the picture components and the Perceived Restorativeness Scale (PRS). Each line indicates the output from a separate model.

Abbreviations: β = model estimate, SE = Standard Error, df = degrees of freedom, BH = Benjamini-Hochberg, R^2 = explained variation, r = Pearson correlation.

** Covariates accounted for approximately 6.1% of the explained variation, this variation is still included in the $R^2_{marginal}$ values.*

List of Figures

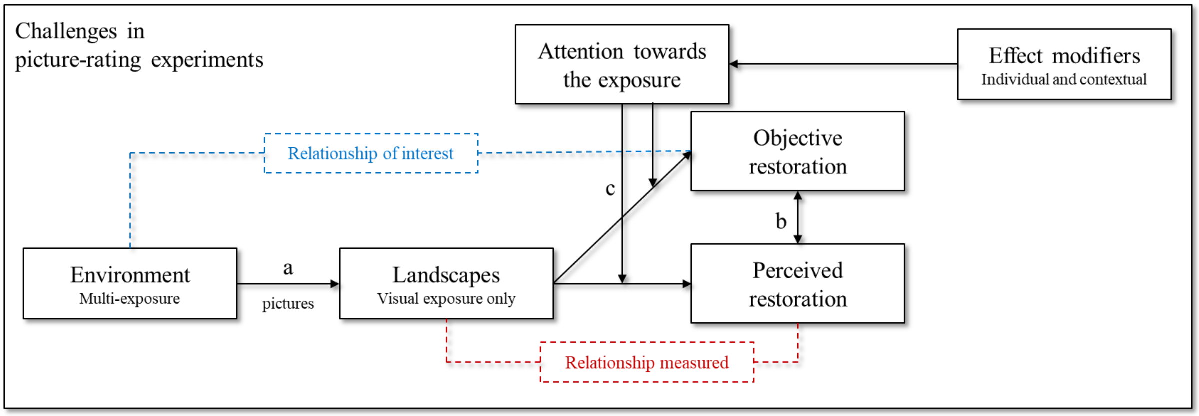


Figure 1: Methodological challenges in picture-rating experiments. The validity of the measured relation (red) for the relation of interest (blue) depends on the representability of the pictures for the real multi-exposure environment (a), the accuracy of the participants' perceived restoration for the objective restoration (b), and visual-attentional processes that are in turn influenced by individual and contextual effect modifiers (c; White et al 2020).

Figure 2: Illustration of a picture of the dike without (A) and with (B) picture component delineations. Each polygon was given a random color by the software and solely serves illustrative purposes.

