

*Bring me to the sea
The quiet home in me*

*Where I drink my joy
And spill my tears
For there is everything and nothing
to fear*

- M.S.

Emotional mechanisms linking coastal
landscapes to well-being

Waves of Emotions

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Marine Severin

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2024

Waves of Emotions: Emotional Mechanisms Linking Coastal Landscapes to Well-Being

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Supervisors: Prof. dr. Ann Buysse
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Waves of Emotions: Emotional Mechanisms linking Coastal Landscapes to Well-Being

In today's global context of increasing instability in both planetary and human health, remedying and promoting a healthy connection between people and nature is crucial. Nature is consistently shown to benefit health and well-being, although research has been primarily focused on green spaces, and less on blue spaces. As a particular type of blue space, evidence for positive effects of coastal landscapes on well-being is growing. Various mechanisms are suggested to explain these effects, however emotional processes remain unclear, as well as the specific contexts they depend on. The aim of the present dissertation was to uncover the emotional mechanisms and moderating factors underlying the effects of coastal landscapes on well-being and pro-environmental attitudes and behaviors.

In the general introduction, I provide a theoretical background of relevant concepts and associations and identify existing research gaps. **Chapter 1** describes a quasi-experimental study that replicates the positive relationship between residential proximity to the Belgian coast and well-being, within the context of a major health crisis. In **Chapter 2**, the emotional processes linked to the coast and their influence on well-being are explored via semi-structured interviews. Coastal residents perceive the coast as a safe haven, in which they experience emotional restoration, awe, and nostalgia, accompanied with adaptive emotion-regulating strategies. Several of these findings have subsequently been experimentally tested in **Chapters 3** and **4**.

Chapter 3 presents two experimental studies testing the effects of virtual exposure to coastal landscapes (vs. an urban landscape) on emotions, stress, and pro-environmental attitudes and behaviors (PEABs). Coastal landscapes led to higher experience of small self, nostalgia, and nature connectedness in both studies, with the latter two emotions mediating the stress-reducing effects of the coast in Study 2. Income level was shown to be a moderator, but not presence of plastic. In **Chapter 4**, effects of real-life exposure to the coast are assessed via a guided walk along the beach or an urban street. Although no differences in terms of stress, mood, and worry were found, being mindfully engaged during the coastal walk led to higher awe, nature connectedness, and adaptive emotion-regulating strategies, compared to being distracted during the urban walk.

Neither virtual nor real-life exposure to the coast had significant effects on PEABs. Nonetheless, **Chapter 5** showcases the positive impact of a citizen science intervention on ocean literacy, pro-environmental intentions, nature connectedness, and well-being, in secondary school students living in North and West Africa. In the general discussion, I present the theoretical applications and practical considerations of the overall findings, as well as future research directions. This dissertation brings forward a rich and complex emotional experience of the coast, with multiple well-being benefits.

Golven van Emoties: Emotionele Mechanismen die Kustlandschappen Verbinden met Welzijn

In de huidige globale context van toenemende instabiliteit van zowel de planetaire als menselijke gezondheid, is het essentieel om een gezonde connectie tussen mensen en de natuur te bevorderen en te herstellen. Het is reeds aangetoond dat de natuur een gunstig effect heeft op gezondheid en welzijn, hoewel onderzoek zich voornamelijk gericht heeft op groene ruimtes en minder op blauwe ruimtes. Als een bepaald type blauwe ruimte, bewijs voor de positieve effecten van kustlandschappen op het welzijn neemt toe. Verschillende mechanismen worden voorgesteld om deze effecten te verklaren, maar de emotionele processen en de specifieke contexten waarin ze optreden blijven onduidelijk. Het doel van dit proefschrift was het onthullen van de emotionele mechanismen en de modererende factoren die ten grondslag liggen aan de effecten van kustlandschappen op welzijn en pro-milieu attitudes en gedragingen.

In de algemene inleiding geef ik een theoretische achtergrond van de relevante concepten en associaties en identificeer ik bestaande onderzoekshiaten. **Hoofdstuk 1** beschrijft een quasi-experimentele studie die de positieve relatie tussen wonen aan de Belgische kust en welzijn repliceert, binnen de context van een gezondheids crisis. In **Hoofdstuk 2** worden de emotionele processen die met de kust verbonden zijn en hun invloed op het welzijn onderzocht via semi-gestructureerde interviews. Kustbewoners ervaren de kust als een veilige haven, waarin ze emotioneel herstel, ontzag en nostalgie ervaren, samen met adaptieve emotieregulerende strategieën. Verschillende van deze bevindingen zijn vervolgens experimenteel getest in **Hoofdstukken 3 en 4**.

Hoofdstuk 3 presenteert twee experimentele studies die de effecten van virtuele blootstelling aan kustlandschappen (vs. een stedelijk landschap) op emoties, stress en pro-milieu attitudes en gedragingen testen. In beide studies leidden kustlandschappen tot een hogere ervaring van een gevoel van kleine zelf, nostalgie en verbondenheid met de natuur, waarbij de laatste twee emoties de stressverlagende effecten van de kust medieerden in Studie 2. Het inkomensniveau bleek een moderator te zijn, maar niet de aanwezigheid van plastic. In **Hoofdstuk 4**, worden de effecten van reële blootstelling aan een kustlandschap beoordeeld via een begeleide wandeling langs het strand of een stedelijke straat. Hoewel er geen verschillen werden gevonden op het gebied van stress, stemming en zorgen, leidde een 'mindful' betrokkenheid tijdens de kustwandeling tot meer ontzag, verbondenheid met de natuur en adaptieve emotieregulerende strategieën, in vergelijking met afgeleid zijn tijdens de stadswandeling.

Noch virtuele, noch reële blootstelling aan de kust had significante effecten op pro-milieu attitudes en gedragingen. Desondanks toont **Hoofdstuk 5** de positieve impact van een burgerwetenschapsinterventie op oceaangeletterdheid, milieuvriendelijke intenties, verbondenheid met de natuur en welzijn bij middelbare scholieren in Noord- en West-Afrika. In de algemene discussie

presenteer ik de theoretische toepassingen en praktische overwegingen van de algehele bevindingen, evenals toekomstgerichte onderzoeksvragen. Dit proefschrift brengt een rijke en complexe emotionele ervaring van de kust naar voren, met meerdere welzijnsvoordelen.

Articles in this dissertation

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Relationship between doctoral thesis and master's theses or other papers

Chapters related to the own master's thesis or paper

None

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Marine Severin was the daily supervisor of three master thesis students at Ghent University (Luka Lambrecht, Evie Notebaert, and Justine Verheye) and of three master thesis students at KU Leuven (Louis Pauwels, Onur Gündüz, and Lore Mertens). Each of these master theses is based on data collected for the purpose of this dissertation and partially reflects the research questions in Chapters 2, 3, and 4. Each of these chapters integrates findings from two theses and Chapter 3 utilizes more advanced statistical analyses (i.e., structural equation modeling) than used by the associated students. All master students are included as co-authors in the relevant chapters.

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General Introduction

“The sea is emotion incarnate.

It loves, hates, and weeps.

It defies all attempts to capture it with words and rejects all shackles.

No matter what you say about it, there is always that which you can't.”

– Christopher Paolini (*Eragon*, 2002)

In 2019, the United Nations projected that by 2050, 68% of the world's population will live in an urban area. In that same year, a global health crisis emerged, notably the COVID-19 pandemic. Not only did the pandemic lead to a devastating loss of life, it also put mental health onto the frontline, revealing further deterioration (Vindegaard & Benros, 2020). In addition to social interactions, the importance of natural environments for mental health became increasingly salient (Pouso et al., 2021). However, direct contact with nature in daily life is diminishing, a phenomenon that has been coined as 'extinction of experience' (Pyle, 1993). This loss of contact with nature has significant consequences, both in terms of human health and planetary health. Soga and Gaston (2016) illustrate a vicious cycle through which a loss of opportunity to experience nature reduces human-nature interactions, leading to the loss of the health benefits of nature, less emotional affinity and perceived value of nature, and less environmental engagement. These consequences ultimately feedback to a further decline in opportunities for nature contact. As Sir David Attenborough puts it, "if children don't grow up knowing about nature and appreciating it, they will not understand it. And if they don't understand it, they won't protect it. And if they don't protect it, who will?" (Learning through Landscapes, 2014). Remedying and promoting a healthy connection between people and nature is therefore of utmost importance.

In this doctoral dissertation, I investigated the relationship between a specific type of natural environment, namely the coast, and mental well-being. More specifically, I examined emotional processes associated with the coast and their effect on well-being, as well as on pro-environmental attitudes and behaviors (PEABs). Emotions are inherently linked with well-being and constitute a strong driving force in motivating and engaging people towards environmental action (Taufik & Venhoeven, 2018). Understanding the emotional mechanisms through which the coast benefits well-being and PEABs enables us to further comprehend and optimize coastal-human interactions.

The present introduction provides a theoretical background of relevant concepts and associations, identifies current research gaps, and gives an overview of the research objectives and empirical chapters included in the dissertation.

Nature and Mental Health

An increasing amount of research demonstrates the importance of natural environments for health and well-being (Hartig et al., 2014). For example, there is empirical evidence linking contact with nature to higher subjective well-being, positive social interactions, a sense of meaning in life, and lower psychological distress (Bratman et al., 2019). Despite this growth in research, the role of natural

environments on mental health remains largely neglected in policy and practice. This is partly due to the complexity of defining and measuring people-nature interactions, and the lack of consideration for the interrelations between well-being dimensions (Betley et al., 2023; Schleicher et al., 2018). Before looking into theoretical approaches, it is essential to define what is meant by ‘nature’, ‘nature contact’, and ‘mental health’.

Nature

In defining nature, White et al. (2023) offer a three-level typology. The first level relates to the broad category of natural ecosystems, which encompasses all abiotic and biotic elements and processes co-existing in a particular habitat. The second level refers to nature settings, i.e., distinct geographical areas existing within larger ecosystems. The third level, nature elements, refers to specific features experienced in nature settings (e.g., geological features, soundscapes, thunderstorms) or outside of nature (e.g., houseplants, pets). Finally, a fourth aspect is included, nature affordances, to reflect features within ecosystems, settings, and elements that encourage or discourage certain behaviors (e.g., swimming, snorkeling, or kayaking at sea; lounging, cycling, or walking along the beach).

An important distinction that is commonly made in the scientific literature is between green spaces and blue spaces. Green spaces relate to outdoor environments marked by vegetation (e.g., urban parks, woodlands, street trees, gardens), whereas blue spaces predominantly feature water (e.g., rivers, lakes, canals, coastal landscapes). Research on nature and health has been largely focused on green spaces, with blue spaces only gaining attention in recent years (Grellier et al., 2017). In this dissertation, I focus on the specific nature setting of coastal landscapes, their particular elements (e.g., dunes, beaches, sunsets), and the affordances they offer (e.g., walking). Going beyond what is defined by nature, we must understand what is experienced through nature. As stipulated in White et al. (2023), “the types of contact people have with nature are a function of the natural ecosystems, settings, elements encountered, and affordances offered” (p. 6).

Nature contact

Throughout the literature, various terms are used to refer to how individuals are exposed to, interact with, or engage in, nature. I continue to follow definitions proposed by White et al. (2023) and focus on the term ‘nature contact’ as it showcases both passive and active people-nature interactions¹.

¹ In Chapter 3, we employ the term ‘nature exposure’, as participants were passively interacting with the coast through the viewing of a video-clip. In Chapter 4, we introduce the term ‘nature engagement’, as we manipulated the level of active interaction with the coast during a walk at the beach.

Nature contact is classified in terms of interactional, temporal, interpersonal, and intrapersonal aspects. Interactional aspects differentiate nature contact as indirect, incidental, or intentional (Keniger et al., 2013). Indirect contact is expressed through experiencing nature without being physically present in it (e.g., watching nature television programs, having a view of the coast from home). Incidental contact entails unintentional encounters with nature (e.g., passing through the coast while commuting). Intentional contact refers to the direct intention to be present in nature (e.g., visiting the coast). There is clear overlap between all three forms of interactional aspects.

Temporal aspects of nature contact relate to the duration of the contact, that can range from a few minutes to several years. Nature contact is also determined by interpersonal aspects, reflecting the social interactions, identities, and norms that shape the experience of nature, and even facilitate or hinder access to nature across socio-demographic groups. Finally, aspects that should be further considered as a form of exposure relates to intrapersonal aspects. Brief experiences in nature may be felt intensely and may lead to long-term memories that can be repeatedly recalled and thereby prolong the total nature contact duration. These memories may also modulate how future encounters with nature are experienced. All four aspects of nature contact are essential determinants in the relationship between nature and mental health.

Mental health

The World Health Organization (WHO, 2022) defines mental health as “a state of mental well-being that enables people to cope with the stresses of life, to realize their abilities, to learn well and work well, and to contribute to their communities” (p. 8). Mental health therefore encapsulates a complex continuum and goes beyond the mere absence of mental disorders. Mental well-being was first conceptualized as hedonic, or subjective, well-being (SWB), that is based on pleasure attainment and pain avoidance (Diener, 1984). SWB consists of high positive affect, low negative affect, and satisfaction with one’s life. Later on, eudaimonic, or psychological, well-being (PWB) emerged. Rather than simply focusing on happiness, PWB reflects living a self-determined and meaningful life, in accordance with one’s values. PWB includes the fulfillment of basic psychological needs (i.e., competence, relatedness, and autonomy; Ryan & Deci, 2000), and six dimensions proposed by Ryff and Keyes (1995): environmental mastery, autonomy, personal growth, positive relationships, purpose in life, and self-acceptance.

In terms of restoring and sustaining mental well-being, there exist two central approaches, i.e., the stress and coping approach and the emotion regulation approach. Based on the work of Lazarus and Folkman (1984), coping is defined as “cognitive and behavioral efforts to manage specific external and/or

internal demands that are appraised as taxing or exceeding the resources of the person” (p. 141). These taxing demands refer to encountered stressors that generate a stress response. A broad array of coping strategies exists and strategies are most commonly classified as either problem-focused (i.e., efforts to modify the situation itself) or emotion-focused (i.e., efforts to manage emotions associated with the situation; Lazarus & Folkman, 1984). Recently, a third type of coping emerged, namely meaning-focused coping, in which appraisal-based efforts are made to find coherence and meaning in the situation (Park & Folkman, 1997). Importantly, whether a coping strategy is adaptive or not depends on the context and adjustment to stress is likely to emerge when the type of coping fits with specific elements of the stressor (Cheng et al., 2014).

Emotion regulation surfaced within the broader framework of coping and is conceived as efforts to modulate the nature, timing, experience, and expression of our emotions (Gross, 1998). According to strategy-based models of emotion regulation, specific strategies that generally benefit well-being are labelled as adaptive and strategies that tend to negatively impact well-being are labelled as maladaptive (Aldao et al., 2010). Adaptive strategies include acceptance, problem-solving, reappraisal, and mindfulness, whereas maladaptive strategies include expressive suppression, experiential/behavioral avoidance, and rumination (Naragon-Gainey et al., 2017). There is considerable overlap between coping and emotion regulation strategies. However, unlike coping, emotion regulation can refer to both positive and negative emotions, and reflect both unconscious and conscious processes (Marroquín et al., 2017). Coping and emotion-regulation are considered as major psychological processes that explain resilience (Troy et al., 2023), a central component in the Nature-based Biopsychosocial Resilience Theory, proposed by White et al. (2023).

In this dissertation, I investigated how coastal landscapes influence multiple dimensions of well-being. Our main focus was on the experience of stress, as it relates to a fundamental theoretical model (i.e., Stress Recovery Theory; Ulrich, 1983) and is most commonly evaluated in the nature-health field. I also addressed aspects of subjective well-being (i.e., positive and negative affect), psychological well-being (i.e., social connectedness, competence, and autonomy), indicators of mental ill-being (i.e., boredom and worry), and components of resilience, namely meaning-focused coping and emotion regulation.

Theoretical frameworks

Research on nature and mental health has been mainly based upon two theoretical frameworks, i.e., Attention Restoration Theory (ART; Kaplan & Kaplan, 1989) and Stress Recovery Theory (SRT; Ulrich,

1983). According to the ART, prolonged use of directed attention can induce mental fatigue, which can lead to impaired cognitive performance and lack of motivation (Boksem et al., 2006; Lorist et al., 2005). The central tenet of the ART is that natural environments can restore this mental fatigue through four properties: being away (sense of distance from usual thoughts and concerns), fascination (effortless attention towards visually appealing stimuli), extent (richness and coherence that enables to be immersed), and compatibility (alignment with one's needs and inclinations; Kaplan, 1995). Although the ART has largely received empirical support for both green and blue spaces (Berto, 2005; Gidlow et al., 2016; Stevenson et al., 2018), other studies have revealed mixed findings (Ohly et al., 2016) and have demonstrated conceptual drawbacks (Joye & Dewitte, 2018).

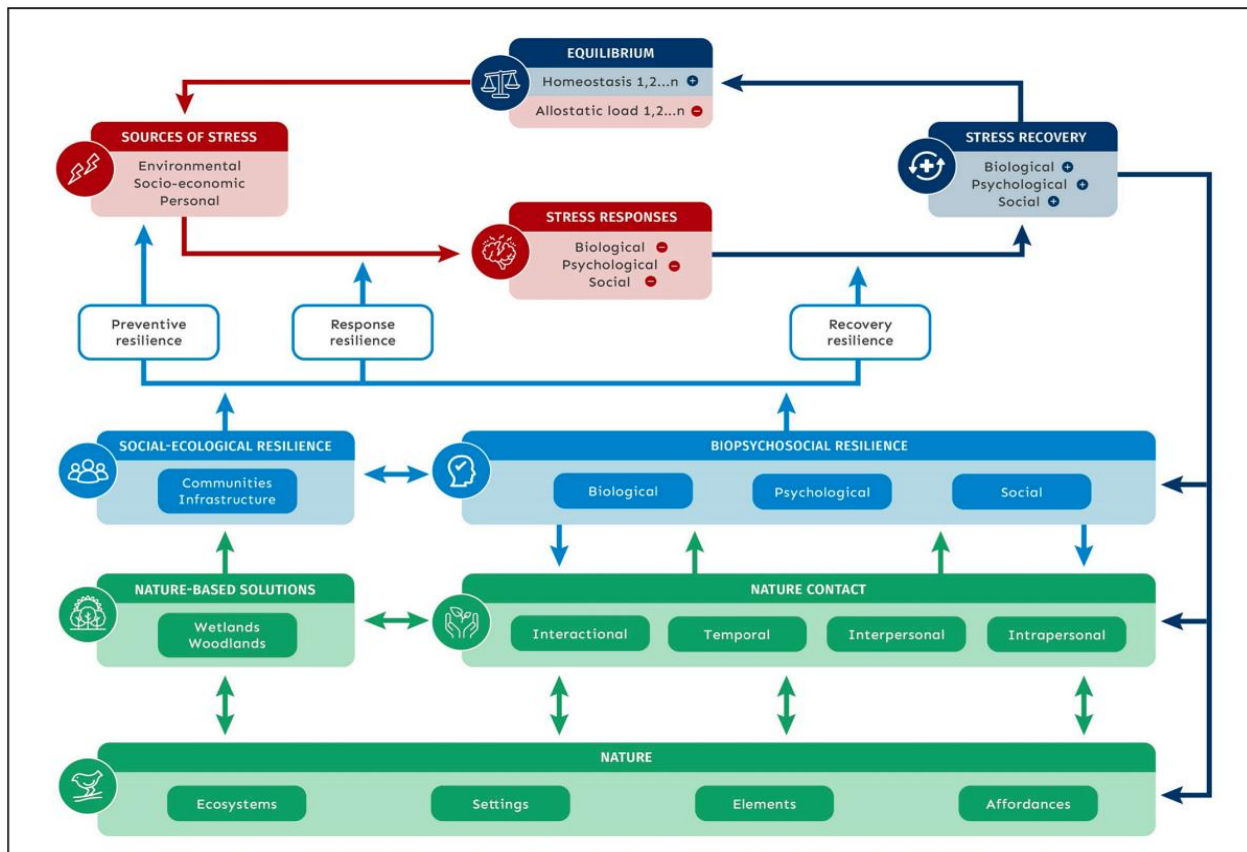
The Stress Recovery Theory (SRT; Ulrich, 1983) explains the processes by which natural environments reduce levels of stress. The theory posits that our initial unconscious response to an environment reflects generalized affect (i.e., like or dislike). Positive responses arise if the environment contains specific features, such as natural content (e.g., vegetation, water), structural elements, and absence of threats. These responses allow further reduction of cognitive and physiological arousal, as well as increase in positive affect. Several studies provide evidence for the SRT, essentially displaying better stress recovery and higher positive mood after exposure to natural environments, compared to urban environments (Berto, 2014; Hooyberg et al., 2023; Ulrich et al., 1991). The present dissertation is primarily set upon the framework of the SRT and thereby helps to elucidate certain aspects of the SRT that remain uncertain (e.g., by assessing both virtual and immersive exposure; Gaekwad et al., 2023).

In addition to the ART and the SRT, there is a new theoretical model that has emerged, namely the Nature-based Biopsychosocial Resilience Theory (NBRT; White et al., 2023). The NBRT is a comprehensive framework that addresses how nature contact supports the development and maintenance of individual biological, psychological, and social resilience-related resources (Figure 1). These resources can subsequently boost resilience in terms of prevention, response, and recovery in relation to stress. Moreover, the NBRT aims to bridge the gap between socio-ecological resilience that is enhanced through nature-based solutions and individual biopsychosocial resilience. In other words, the theory will gather greater understanding of the inextricable links between the health of the planet and of humans. Although the theory has not yet been specifically investigated, its conceptualization generates important implications for the development of nature-based therapies.

Other theoretical models worth mentioning but that are beyond the scope of this dissertation are: biophilia hypothesis (Wilson, 1986), goal-discrepancy account of restorative nature experiences (Joye et al., 2024), and conditioned restoration theory (Egner et al., 2020).

Figure 1

Schematic Visualization of the Nature-Based Biopsychosocial Resilience Theory from White et al. (2023)



Coastal Landscapes and Mental Well-Being

Throughout the theoretical underpinnings and research regarding nature and mental health, there has been relatively little focus on blue spaces, including coastal landscapes². The coast, and more specifically the ocean, is a major contributor to our health and well-being, but is increasingly under threat due to climate change and overexploitation (Claudet et al., 2020). The importance of preserving and restoring a healthy ocean is illustrated through the United Nations Decade of Ocean Science for Sustainable Development (2021 to 2030). One of the challenges posed by this ‘Ocean Decade’ is to change people’s relationship with the ocean (Ocean Decade, 2023). Fulfilling this challenge includes gaining an understanding of how the ocean impacts well-being and addressing the barriers to necessary behavior

² Although there is no clear definition of ‘coastal landscape’, a typical point of reference is “where land meets sea” (Leyshon, 2018, p. 151). As demonstrated in Hooyberg et al. (2022), there is high variability in what a coastal landscape can represent, although common elements include beaches, piers, dunes, salt marshes, dikes, harbors, and seawater.

change for a positive relationship with the ocean. I undertake this challenge by investigating how coastal landscapes affect primarily well-being, but also pro-environmental attitudes and behaviors.