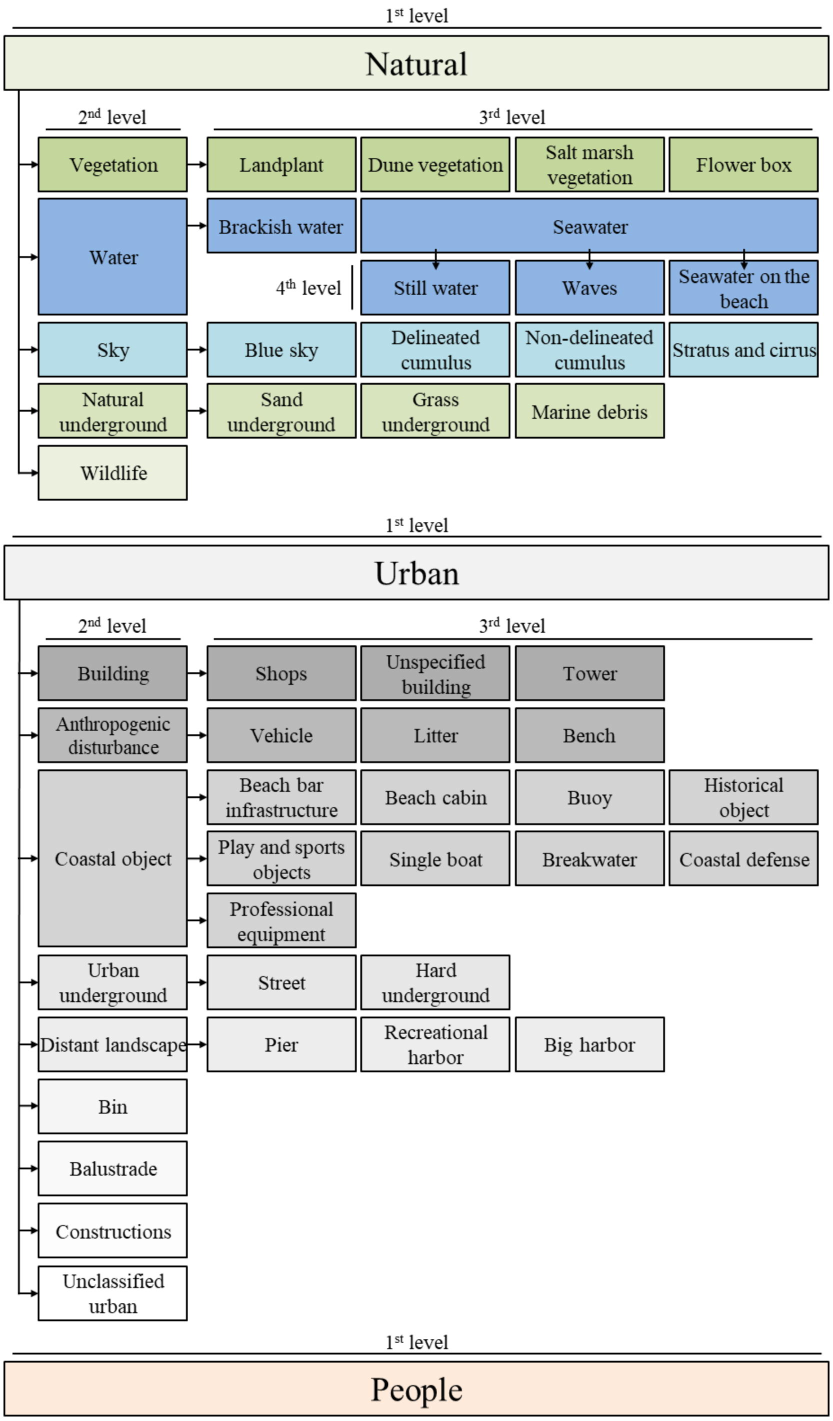


Figure 3: Hierarchical classification of the natural and urban components and people identified on the pictures. Natural and urban components harbor different types of lower-level constituents. Each arrow represents the transition from a higher level to a lower level. The colors of the classes are purely illustrative.

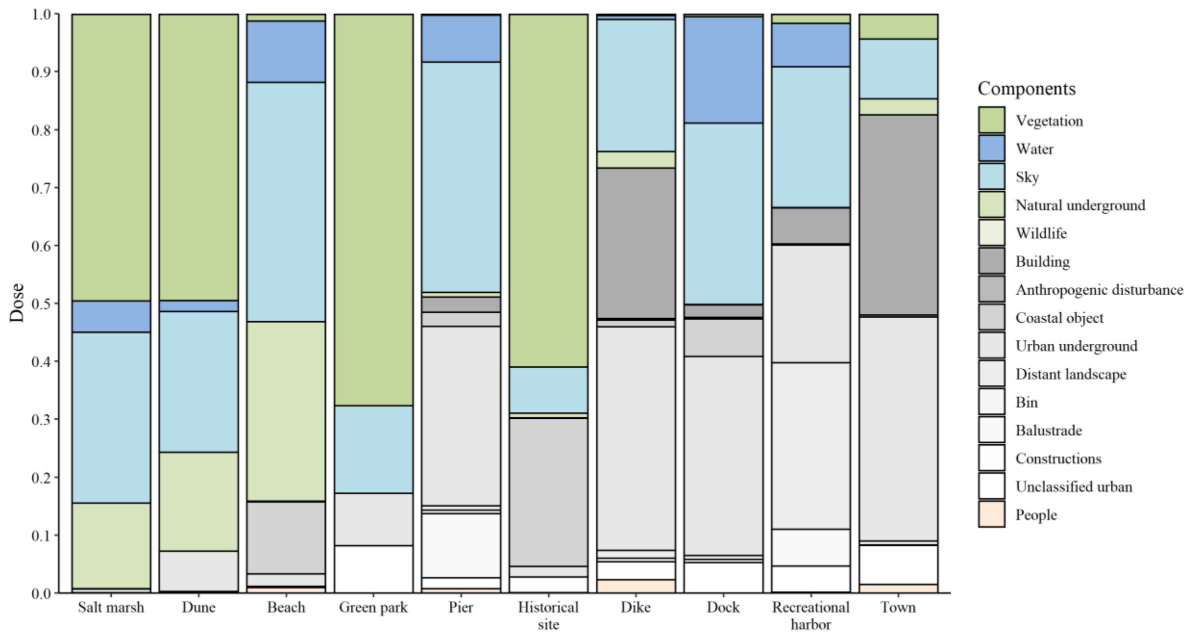
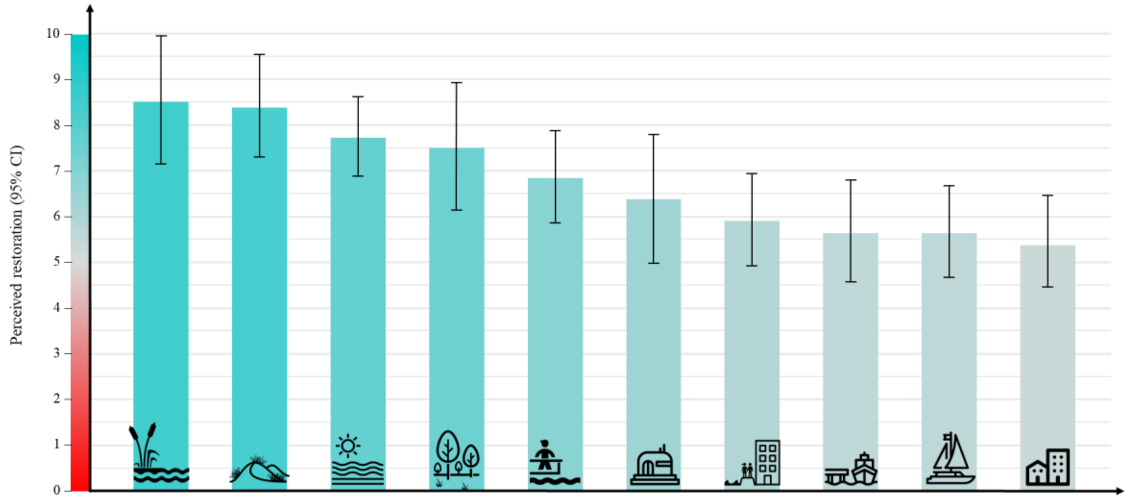
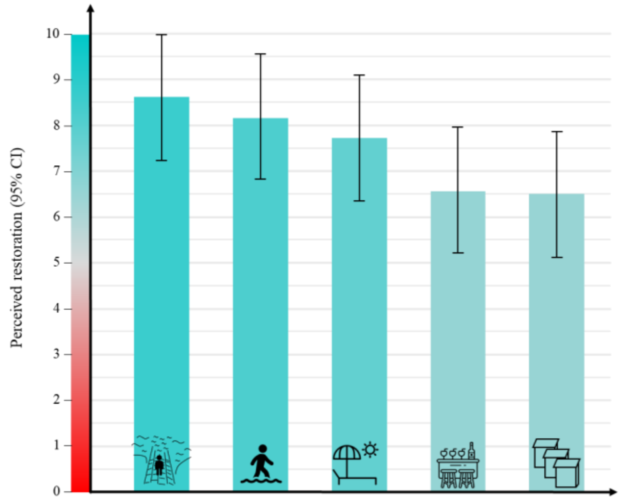