Developments in research and policy

The use of coastal landscapes for therapeutic aims already dates back to the 18th century, through the means of thalassotherapy (Charlier & Chaineux, 2009). Throughout Europe, several health centers along the coast were developed on the basis of the healing effects of the sea, such as the Royal Sea Bathing Hospital in Margate, UK (Strange, 1991; Verhaeghe, 1843). Nowadays, the applications of modern thalassotherapy (e.g., use of seawater, marine-derived substances, and sea air) have become closely linked to health and wellness tourism (Gomes et al., 2021).

A catalyst in applying the well-being effects of coastal landscapes within a research agenda was the Blue Gym initiative that originated in the UK (Depledge & Bird, 2009). Its aims were to assess the health-promoting potential of blue spaces and to raise awareness to the public to preserve and protect these blue spaces. The initiative not only yielded positive findings that supported the benefits of blue spaces (especially coastal landscapes; White et al., 2016), it also laid the groundwork for further research within the transdisciplinary field of 'Ocean and Human Health' (OHH; Fleming et al., 2014).

OHH is set to explore the circular interconnections between the health of the ocean and human health (H2020 SOPHIE Consortium, 2020). Initially, research was concentrated upon the risks and hazards of the ocean on human health, such as harmful algal blooms, chemical and microbial pollution, and natural events (European Marine Board, 2013). Recently, there has been increased focus on the positive impacts of the ocean, specifically in the areas of seafood, marine biotechnology and medicine, and tourism and well-being (H2020 SOPHIE Consortium, 2020). Two influential pan-European research projects have brought forward the significance of understanding how coastal landscapes impact well-being, i.e., the Seas, Oceans and Public Health in Europe project (SOPHIE) and BlueHealth.

Concurrent with advancements in the broader field of OHH, health geographers have investigated the salutogenic effects of blue spaces, in the context of therapeutic landscapes (Finlay et al., 2015; Foley & Kistemann, 2015; Völker & Kistemann, 2011). Gesler (1993) defined a therapeutic landscape as a place with "an enduring reputation for achieving physical, mental, and spiritual healing" (p. 171). Studies by Bell et al. (2015) and Satariano (2019) demonstrated coastal landscapes as a highly prominent therapeutic landscape. Within the field of environmental psychology, based on the theoretical frameworks of the ART and the SRT, coastal landscapes have been characterized as a restorative environment (White et al., 2013).

The present dissertation is built upon perspectives from both health geography and environmental psychology.

Empirical support for coastal landscapes and well-being

Research has found positive associations between various forms of contact with coastal landscapes and multiple dimensions of well-being. Initial studies revealed that living near the coast is linked with better self-reported physical and mental health, compared to living further inland (Garrett et al., 2019; Hooyberg et al., 2020; Wheeler et al., 2012). In terms of intentional exposure, visits to the coast have been linked with happiness (MacKerron & Mourato, 2013), positive mood (Vert et al., 2020), and positive well-being (White et al., 2021). Other studies have found support for indirect exposure, in which a home view of the coast was associated with lower risk of depression (Dempsey et al., 2018) and psychological distress (Nutsford et al., 2016). In Garrett et al. (2019), blue spaces, including coastal landscapes, were linked with better health for all three types of exposure (i.e., intentional, indirect, and incidental). Importantly, the majority of these studies include other natural environments in their assessments. However, benefits of coastal landscapes have often been shown to be superior in comparison to other blue or green space types (Garrett et al., 2023b; Hooyberg et al., 2023; MacKerron & Mourato, 2013).

Given these positive effects of coastal landscapes, studies have progressed to evaluate therapeutic interventions incorporating coastal environments in clinical populations. A systematic review of 33 studies, of which 19 took place in a coastal landscape, found an improvement of mental health and psycho-social well-being after a blue space intervention (Britton et al., 2020). It should be noted however that the majority of these studies had a moderate to high risk of bias due to small sample sizes, self-selection bias, and lack of control groups. In terms of understanding how the coast impacts people with a mental illness, research is very limited. A qualitative study by Wright et al. (2024) did demonstrate the importance of blue spaces for the well-being of people with bipolar, schizophrenia, and other psychotic conditions.

Coastal landscapes and pro-environmental attitudes and behaviors

Compared to well-being, research assessing the relationship between coastal landscapes and pro-environmental attitudes and behaviors (PEABs) is even more limited. There are indications of a positive link, as living near the coast, versus inland, has been associated with a higher likelihood to report pro-environmental behaviors (Alcock et al., 2020), to demonstrate stronger belief in climate change, and to show greater support for government regulation of carbon emissions (Milfont et al., 2014). A larger

number of studies display positive associations between PEABs and natural environments in general (Deville et al., 2021; Martin et al., 2020; Rosa & Collado, 2019; Whitburn et al., 2019). Effects of nature exposure on pro-environmental behavior within experimental studies are promising (Arendt & Matthes, 2016; Zelenski et al., 2015), however findings remain unclear (Lange & Truyens, 2022).

The positive link between nature contact and PEABs is primarily attributed to heightened connection with nature (Barragan-Jason et al., 2022). Positive experiences in nature can lead to a deepened appreciation of nature, potentially fostering a commitment to behaviors aimed at its preservation (Lange & Truyens, 2022). Further explanation of this underlying mechanism is provided in the following section.

The investigation of PEABs can be tailored more specifically with regards to coastal landscapes, through the concept of ocean literacy. At first considered as the level of knowledge and awareness of ocean-related topics (Schoedinger et al., 2005), ocean literacy now encompasses ocean-friendly attitudes and behaviors, and connectedness to the ocean (Kelly et al., 2022; Paredes-Coral et al., 2022). Enhancing ocean literacy in the global population has been identified as a key target for promoting sustainable behavior change by the United Nations Ocean Decade (Intergovernmental Oceanographic Commission, 2018).

One way to boost ocean literacy is with the use of citizen science. For example, citizen science initiatives that focus on marine litter have been shown to positively affect ocean literacy, through increasing awareness, knowledge, and concern towards marine litter, and encouraging pro-environmental intentions and actions to reduce marine litter (Hartley et al., 2015; Locritani et al., 2019; Wichmann et al., 2022). In this dissertation, I evaluate the impact of a specific citizen science project on both ocean literacy and well-being.

Mechanisms Underlying the Relationship Between Coastal Landscapes and Well-Being

To further comprehend how and why nature positively affects mental health, researchers have evaluated several underlying mechanisms. Markevych et al. (2017) have identified three prominent mechanisms that link green spaces to health, i.e., mitigation, instoration, and restoration, which have since then been extended to blue spaces in White et al. (2020).

The mechanism of mitigation refers to reducing harm, via for example reduced exposure to environmental stressors such as air pollution, noise, and heat. Blue spaces can regulate temperature by absorbing and releasing heat (Völker et al., 2013) and can mitigate unpleasant traffic noise via calming water sounds (Rådsten-Ekman et al., 2013). Specific to coastal landscapes, sea spray aerosols are shown

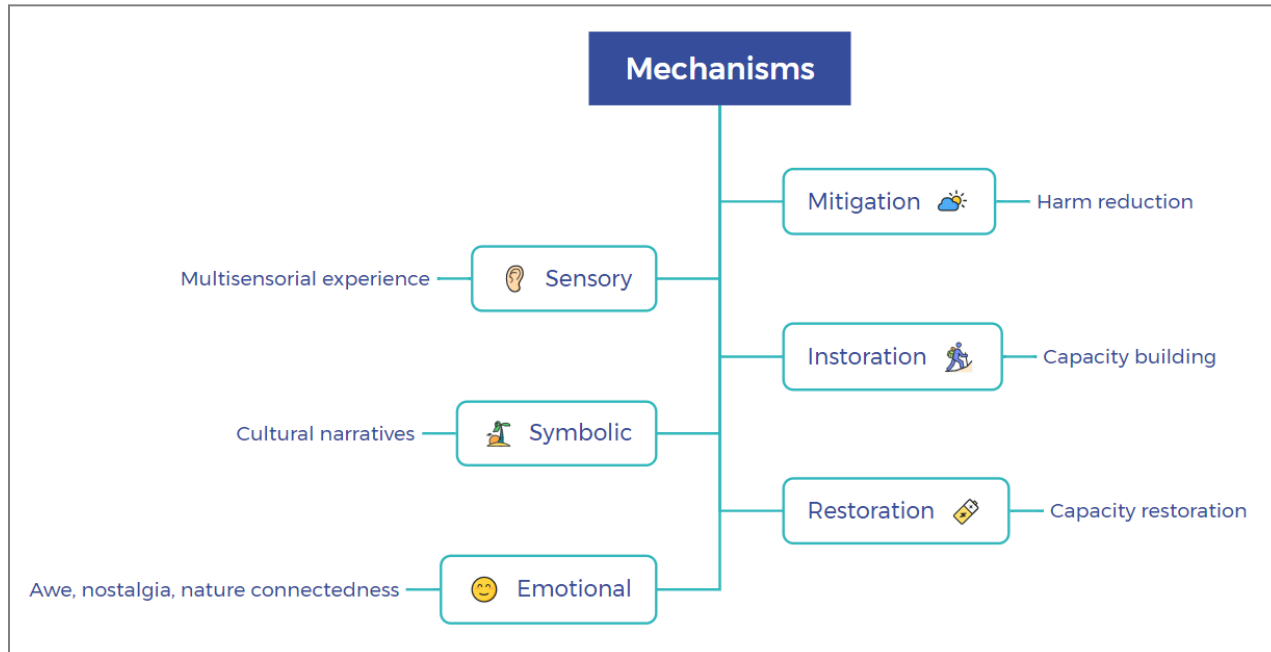
to provide beneficial health effects (Van Acker, 2021), via for example their immunostimulatory activity (Li et al., 2024). Instoration relates to the promotion of physical and psychological resources such as physical activity and social interactions. Coastal landscapes offer a multitude of active pursuits that boost health, such as swimming, surfing, and walking. In fact, living near the coast is linked with higher rates of physical activity (Garrett et al., 2020; White et al., 2014). Moreover, the coast is inherently a social space, providing numerous opportunities for spontaneous and planned social interactions, as well as creating significant experiences that enhance family well-being (Ashbullby et al., 2013; Bell et al., 2015). Finally, the mechanism of restoration refers to the recovery of depleted cognitive and physiological capacities, as expressed through the attention restoration theory and the stress recovery theory.

Two mechanisms that are not explicitly addressed in White et al. (2020) concern the sensory and symbolic dimensions of coastal landscapes. The coast offers an immersive and multisensorial experience that strengthens well-being (Bell et al., 2015). For example, it contains appealing visual properties, such as light reflection with fractal patterns (Van den Berg et al., 2016; White et al., 2010), and restorative sounds (e.g., breaking waves; Nicolosi et al., 2021). In terms of the symbolic dimension, the well-being benefits of the coast are closely linked to perceptions that have been shaped by cultural narratives and individual experience (Bell et al., 2015; Foley & Kistemann, 2015; Wheaton et al., 2020).

In consideration of these mechanisms, we can identify physical, social, cognitive, sensory, and symbolic dimensions. Nonetheless, a dimension that remains ambiguous is the emotional dimension. The study of emotions in connection to blue spaces has been limited to general positive and negative affect, and has so far not included more complex emotional processes. Moreover, the role of emotional processes as underlying mechanisms in the effect of coastal landscapes on well-being has yet to be investigated. The primary aim of the present dissertation was therefore to determine emotional processes linked with the coast and to assess their effect on well-being. I examined three emotional states that have received limited attention in the context of contact with nature, particularly in coastal landscapes: awe, nostalgia, and nature connectedness (Figure 2). I additionally explored how each emotional state relates to PEABs and the role of emotion-regulating strategies in coastal landscapes. Importantly, this investigation of emotional processes addresses fundamental questions outlined in the research agenda on nature contact and health proposed by Frumkin et al. (2017).

Figure 2

Overview of Mechanisms Underlying Relationship between Coastal Landscapes and Well-Being



Awe and feelings of small self

The emotion of awe arises with a perception of vastness, accompanied with a need for accommodation (Keltner & Haidt, 2003). A stimulus may be vast in terms of physical space, time, number, complexity of detail, or ability. This stimulus expands one's usual frame of reference, leading to a need to update one's mental schema. Common triggers of awe thereby include panoramic views, art, music, and human accomplishments (Shiota et al., 2007). Awe has been characterized as an ambivalent emotion, combining elements of fear and happiness (Arcangeli et al., 2020). Fear may become predominant when faced with threatening stimuli (Gordon et al., 2016) and/or when one fails to satisfy the need for accommodation (Keltner & Haidt, 2003). Positively valenced awe is shown to highly benefit well-being, in terms of increasing life satisfaction, meaning in life (Rudd et al., 2012; Zhao et al., 2019) and reducing stress (Bai et al., 2021).

A central component that explains the well-being effects of awe is self-diminishment (Monroy & Keltner, 2023). Studies show that feeling awe can lead to a shift in attention towards larger entities, thereby eliciting a broader perspective and reduced importance of personal concerns and goals (Piff et al., 2015; Shiota et al., 2007). This is corroborated by neuroscientific work in which watching awe-eliciting videos led to a reduction in self-reflective thought (van Elk et al., 2019).

Several studies have demonstrated awe as an underlying mechanism in the effect of nature on well-being (Anderson et al., 2018), positive mood (Joye & Bolderdijk, 2014), and reduced rumination (Lopes et al., 2020). With regards to coastal landscapes, only a few qualitative studies have shown the potential of the coast to trigger awe, due its grandeur and aesthetic appeal (Jarratt & Sharpley, 2017; Pearce et al., 2017; Willis, 2015).

In consideration of awe leading to a reduced focus on the self and increasing prosocial behaviors (Piff et al., 2015), researchers have tested the potential of awe to foster pro-environmental behaviors and have found positive effects (Chirico et al., 2023; Yang et al., 2018). These effects appear to be explained by feelings of small self (Kaplan et al., 2023). Further research on whether awe linked to coastal landscapes affects PEABs remain nonetheless lacking.

Nostalgia

Nostalgia is another emotion marked by ambivalence. Characterized as a sentimental longing for the past, nostalgia reflects a bittersweet experience, a mixture of sadness and happiness (Leunissen, 2023). Recalled nostalgic events most often feature the self interacting with close others or momentous events, and follow a redemptive narrative, through which a negative standpoint progresses towards a positive perspective (Wildschut et al., 2006). Nostalgia can be triggered by negative mood and loneliness, but functions as a psychological resource that counteracts these triggers (Hepper & Dennis, 2023; Wildschut et al., 2006). In fact, nostalgia provides both an enhancing and regulatory function for well-being. The former relates to nostalgia increasing well-being, such as positive mood, self-esteem (Wildschut et al., 2006), and meaning in life (Abeyta & Pillarisetty, 2023). The latter refers to nostalgia mitigating against threats to well-being, such as stress (Routledge et al., 2011) and boredom (van Tilburg et al., 2013). Nostalgia also engages brain regions implicated in self-reflection, autobiographical memory, emotion regulation, and reward processing (Yang et al., 2023).

To our knowledge, only one study has investigated the links between nature and nostalgia, in which adding natural sounds to virtual nature exposure heightened feelings of nostalgia (Smalley et al., 2023). In a qualitative study, Jarratt and Gammon (2016) demonstrated nostalgia as a central element when visiting the seaside, linking it to the familiar and timeless nature of the coast, in contrast to the fast-paced modern world. Moreover, the coast is likely to hold significant memories featuring shared social experiences, that can be recalled through its particular sensory stimuli such as the scent of the ocean (Reid et al., 2015).

Very little is known as to whether nostalgia impacts PEABs. Similar to awe, nostalgia has been linked to prosocial behavior. Based on cross-sectional data, people who are more prone to nostalgia are more likely to engage in prosocial behavior, due to greater attachment security and affective empathy (Juhl et al., 2020). Furthermore, in the context of nostalgic feelings linked to attachment to a specific place (Scannell & Gifford, 2017), it is possible that these feelings boost the existing positive effect of place attachment on pro-environmental behavior (Daryanto & Song, 2021).

Nature connectedness

Nature connectedness is defined as “an individual’s emotional and cognitive bond to the natural world” (Wyles et al., 2019, p. 3). Variations in nature connectedness can arise from trait-level differences, where some individuals are inherently more predisposed to feeling connected to nature, or from state-level differences, such as experiencing heightened connection to nature within specific contexts. Nature connectedness has received greater attention than awe and nostalgia within the nature-health literature. In White et al. (2020), the construct is considered as part of the instoration mechanism, as it is a resource that is enhanced during contact with blue spaces and that highly benefits well-being. Indeed, nature connectedness is linked with increased hedonic and eudaimonic well-being (Capaldi et al., 2014; Pritchard et al., 2020). Cleary et al. (2017) suggest that nature connectedness benefits eudaimonic well-being through satisfaction of the need for relatedness and promotion of intrinsic value orientation (e.g., humanitarianism, kindness, altruistic concern). Furthermore, as previously mentioned, nature connectedness is a major predictor in PEABs (Whitburn et al., 2019).

A growing body of research illustrates positive associations between nature contact, nature connectedness, well-being, and PEABs. In a systematic review, Barragan-Jason et al. (2023) reveal positive effects of nature contact on nature connectedness, which in turn also positively affects PEABs and physical and mental health. Other studies have demonstrated that trait nature connectedness plays a moderating role in the relationships between nature contact, well-being, and pro-environmental behaviors (Martin et al., 2020). Additionally, state nature connectedness has been found to mediate the effect of nature contact on positive affect and ability to reflect (Mayer et al., 2009). To our knowledge, only one study has examined nature connectedness in relation to coastal landscapes, revealing that visits to the coast result in higher levels of nature connectedness compared to visits to urban green spaces (Wyles et al., 2019).

Emotion-regulating strategies

Although the positive effects of nature on well-being have been extensively studied, few studies have explicitly explored the relationship between nature and emotion-regulation. Johnsen (2011) provided a conceptual framework linking the use of nature to regulate emotions with two strategies from the process model of Gross (1998). The first, 'situation selection', refers to seeking nature to activate positive emotions, while the second, 'situation modification', entails using nature to prevent or reduce negative emotions. These regulating processes are considered to stem from nature's facilitation of restoration and self-reflection (Johnsen, 2011). Indeed, Johnson (2013) found that emotion-regulation in nature predicted the restorative effects of nature. Additionally, Korpela et al. (2018) demonstrated a positive association between the perceived efficacy of 'environmental strategies', defined as "the use of specific places or socio-physical settings in the service of affect regulation" (p. 2), and life satisfaction in regulating sadness. Extensive research is necessary to understand how nature, including coastal landscapes, facilitates emotion-regulation, and how specific emotion-regulating strategies serve as underlying mechanisms in the well-being benefits of nature.

Moderating Factors in the Relationship Between Coastal Landscapes and Well-Being

The relationship between coastal landscapes and well-being is shaped by a variety of situational and individual factors, as well as visit characteristics (Garrett et al., 2023b; White et al., 2020). In terms of situational factors, important elements include the quality of the environment (e.g., water quality, biodiversity, litter), weather, tide, and landscape structure (Cracknell et al., 2018; Hipp & Ogunseitan, 2011; Hooyberg et al., 2022; Wyles et al., 2019). Individual factors that have been considered include socio-economic status, age, gender, and ethnicity (Elliott et al., 2018; Garrett et al., 2019; Phoenix et al., 2021). Regarding visit characteristics, central aspects are type of activities, type of social company, and type of experiences occurring during contact with the coast (Hooyberg et al., 2024).

In this dissertation, I have evaluated the potential moderating roles of presence of litter (situational factor), income level (individual factor), and level of engagement (visit characteristic). Due to the growing issue of marine litter and its consequences for planetary and human health (Agamuthu et al., 2019), it is essential to understand how it impacts the relationship between coastal landscapes and well-being. Furthermore, although a few studies have assessed the well-being benefits of the coast for people with low-income, it remains unclear why these benefits appear to be more pronounced for this population group. Finally, to further utilize the positive effects of coastal landscapes, research into potential pathways maximizing these effects, such as through heightened engagement, is needed.

Litter

Although litter, particularly plastic, is increasing present in coastal landscapes (Lacroix et al., 2022), little is known about how it affects coastal benefits on well-being. Wyles et al. (2016) do display a reduction in restorative quality and an increase in negative emotions after exposure to littered coastal landscapes. Reasons for why litter negatively impacts restorative benefits include: disrupting the aesthetics and naturalness of the environment, anticipating negative environmental consequences, and presenting physical risks (Rangel-Buitrago et al., 2018; Wyles et al., 2016).

In contrast to well-being outcomes, presence of litter might enhance the effects of coastal landscapes on PEABs, as illustrated in Wyles et al. (2016) in which participants reported behavioral intentions to actively deal with the exposed litter by removing it. It remains unclear what drivers and in what contexts such a reinforcement effect arises, although there are indications that within a citizen science setting involving beach clean-ups, PEABs greatly increases (Locritani et al., 2019; Wichmann et al., 2022; Wyles et al., 2017).

Income level

Recent research has shown that the positive effects of coastal landscapes on well-being may be stronger for people with low income levels. For example, the effect of residential coastal proximity on health was greater for income-deprived individuals (Wheeler et al., 2012), a pattern similarly observed in terms of mental health (Garrett et al., 2019). The equigenesis theory contextualizes these findings by stating that natural environments reduce health disparities via its health-promoting attributes, such as increased physical activity and reduced stress, ultimately fostering resilience (Mitchell & Popham, 2008). Various studies have found support for this theory, demonstrating associations between nature exposure and lower socioeconomic inequalities in well-being (Garrett et al., 2023a; Mitchell et al., 2015), particularly with coastal landscapes (Wheeler et al., 2015).

To further understand why coastal landscapes appear to particularly benefit people with low income, I aimed to investigate to what extent the aforementioned emotional mechanisms apply for this population group. In fact, people with low socio-economic status have a higher tendency to experience awe, nostalgia, and nature connectedness (Hepper et al., 2021; Piff & Moskowitz, 2018; Richardson et al., 2022). Therefore, it is possible that these emotional states are felt more intensely by low-income individuals during contact with the coast, thereby offering additional explanation of why the coast is an equigenic environment.

Level of engagement

When considering the well-being effects of nature, two individuals who are exposed to the same environment may obtain different effects due to how they are engaging with that environment. More specifically, one individual may be fully aware of their surroundings, while another may be preoccupied with their thoughts. Heightened awareness, or engagement, during nature contact has been shown to boost the well-being effects (Duvall, 2011; Korpela et al., 2017), as well as nature connectedness (Lumber et al., 2017).

I focus on two specific types of engagement in this dissertation: mindful engagement and mind-wandering. Mindful engagement entails the use of mindfulness principles during nature contact, namely awareness of the present moment and non-judgmental acceptance of one's thoughts, feelings, and sensations (Kabat-Zinn, 1990). This form of engagement strengthens the effect of nature contact on reducing negative mood and increasing nature connectedness (Barrable et al., 2021; Nisbet et al., 2019), through suggested mechanisms of perceptual sensitivity, decentering, and non-reactivity (Macaulay et al., 2022).

Typically considered as opposing to mindfulness, mind-wandering is defined as task-unrelated and/or stimulus-independent thought (Smallwood & Schooler, 2015). Mixed findings regarding the effect of mind-wandering on well-being are most likely due to the distinction between spontaneous and deliberate mind-wandering (Seli et al., 2015). For example, anxiety and stress are positively linked with spontaneous mind-wandering and negatively linked with deliberate mind-wandering (Seli et al., 2019). Moreover, deliberate mind-wandering during nature contact is shown to increase nature connectedness and reduce negative mood (Macaulay et al., 2024).