Figure 4: Overview of the dose of natural and urban components and people per coastal environment. The dose of a component is calculated as its relative surface area on each picture, averaged for the pictures per coastal environment. Only the second-level constituents of the natural and urban components are shown for balancing clarity and information. Full details are available in Supplementary Material Section 1.3. The five beach-specific environments also assessed in this study are embedded under 'Beach'. Colors are purely illustrative.



Coastal environments	Salt marshes	Dunes	Beaches	Green parks	Piers	Historical sites	Dikes	Docks	Recreational harbors	Towns
Upper 95% CI	9.94	9.53	8.61	8.92	7.86	7.79	6.93	6.81	6.67	6.47
EM Mean	**8.54**	**8.41**	**7.75**	**7.53**	**6.86**	**6.39**	**5.92**	**5.69**	**5.66**	**5.46**
Lower 95% CI	7.14	7.29	6.88	6.13	5.85	4.99	4.91	4.57	4.66	4.45
Different environments ($p < 0.05$)										

Figure 5: Inter-environment variation in perceived restorativeness: estimated marginal means of PRS-scores of ten coastal environments identified at Belgian coast. Differences between environments were deduced from pairwise comparisons with Tukey-corrected p-values at α = 0.05, which are visualized here as shared lines between environments for which no significant differences were found. So, two environments differ significantly if they do not share a line (e.g. the PRS-scores of piers differ significantly from those of salt marshes, dunes, recreational harbors, and towns). Illustrations are purely aesthetic, we refer to the actual pictures for accurate representations of the environments (XXX, 2022 masked for blind review). Abbreviations: CI = Confidence Interval; EM Mean = Estimated Marginal Mean.



Beach environments	On a breakwater	In the seawater	Open beach	In a beach bar	Between beach cabins
Upper 95% CI	9.99	9.57	9.12	7.97	7.88
EM Mean	**8.62**	**8.20**	**7.74**	**6.59**	**6.50**
Lower 95% CI	7.24	6.82	6.37	5.22	5.13
Different environments ($p < 0.05$)					

Figure 6: Intra-environment variation in perceived restorativeness: estimated marginal means of PRS-scores of five beach environments identified at Belgian coast. Differences between environments were deduced from pairwise comparisons with Tukey-corrected p-values at α = 0.05, which are visualized here as shared lines between environments for which no significant differences were found. So, two environments differ significantly if they do not share a line (e.g. the PRS-scores of on a breakwater differ significantly from those of in a beach bar, and between beach cabins). Illustrations are purely aesthetic, we refer to the actual pictures for accurate representations of the environments (XXX, 2022 masked for blind review). Abbreviations: CI = Confidence Interval; EM Mean = Estimated Marginal Mean.