Although it has been suggested that nature facilitates both mindful engagement (Brymer et al., 2021) and mind-wandering (Williams et al., 2018), it remains unclear whether this applies to coastal landscapes and whether these forms of engagement strengthen the well-being benefits of the coast.

Research Objectives and Chapter Overview

The overall goal of the present dissertation was to increase our knowledge of how and why coastal landscapes affect well-being. Building upon the identified research gaps, our aim was to investigate the associations depicted in Figure 3 by delineating three research objectives (RO). These objectives are addressed through five empirical chapters, each representing a research paper. While there is some overlap in the content of these chapters, they address the objectives from distinct methodological perspectives. Here, I introduce each research objective along with its corresponding chapters (see Table 1 for an overview of the chapters).

RO1: To understand the emotional mechanisms underlying the relationship between coastal landscapes and well-being

The primary aim of this dissertation was to investigate the emotional processes linked with coastal landscapes and to determine to what extent these processes act as underlying mechanisms in the effect of the coast on well-being.

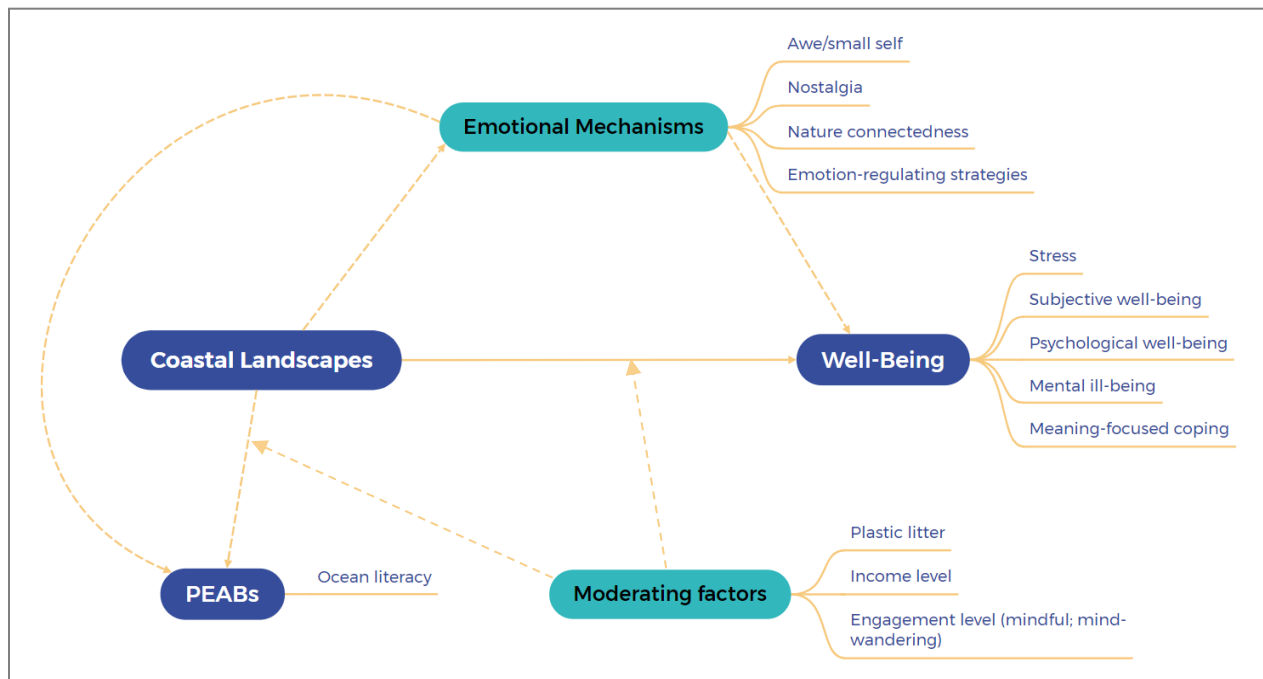
In **Chapter 1**, due to the restrictions of the COVID-19 pandemic, I had the opportunity to conduct a quasi-experimental study in which I assessed whether access and visits to the coast positively influenced well-being during the first-wave lockdown. A total of 687 adults living in Flanders completed an online survey during the months of April, May, and June 2020. Importantly, this study enabled to replicate the positive relationship between coastal landscapes and well-being within Belgium and within the context of a global health crisis. Moreover, I had an initial look into whether the emotions of awe and nostalgia mediated the link between coastal visits and well-being.

In order to obtain comprehensive and insightful findings with regards to the emotional processes linked with the coast, I then conducted a qualitative study in **Chapter 2**. With this study, I examined coastal residents' emotional experiences of the coast and how these experiences influenced their well-being. I carried out semi-structured interviews with eight young adults, aged 21 to 25 years old, that grew up near the Belgian coast and/or were current coastal residents. The interviews were analyzed with the use of Interpretative Phenomenological Analysis (IPA; Smith et al., 2009). This particular type of analysis was chosen as it enables a detailed evaluation how one interprets a certain phenomenon or experience and the meanings one attaches to it. The study revealed many important findings that served as a basis for the following chapters.

In **Chapter 3**, I aimed to examine the causal relationships between coastal landscapes, emotional processes, and well-being. More specifically, I experimentally tested whether the emotions of awe/small self and nostalgia act as mediators in the effect of coastal landscapes on well-being. I included nature connectedness as an additional mediator due to emerging research displaying its importance for blue spaces (White et al., 2020). Two online experiments were conducted, in which I manipulated exposure to coastal and urban landscapes via the use of video-clips. Effects of nature on mental health are frequently assessed with the use of virtual exposure such as videos (Yeo et al., 2020). Moreover, an online setting was chosen due to previous restrictions set by the COVID-19 pandemic.

Figure 3

Schematic Visualization of Investigated Associations in Present Dissertation



Note. PEABs = pro-environmental attitudes and behaviors. Solid lines represent associations that are supported by empirical evidence. Dotted lines represent hypothesized associations. The interplay between emotional mechanisms and moderating factors is not visually depicted but is examined in the present dissertation

In Study 1, I assessed mediation of awe/small self, nostalgia, and nature connectedness in the effect of coastal exposure on stress reduction and meaning-focused coping. A total of 248 first-year psychology students participated and were randomly assigned to watch a video-clip of either an urban street, coastal dunes, or a beach with a sunset. I employed structural equation modeling with path analysis to accurately test the mediation pathways.

For Study 2, I replicated the manipulation of environment type and evaluated the effect of coastal exposure on stress reduction, with awe/small self, nostalgia, and nature connectedness as potential mediators. The online experiment was conducted with a larger and more diverse sample in terms of age, gender, educational attainment, and income level ($N = 494$). To further investigate the emotion-regulating strategies identified in Chapter 2, I created a scale that measured these strategies and assessed to what extent participants associated the coast with the use of these strategies.

RO2: To determine factors that moderate the relationship between coastal landscapes and well-being

A secondary aim of the present dissertation was to examine to what extent presence of plastic litter, income level, and engagement level moderate the effect of coastal landscapes on well-being. The moderating role of plastic litter was assessed in Study 1 of Chapter 3. Each video-clip representing an environment type either contained plastic or not. I tested whether the presence of plastic moderated the direct effect of environment type on stress reduction, as well as the mediation pathways of awe/small self, nostalgia, and nature connectedness.

Income level was investigated as a potential moderator in Study 2 of Chapter 3. I had initially aimed to conduct Study 2 with solely people with low income. Although I was not able to recruit a total sample from low income individuals, I obtained a sample with about 60% of people with low individual net income, who either had no income (26%), income lower than €1250 (9%), or income between €1250 to €2000 (25%). The remaining 40% either had income between €2000 to €2500 (23%), or more than €2500 (17%). This range in income levels enabled to assess for moderation of income in the direct effect of environment type on stress reduction, as well as in the mediation pathways of awe/small self, nostalgia, and nature connectedness.

Chapter 4 examined the role of engagement level, although it was not explicitly tested as a moderator, but rather as a factor that potentially enhanced the effect of coastal landscapes on well-being. In line with previous studies that manipulated engagement level (Nisbet et al., 2019; Pasanen et al., 2018), I conducted an *in situ* experiment in which participants took part in a 20-minute guided walk along the beach or in an urban street. For participants exposed to the coast, I constructed three types of engagement interventions that each reflected a specific engagement level. Participants were instructed to either be mindful of their surroundings (mindful engagement), let their mind wander (mind-wandering), or follow mental visualization tasks (distraction). A total of 77 adults from different age, gender, and educational attainment groups participated. Along with comparing the effects of being exposed to the beach versus the urban street on well-being, I also compared differential effects of the three engagement levels. Furthermore, I evaluated to what extent awe/small self, nostalgia, nature connectedness, and adaptive emotion-regulating strategies differed across the three engagement levels and whether they acted as potential mediators in the effect of engagement level on well-being.

RO3: To comprehend the relationship between coastal landscapes and pro-environmental attitudes and behaviors, as well as the associated emotional mechanisms and moderating factors

I included pro-environmental attitudes and behaviors (PEABs) as an outcome in our research studies to gather a more holistic understanding of how we can optimize the interactions between coastal landscapes

and humans. In addition to comprehending how the coast benefits us, I aimed to gain knowledge on how we could potentially benefit the coast. I therefore investigated whether exposure to the coast affects PEABs, whether the emotional processes of awe/small self, nostalgia, and nature connectedness act as underlying mechanisms, and whether presence of plastic litter and engagement level act as moderators. Pro-environmental attitudes were measured as an outcome in Study 1 of Chapter 3, and pro-environmental behaviors were evaluated as an outcome in Study 2 of Chapter 3 and in Chapter 4.

Going beyond assessing virtual or real-life exposure to coastal landscapes, **Chapter 5** presents a study that evaluated the impact of a marine-litter focused citizen science intervention on ocean literacy. This study was part of a larger project, i.e., Citizen Observation of Local Litter in coastal ECosysTems (COLLECT; Catarino et al., 2023), that implemented citizen science initiatives in several countries of North and West Africa, and one country in South-East Asia. Secondary school students were trained to sample and analyze plastics from the beach. We analyzed the impact of COLLECT on participants' ocean literacy, pro-environmental intentions and attitudes, nature connectedness, and well-being. These outcomes were measured with a pre- and post-survey, completed via online or paper format, by 239 students.

Table 1*Chapter Overview*

Chapter	Methodology	Participants	Main research questions	Exploratory research questions
Chapter 1	Quasi-experimental online survey	687 adults	To what extent does access and visits to the coast influence well-being during the first-wave lockdown of the COVID-19 pandemic? Do feelings of awe and nostalgia mediate the relationship between coastal visits and well-being?	
Chapter 2	Qualitative semi-structured interviews	8 young adults living near the coast	How do coastal residents make sense of the emotions they experience at the coast and of how these emotions affect them?	
Chapter 3	Experimental manipulation of virtual exposure to coastal and urban landscapes and manipulation of presence of plastic	248 first-year psychology students	To what extent does exposure to coastal landscapes affect stress, meaning-focused coping and pro-environmental attitudes? Do feelings of awe/small self, nostalgia, and nature connectedness act as mediators? Does the presence of plastic act as a moderator?	
	Experimental manipulation of virtual exposure to coastal and urban landscapes	494 adults from different age, gender,	To what extent does exposure to coastal landscapes affect stress and pro-environmental behaviors?	To what extent does exposure to coastal landscapes affect time perception?

		educational attainment, and income groups	Do feelings of awe/small self, nostalgia, and nature connectedness act as mediators?	Are coastal landscapes more likely to be associated with adaptive emotion-regulating strategies? Does individual net income act as a moderator in the mediation pathways of awe/small self, nostalgia, and nature connectedness?
Chapter 4	Experimental manipulation of real-life exposure to coastal and urban landscapes and manipulation of engagement level	77 adults	To what extent does exposure to coastal landscapes affect well-being and pro-environmental behaviors? Do mindful engagement, mind-wandering, and mental visualization at the coast have a differential effect on well-being and pro-environmental behavior?	Do feelings of awe/small self, nostalgia, nature connectedness, and adaptive emotion-regulating strategies differ according to environment type and engagement level? Do these emotional processes act as mediators?
Chapter 5	Pre and post-assessment of a citizen science intervention	239 secondary school students in six north/west African countries and Malaysia	To what extent does a citizen science intervention based on marine litter affect ocean literacy, pro-environmental intentions and attitudes, nature connectedness, and well-being?	

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Don't Forget to
Protect the Planet
After You're Done
Protecting Yourself.

Chapter 1

Influence of the Belgian Coast on Well-Being During the COVID-19 Pandemic¹

Abstract

There is increasing evidence that blue spaces, particularly coastal environments, are beneficial for well-being. During the first-wave lockdown of the COVID-19 pandemic in Belgium, access to the coast was restricted due to restraint in circulation. Making use of this unique opportunity, this study investigated whether access and visits to the coast were positively associated with well-being by using a quasi-experimental design. The emotions of awe and nostalgia were studied as potential mediators between coastal visits and well-being. A total of 687 Flemish adults took part in an online survey that was launched end of April until beginning of June 2020. After controlling for covariates, results showed that access to the coast, but not visit frequency, was positively associated with well-being. More specifically, coastal residents reported less boredom and worry, and more happiness than inland residents. Awe and nostalgia were not significantly associated with coastal visits, but awe was negatively correlated with boredom. The study suggests a potential buffer effect of residential proximity to the coast against negative psychological consequences of the COVID-19 pandemic, supporting the notion that the coast has a positive impact on well-being.

¹ Based on Severin, M.I., Vandeghechuchte, 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. doi:10.5334/pb.1050

The COVID-19 pandemic that arose in December 2019 has led to many restrictions for people's daily activities. One of these restrictions was that during Belgium's national lockdown between March 18th and June 8th 2020, a large proportion of its population no longer had access to the coast. This situation led to a chance to use a quasi-experimental design to assess the effect of coastal environments on well-being.

The relationship between coastal environments and well-being has recently been the subject of several studies. Coastal environments are part of what are called *blue spaces*, which are defined as "outdoor environments, either natural or manmade, that prominently feature water and are accessible to humans either proximally (being in, on, or near water) or distally/ virtually (being able to see, hear or otherwise sense water)" (Grellier et al., 2017, p. 3). In a systematic review, Gascon et al. (2017) reveal a positive association between greater exposure to blue spaces and benefits to mental health and well-being. Some studies found that the positive effects of blue spaces might even be stronger than those of green spaces such as parks, forests, and fields (White et al., 2013b).

Investigating the relationship between blue spaces and well-being is becoming increasingly valuable in today's context. On the one hand, researchers discern a growing trend in human disconnection from nature (Kesebir & Kesebir, 2017). On the other hand, further deterioration in mental health is becoming apparent with regards to the COVID-19 pandemic, as recently demonstrated by Vindegaard and Benros (2020). Understanding how and why blue spaces benefit mental health could help us optimize the use of these spaces to potentially build resilience in mental health, especially in times of crisis.

Well-Being

Well-being is a complex concept that can be defined according to two different perspectives. The first perspective, hedonism (also referred to as subjective well-being), defines well-being as a state of positive affect and absence of negative affect (Kahneman et al., 1999). Indicators such as life satisfaction and happiness are typically used to measure hedonic well-being. The second perspective, eudaimonism, views well-being as more than just happiness but as the result of living in accordance with one's true self (Waterman, 1993). Eudaimonic well-being can be conceptualized with the six dimensions posited by Ryff and Keyes (1995) namely, autonomy, environmental mastery, personal growth, positive relationships, purpose in life, and self-acceptance. Both perspectives are taken into account in the present study.

Studying how to preserve and promote well-being is fundamental due to its impact on health and society (Maccagnan et al., 2019). Nonetheless, research on the factors that affect well-being has been largely centered around individual and social parameters such as personality traits (Sirgy, 2021) and social support (Taylor, 2011). There is a lack of investigation on the role of the environment on well-being

(Schleicher et al., 2018). Environmental factors are however central to the development of well-being as displayed, for example, by the negative effect of urbanization on well-being. For instance, studies show a higher prevalence of mood and anxiety disorders (Peen et al., 2010) and a lower life satisfaction (Sørensen, 2014) in urban residents compared to rural residents. Considering that 68% of the world's population is projected to live in an urban area by 2050 (Population Division, 2019), it is becoming crucial to investigate the role of the environment on well-being and provide solutions to promote a healthy relationship between the two. One important aspect that is being increasingly looked into is the benefit of nature, and, more specifically coastal environments, on well-being.

The Coast and Well-Being

Evidence that coastal environments have a positive impact on mental health is being progressively gathered. A systematic review of therapeutic blue space interventions indicated a positive association with mental health indicators such as increased psychological restoration, of which 50% of the studies focused on the coast (Britton et al., 2020). Studies in England (Wheeler et al., 2012; Garrett et al., 2019a; see also White et al., 2013a for longitudinal data) and Belgium (Hooyberg et al., 2020) found that living near the coast is beneficial, as residential proximity to the coast was linked with a significantly better general health and mental health compared to residents living inland. Furthermore, visits to the coast have also been associated with improved well-being in studies done in Spain (Vert et al., 2020) and Hong Kong (Garrett et al., 2019b). Finally, higher coastal visibility from one's home was related to lower psychological distress in a study implemented in New Zealand (Nutsford et al., 2016). There is therefore a strong basis for stating that the coast has a beneficial effect on well-being.

Mechanisms

Despite the increasing evidence of a positive effect of the coast on well-being, the suggested explanations or mechanisms of this effect are not yet fully investigated. Physical activity has been advocated as a potential mechanism, as coastal proximity is positively associated with an increased likelihood of physical activity thereby possibly explaining its benefits on well-being (White et al., 2014). Moreover, in the UK, an initiative called "The Blue Gym" was launched in order to promote the physical and mental health benefits from doing exercise along the coast (Depledge & Bird, 2009). Other studies manifest that the multisensory stimulation of the coast can explain its restoration effects, such as the sounds of the breaking waves or the reflection of light on the water as it creates fractal patterns (Bell et al., 2015; White et al., 2010).

The emotional experience that the coast brings has been proposed as yet another potential mechanism (White et al., 2020). Amongst the many emotions that the coast potentially induces are the emotions of awe and nostalgia (Willis, 2015; Pearce et al., 2017). Awe is triggered by anything that is experienced as being larger than the self, and leads to a need for accommodation to assimilate this experience (Keltner & Haidt, 2003). Qualitative interviews conducted with visitors at a seaside resort demonstrate that the coast can provoke awe-inspiring experiences, due to its grandeur and sublimity (Jarratt & Sharpley, 2017). Participants also mentioned that the coast generated feelings of nostalgia (Jarratt & Gammon, 2016), defined as “a wistful or excessively sentimental yearning for return to or of some past period or irrecoverable condition” (Merriam-Webster, n.d.). The emotion was described to arise from a reconnection with childhood memories created at the coast and the coast’s sharp contrast with one’s often fast-paced daily life (Jarratt & Gammon, 2016).

Both awe and nostalgia seem to be linked to the aspect of timelessness of the coast through its perceived unchanging nature and broad horizon. This aspect of timelessness can perhaps be an antecedent to a perception of expanded time availability which has been shown to mediate the relationship between awe and momentary life satisfaction (Rudd et al., 2012). Anderson et al. (2018) also found awe to positively mediate the effect of nature experiences on daily life satisfaction and improved well-being at follow-up. In parallel, Hepper et al. (2021) demonstrate that nostalgia helps maintain well-being in the face of limited time perspectives and is an important resource to cope with distress (Sedikides & Wildschut, 2016). Nostalgia and awe have both also been associated with an enhancement in meaning in life: awe by placing the self within a bigger picture and gaining perspective on life (Danvers et al., 2016) and nostalgia by boosting social connectedness (Routledge et al., 2012). Meaning in life is seen as an essential contributor to well-being (Steger, 2009). Taken together, there is a clear rationale to investigate whether coast-induced awe and/or nostalgia positively influence well-being.

The COVID-19 Pandemic

The COVID-19 pandemic presents a deep contrast with normal living conditions and has been a global source of stress and anxiety. A systematic review of studies from various countries by Vindegaard and Benros (2020) demonstrates a decrease in psychological well-being and an increase in scores of depression and anxiety in the general public, compared to before COVID-19. Similar results have been found for the Belgian population, with the majority of the population also suffering from a lack of good quality sleep (Charafeddine et al., 2020).

In order to slow down the further spread of the coronavirus, many countries resorted to extreme measures such as restricting circulation. In Belgium, the government issued a state “lockdown” on March 18 2020, meaning that all citizens were asked to stay at home and could only go outside for essential trips or outdoor physical activity not far from one’s own home. Circulation between cities was not allowed. Consequently, those who did not live close to the coast no longer had access to coastal environments, until June 8 2020.

It has been shown that quarantine can lead to negative psychological effects such as post-traumatic stress symptoms, with some stressors including frustration, boredom, fears, and inadequate information (Brooks et al., 2020). Faced with the strong psychological impact of the coronavirus, we wanted to investigate whether being exposed to the coast could potentially buffer this impact.

The Present Study

Our study aimed to evaluate whether access and visits to the coast would be associated with higher well-being during the first-wave lockdown, as well as suggest a possible pathway to explain this association. The COVID-19 pandemic provided an opportunity to investigate the relationship between the coast and well-being within a quasi-experimental design. Using an online survey, three hypotheses were tested. We first examined whether those who had access to the coast experienced higher levels of well-being than those who did not have access (H1). We then evaluated whether more frequent visits to the coast were positively associated with well-being (H2). Finally, we wanted to test whether awe and/ or nostalgia were mediators in the relationship between coastal visits and well-being, in the condition that the prerequisites of mediation were fulfilled (H3).

Method

Participants

We launched an online survey, available through the platform Limesurvey, on April 22nd until June 8th. A total number of 687 participants took part in the survey. The percentage of participants who identified as women was about 68.9% ($n = 473$), 30.9% of the participants identified as men ($n = 212$), and 0.3% of the participants identified as “other” ($n = 2$). The age range was from 19 to 81 years old ($M = 43.29$, $SD = 15.37$), with 65.8% being older than 40 years old. Almost half (46%) were educated on a university level and 45.4% declared working from home due to the coronavirus pandemic. The majority of participants lived in Flanders, the Dutch speaking part of Belgium (97.7%). Of the total sample, 44.3% lived in the westernmost province of Flanders, i.e. West Flanders, and 24.2% lived up to 5 km away from the coast. In

consideration of these numbers, it is important to mention that our sample is not representative of the entire Dutch-speaking population of Belgium.

Measures

The online survey consisted of a series of questions aiming to assess the effect of the coast on well-being during the first-wave lockdown. The survey was presented in Dutch. In the questionnaire, we evaluated access to the coast and visit frequency (predictor variables), frequency of emotions during visits to preferred environment (mediator), well-being (outcome variable), and various control variables.

Access to the coast and visit frequency

To measure access to the coast, participants were asked to report their postal code. Visit frequency was assessed by asking participants how often they visited the following environments during the lockdown: coast (e.g. beach, dunes, dike), natural green spaces (e.g. city parks, forests), countryside (e.g. agricultural areas), urban or urbanized spaces (e.g. village and city centers), and their own balcony, terrace, or garden. Response options were *never*, *less than once a week*, *once a week*, *more than once a week*, and *every day*.

Frequency of emotions during visits to preferred environment

Before asking about their emotions, participants needed to indicate which environment they preferred to visit during the lockdown. They then could report the frequency of the following emotions when they visit that particular environment: satisfied, angry, anxious, in awe, grateful, sad, nostalgic, proud, amused, relaxed. Response options were: *never*, *seldom*, *sometimes*, *often*, and *always*.

Well-being

Three dimensions of well-being were assessed. The first, general well-being, was measured by the Dutch version of the Short Warwick Edinburgh Mental Well-being Scale (SWEMWBS; Stewart-Brown et al., 2009; Ikin et al., 2012). The SWEMWBS was developed by the Universities of Warwick, Edinburgh and Leeds in conjunction with NHS Health Scotland. Several items in this seven-item scale represent aspects of eudaimonic well-being such as agency, social connection, and clarity of thoughts, while other items represent aspects of hedonic well-being such as positive affect. Subjects were asked to choose the best option that suits them according to certain thoughts and feelings experienced over the past two weeks, going from *never* to *always*. In this sample, Cronbach's alpha for the SWEMWBS was .81. The second dimension, negative experiential well-being, was represented by items on worry, stress, and boredom. These items were evaluated on a seven-point Likert scale, with responses on the lower end representing an experience of *less than usual* and on the higher end *more than usual*, over the past two weeks. For the

third dimension, positive experiential well-being, participants were asked to rate their current happiness on a 10-point scale, going from *extremely unhappy* to *extremely happy*.

Control variables

As this was a quasi-experimental study, several influential variables for well-being needed to be controlled for. Participants were asked to report their age, gender, level of education, and presence or absence of a mental illness. Level of education was used as an indicator of socio-economic status as it particularly depicts effects on health and lifestyle (Shavers, 2007). Participants also indicated the extent to which the quality of their sleep and frequency of physical activity had changed since the beginning of the lockdown, using a scale from 1 (*I sleep much worse*) to 5 (*I sleep much better*) for sleep quality and 1 (*a lot less*) to 5 (*much more*) for physical activity. Variables that were important when considering the effect of the lockdown such as household composition (e.g. “alone with children”, “couple with no children”) and change in work situation (e.g. “working from home”, “temporarily unemployed”) were included.

Procedure

Participants were recruited by releasing a message to the press via the Flanders Marine Institute website on April 22nd (VLIZ, 2020). Advertisement of the survey was also spread through social media networks and via the newsletter of the province of West Flanders. The ad contained the link to the survey, its estimated duration time, and the aim of the study, namely, to examine how outdoor visits influence our emotions and our health, given the current circumstances related to COVID-19.

Upon opening the link to the questionnaire, subjects were presented with a short introduction and an informed consent form. After finishing the survey, participants were thanked and were informed about the current measures that help protect oneself and others of the coronavirus, official government information sources, and contact details of a free telephone and chat support service that offers a listening ear for anyone that needs it. Participants were also offered the chance to send an email to the researchers in order to receive a debriefing or to ask any questions they had.

Statistical analysis

To determine the effect of access to the coast on well-being, i.e. the first hypothesis, participants were assigned to one of two groups based on their postal code. Only those living in municipalities which border the Belgian shoreline (“coastal residents”; $n = 168$) had access to the coast during the lockdown due to the restriction of circulation. Respondents living in other municipalities (“inland residents”; $n = 519$) did not have access. For the second hypothesis, coastal residents were divided into three groups with

different visit frequencies. The first group visited the coast once a week or less ($n = 43$), the second group visited the coast more than once a week ($n = 67$), and the last group visited the coast every day ($n = 58$). Considering the high intercorrelations between the indicators of well-being, multivariate analyses of covariance (MANCOVA) were used to test the two hypotheses. As follow-up, univariate analyses of covariance (ANCOVA) were employed to assess the effect on each outcome variable. Covariates that were associated with one or several outcome variables were included in the models. Multivariate outliers were identified by calculating the Mahalanobis distance and were consequently taken out of the analysis. All tests were conducted with an alpha significance level of .05.

The MANCOVAs were performed with all five indicators of well-being as outcome variables, and access to the coast (H1) and visit frequency (H2) as predictor variables. For the first model (H1), gender, mental illness, household composition, sleep quality, and physical activity were included as covariates. Five outliers were taken out and no serious violations were detected, except for a significant interaction between access to the coast and the covariate household composition, $F(20, 2632) = 1.80, p = .016$, violating the assumption of homogeneity of regression slopes. This interaction term was therefore included in the model. For the second model (H2), household composition and sleep quality were included as covariates. Four outliers were removed and the assumptions were met. To test the third hypothesis (H3), a one-way ANOVA was used to assess the relationship between the preferred environment of the coastal residents and the frequency of awe and nostalgia felt in that environment. Then, Pearson correlations were conducted to examine the associations between awe and nostalgia with the indicators of well-being, for coastal residents whose preferred environment was the coast.

Results

Coastal residents versus inland residents

Results showed higher well-being for coastal residents compared to inland residents during the lockdown, while controlling for gender, mental illness, household composition, sleep quality, physical activity, and the interaction between access to the coast and household composition. Based on Pillai's Trace, the MANCOVA indicated a significant association between access to the coast and the combined indicators of well-being, $V = .024, F(5, 655) = 3.23, p = .007$, with a small effect size ($\eta^2 = .024$), as shown in **Table 1**. Follow-up univariate ANCOVAs on the outcome variables demonstrated differences for boredom, $F(1, 659) = 4.91, p = .027, \eta^2 = .007$, worry, $F(1, 659) = 9.15, p = .003, \eta^2 = .014$ and happiness, $F(1, 659) = 6.89, p = .009, \eta^2 = .010$. Coastal residents reported less boredom and worry and more happiness during the lockdown than inland residents. Indeed, the estimated marginal means (which are adjusted for the

covariates) show a relative difference of –9.1% for both boredom and worry, and a relative difference of +5.5% for happiness, for coastal residents compared to inland residents (**Table 2**). The covariates of age and level of education, which are typically considered as influential to well-being, were not included in the final model as they were not statistically relevant in this context. Note that including them did not meaningfully change our results.

Visit frequency in coastal residents

Coastal residents who visited the coast daily during the lockdown did not differ in well-being from those who visited the coast more than once a week or less, while controlling for household composition and sleep quality. Based on Pillai's Trace, visit frequency had no significant association with the indicators of well-being, $V = .094$, $F(10, 310) = 1.54$, $p = .126$, with a small effect size, $\eta^2 = .047$ (**Table 3**). Including participants' preferred environment as a covariate did not meaningfully change our results.

Mechanisms of awe and nostalgia

Coastal residents who preferred to visit the coast ($n = 89$) did not experience awe nor nostalgia during their visits more frequently than those who preferred to visit natural green spaces ($n = 28$), the countryside ($n = 6$), or their own balcony, terrace, or garden ($n = 45$). Results were non-significant for both awe, $F(3, 164) = 1.36$, $p = .256$, and nostalgia, $F(3, 164) = .85$, $p = .468$, with small effect sizes ($\eta^2 = .024$ and $\eta^2 = .015$, respectively). No participants chose urban space as their preferred environment; therefore, it was not included in our analysis.

For coastal residents whose preferred environment was the coast, awe was found to be significantly negatively correlated with boredom, $r = -.32$, $p = .003$, but was not correlated with the other outcome variables. Nostalgia did not correlate with the well-being variables (**Table 4**). In conclusion, as there was no significant association between coastal visits and the frequency of awe and nostalgia, we could not further investigate a possible mediation of awe or nostalgia in the relationship between the coast and well-being. However, there is a negative relationship between awe felt at the coast and boredom, such that the greater the frequency of awe, the lower the experience of boredom.

Table 1*Multivariate and Univariate Analyses of Covariance for Well-being as a Function of Access to the Coast, With Covariates*

Variable	Univariate											
	Multivariate		Boredom		Worry		Stress		Happiness		General Well-being	
	<i>F</i>	η^2	<i>F</i>	η^2	<i>F</i>	η^2	<i>F</i>	η^2	<i>F</i>	η^2	<i>F</i>	η^2
Access to coast	3.23**	.024	4.91*	.007	9.15**	.014	1.66	.003	6.89**	.010	.90	.001
Household composition	2.85***	.021	.66	.004	3.23*	.019	4.17**	.025	3.73**	.022	1.24	.007
Gender	2.24*	.017	1.87	.006	.59	.002	4.14*	.012	1.53	.005	1.96	.006
Mental Illness	5.00***	.037	1.16	.004	1.39	.004	9.51***	.028	22.2***	.063	9.53***	.028
Sleep quality	33.78***	.205	26.34***	.038	110.3***	.14	126.7***	.16	78.19***	.11	74.24***	.101
Physical activity	2.44*	.018	2.14	.003	8.71**	.013	6.63**	.010	4.47*	.007	.80	.001
Access to coast x Household composition	1.80*	.013	3.79**	.022	1.53	.009	.27	.002	2.22	.013	.34	.002

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 2*Estimated Marginal Means of Well-Being for Coastal and Inland Residents*

Variable	Group	<i>M</i>	[min, max]	<i>SE</i>	95% CI
Boredom	Inland	2.92	[1, 7]	.44	[2.07, 3.78]
	Coastal	2.28		.52	[1.27, 3.30]
Worry	Inland	4.47	[1, 7]	.31	[3.84, 5.05]
	Coastal	3.83		.36	[3.11, 4.55]
Stress	Inland	3.98	[1, 7]	.32	[3.36, 4.59]
	Coastal	3.71		.37	[2.97, 4.44]
Happiness	Inland	5.99	[1, 10]	.32	[5.36, 6.61]
	Coastal	6.54		.38	[5.80, 7.28]
General well-being	Inland	21.01	[7, 35]	.76	[19.52, 22.49]
	Coastal	21.48		.90	[19.71, 23.24]

Table 3*Multivariate Analysis of Covariance for Well-being as a Function of Visit Frequency to the Coast, With Covariates*

Variable	<i>F</i>	η^2
Visit frequency	1.54	.047
Household composition	1.59*	.048
Sleep quality	12.37***	.287

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

Discussion

The present study demonstrates that those who had access to the coast during the first-wave lockdown in Belgium self-reported higher well-being than those who did not have access. Our findings are in accordance with those of Hooyberg et al. (2020) who found that living in proximity to the Belgian coast (i.e. <5 km from the coast) was linked with a better self-reported general health. Additionally, in the

context of COVID-19, results mirror those of a recent study indicating that lockdown severity worldwide negatively affected mental health, but that contact with nature buffered this effect (Pouso et al., 2021). More specifically, depression and anxiety increased with greater lockdown severity, but less so if individuals had access to private outdoor spaces and if their home views included natural elements. Our study produces similar findings because, despite the lockdown, coastal residents were less likely to report an increase in boredom and worry, and lower happiness, than inland residents. Hence, having access to the coast acted as a potential buffer against negative psychological consequences of COVID-19.

Table 4

Intercorrelations Between Awe, Nostalgia, and Well-being Indicators for Coastal Residents with the Coast as Preferred Environment

Variable	Nostalgia	Boredom	Worry	Stress	Happiness	General Well-being
Awe	-.09	-.32**	-.15	-.13	.17	.17
Nostalgia	–	.03	-.03	-.04	.01	.02
Boredom	–	–	.34**	.36***	-.46***	-.43***
Worry	–	–	–	.71***	-.37***	-.49***
Stress	–	–	–	–	-.53***	-.61***
Happiness	–	–	–	–	–	.63***

Note. ** $p < .01$. *** $p < .001$.

Despite support for the positive impact of access to the coast, more frequent visits to the coast were not significantly associated with higher well-being. An exposure-response relationship between visit frequency in nature and eudaimonic well-being was found by White et al. (2017). The authors detected significant differences with “never visiting”, starting from “once/twice a month” to “once a week”, “several times a week” and “every day”. Nonetheless in our study, the limited sample size of coastal residents did not allow to include meaningful categories for visiting the coast less than once a week. Another factor that might have played a role is that experiencing a lockdown could have been accompanied with fears of being outdoors, such as encountering other people and contracting the coronavirus. These fears could have potentially counteracted the benefits of visiting the coast. Finally, it could be that in comparison to

those who visited the coast several times a week, those who felt the need to visit every day were more anxious or bored and their daily visits did not help alleviate these feelings.

Exposure to blue or green spaces can be conceptualized into three types: incidental, indirect, or intentional (Keniger et al., 2013). Indirect exposure involves any experience of nature without necessarily being present in nature, such as watching nature television programs, or having a home view of the coast. Incidental exposure entails encountering nature but unintentionally, such as passing by the coast while cycling to work. Intentional exposure is having the direct intention to be present in a natural space, such as visiting the coast (Keniger et al., 2013). The present study found support for a beneficial influence of residential proximity to the coast which can be considered as a combination of the three types of exposure as being proximal to the coast increases the chances of having a sea view (indirect), incidentally encountering it (incidental), and directly visiting it (intentional) (White et al., 2020). Nonetheless, benefits of intentional exposure of the coast were not supported in our study. This is in contrast to other studies that investigated the effect of nature on mental health during the COVID-19 pandemic. Both Soga et al. (2021) and Dzhambov et al. (2021) demonstrate positive effects of indirect (e.g., view of greenery from indoors) and intentional (e.g., frequency of greenspace use) exposure on mental health. However, Soga et al. (2021) do mention that the indirect effect was greater than the intentional effect. Further research should aim at assessing the differential effect of nature exposure on mental health.

Because we did not observe a significant association between coastal visits and well-being, we could not test whether the emotions of awe and/or nostalgia are possible mechanisms in the coast and well-being relationship. The relationship between coastal visits and awe and nostalgia was also non-significant. Participants who preferred to visit the coast during the lockdown did not experience awe nor nostalgia more frequently during their visits than participants who preferred to visit other environments. The reduced sample size of coastal residents limited the power of the statistical test to detect small effects (Wilson Van Voorhis & Morgan, 2007). Additionally, perhaps no difference was revealed as green spaces potentially have the capacity to trigger awe and nostalgia as well (Anderson et al., 2018). A stronger contrast might have been found if we could have compared the emotions at the coast with the emotions in urban spaces.

Interestingly, a negative correlation ($r = -.32$) was found between awe felt at the coast and boredom, such that the higher the frequency of feeling awe, the lower the experience of boredom. Although awe triggered by nature has been found to improve mood (Joye & Bolderdijk, 2015) and to enhance life satisfaction (Anderson et al., 2018), it has yet to be linked with a reduction in boredom. Nonetheless, boredom is shown to be associated with a lack of meaning in life (Fahlman et al., 2009),

while positive awe experiences have been shown to increase meaning in life through happiness (Rivera et al., 2020). It could be that awe serves as a protective factor against boredom through its enhancement of a sense of meaning in life. In regards to nostalgia, correlations with indicators of well-being were non-significant, although studies have shown nostalgia to be a buffer against stress and boredom (Sedikides & Wildschut, 2016), and to generate positive affect (Wildschut et al., 2006). Further research is needed to investigate how strongly the coast induces awe and nostalgia and whether this explains the well-being benefits perceived at the coast.

Despite the study's advantage of following a quasi-experimental design, certain limitations are also present. One of these limitations is the sample's lack of diverseness, undermining the generalizability of the study. This is a common issue in internet-based survey research (Brenner, 2002). As aforementioned, the majority of the participants were women, older than 40 years old, educated on a university level, and had a stable working condition during the lockdown. A more diverse sample in terms of socioeconomic indicators could have led to different results, as these appear to moderate the effect of the coast on well-being (Garrett et al., 2019a). Furthermore, even though we have accounted for several covariates, it is still possible that other confounding variables for which we did not take into account influenced our findings. We acknowledge that experimental studies are more suitable to have control over confounding variables (Davis, 2008), therefore we suggest to experimentally compare people exposed to the coast with people exposed to green or urban spaces, to assess potential differences in well-being.

We also recognize that the effect size for access to the coast on well-being is small. However, in research on nature and well-being, it is not uncommon to find small effect sizes and these effect sizes are similar to those of other influential variables such as gender and socioeconomic status (Capaldi et al., 2014; Martin et al., 2020; White et al., 2013a). Finally, the concept of perceived environmental restoration would have been valuable to include as outcome variable given its impact on mental fatigue (Berto, 2005) and its possible association with awe. In line with Attention Restoration Theory (ART), Kaplan and Kaplan (1989) posit four conditions that determine a restorative environment of which the first two could be related to awe. The first condition, fascination, refers to effortless attention towards aesthetically pleasing stimuli and awe is typically characterized as being captivated by something perceived as vast and sublime (Shiota et al., 2007). The second condition, being away, refers to a sense of distance from one's usual thoughts and concerns and the experience of awe is accompanied with reduced self-reflective thought and increased externally directed attention (van Elk et al., 2019). We therefore suggest for future studies to look into the relationship between perceived restoration of, and awe triggered by, the coast.

Conclusion and Practical Implications

The COVID-19 first-wave lockdown in Belgium was an ideal opportunity to investigate the effect of access and visits to the Belgian coast on well-being. Results demonstrate that having access to the coast during the lockdown was associated with higher well-being, but the frequency of actual visits to the coast was not. The emotions of awe and nostalgia were not more frequently experienced during coastal visits in comparison to visits to other environments. However, awe felt at the coast negatively correlated with boredom. The study confirms the importance of the coast for well-being, even in times of crisis, as it seems to have provided a buffer against psychological consequences of the COVID-19 pandemic, such as boredom and worry. The potential mechanisms of the emotions of awe and nostalgia in the relationship between the coast and well-being are not fully understood yet. However, our study suggests that awe triggered by the coast might be a protective factor against boredom.

Policy-makers should consider making use of the coast to prevent further strain on mental health for future crises. For example, in case of future lockdowns, virtual exposure of the coast could be employed to counteract possible detriments to mental health. Indeed, a study by Yeo et al. (2020) demonstrates that virtual exposure of an underwater coral reef reduced boredom and negative affect and increased positive affect and nature connectedness. Although benefits would be greater with exposure to real-life natural environments (Mayer et al., 2009), virtual exposure could be an appropriate alternative in case of strict lockdown measures or inaccessibility to nature. Furthermore, we suggest that clinical practitioners consider recommending patients to increase interactions with blue spaces, either directly or indirectly with the use of images or videos, and to focus on triggered emotions, particularly awe, as means to alleviate feelings of worry and boredom and to boost positive affect.

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Chapter 2

A Qualitative Study on Emotions Experienced at the Coast and Their Influence on Well-Being¹

Abstract

Coastal environments are increasingly shown to have a positive effect on our health and well-being. Various mechanisms have been suggested to explain this effect. However, so far little focus has been devoted to emotions that might be relevant in this context, especially for people who are directly or indirectly exposed to the coast on a daily basis. Our preregistered qualitative study explored how coastal residents experience the emotions they feel at the coast and how they interpret the effect these emotions have on them. We conducted semi-structured interviews with a purposive sample of eight Belgian coastal residents aged 21–25 years old. The interviews were analyzed with the approach of interpretative phenomenological analysis. Five superordinate themes were identified and indicate that, for our participants, the coast represents a safe haven (1) in which they can experience emotional restoration (2), awe (3), and nostalgia (4). These emotional states are accompanied with adaptive emotion regulating strategies (5), such as reflection and positive reappraisal, that may facilitate coping with difficult thoughts and feelings. Our study demonstrates the importance of investigating specific emotions and related processes triggered at the coast and how these could contribute to the therapeutic value of the coast.

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Introduction

Throughout recent years, there has been an increasing amount of research demonstrating multiple health and well-being benefits from exposure to blue spaces, i.e., natural environments that feature water (Gascon et al., 2017; White et al., 2020), with a particular focus on coastal environments. Although the coast has been visited by people for leisure, relaxation and thalassotherapy already since the 18th century (Verhaeghe, 1843; Strange, 1991), it is only until recently that there is empirical evidence of the relationship between the coast and well-being. Much of this evidence has demonstrated that residential proximity to the coast is associated with a better physical and mental health in comparison to residents living inland (Garrett et al., 2019; Hooyberg et al., 2020).

Various factors have been suggested to contribute to the well-being benefits of living near the coast. For example, coastal proximity is positively associated with the likelihood of achieving recommended guidelines of physical activity a week (White et al., 2014). Coastal environments are also seen as areas that boost social interactions (Ashbullby et al., 2013) and spending time with family and friends is stated as a key motivation for visiting the coast (Elliott et al., 2018). Furthermore, several environmental factors can explain the positive effects of the coast on well-being such as temperature regulation (Völker et al., 2013) and sea spray aerosols (Van Acker, 2021). Finally, coastal environments are considered as restorative in terms of stress reduction (White et al., 2013) and restoration of depleted cognitive abilities (Gidlow et al., 2016).

Considering the suggested mechanisms underlying the relationship between the coast and well-being, research has hitherto mainly focused on physical, social, and cognitive factors whereas emotional factors remain ambiguous. To create a more comprehensive framework of how and why the coast benefits well-being, it is imperative to also consider potential emotional processes. Although various emotional processes related to the coast have been suggested by earlier studies (Bell et al., 2015), the exact nature of these emotions and their effect on our well-being remain unclear. One way to investigate these emotions is to look at how people experience their emotions when they are at the coast. Nonetheless, the majority of qualitative research on emotions at the coast were conducted with visitors or tourists (Willis, 2015; Jarratt & Sharpley, 2017; Pearce et al., 2017), and not coastal residents. Due to the direct or indirect exposure to the coast on a daily basis, we can question whether coastal residents experience similar emotional processes at the coast, or perhaps to a lesser degree. To fill this knowledge gap, the present study is therefore based on the following research question: how do coastal residents make sense of the emotions they experience at the coast and of how these emotions affect them?

The coast as a therapeutic landscape

The relationship between the coast and well-being can be set within the concept of therapeutic landscapes, defined by a landscape where “physical and built environments, social conditions, and human perceptions combine to produce an atmosphere which is conducive to healing” (Gesler, 1996, p. 96). In other words, a therapeutic landscape can be any place with physical and social features that enable physical, mental, and spiritual well-being, as perceived by the people engaging in it.

Blue spaces, and thereby coastal environments, have been investigated as therapeutic landscapes (Völker & Kistemann, 2013; Bell et al., 2015; Finlay et al., 2015; Foley & Kistemann, 2015; Satariano, 2019). These studies explored three key dimensions of therapeutic landscapes experienced at the coast, namely the physical dimension, the social dimension, and the symbolic dimension (Gesler, 2003). The physical dimension relates to the diverse set of activities that the coast offers and its associated benefits. Participants from the study of Bell et al. (2015) described that these activities can fulfill a desire for challenge and achievement and provide emotional and cognitive release. Swimming, for example, has been shown to have a beneficial effect in the treatment of chronic disorders such as rheumatism or arthritis (Foley, 2010) and is known to support the maintenance and recovery of health (Foley, 2017). The social dimension refers to the opportunities for planned or spontaneous social interactions at the coast, as well as a collective experience of nature that enables a sense of community and social identity (Finlay et al., 2015). In addition, the coast is considered to be of intergenerational value as it has been shown to be beneficial for all age groups, containing an atmosphere of play and relaxation (Ashbullby et al., 2013; Satariano, 2019). The symbolic dimension of therapeutic landscapes relates to the historical, cultural, and individual perceptions of the coast and its effects on well-being. For example, in Bell et al. (2015), perceptions of water as cleansing or purifying conditioned the participants’ experience with coastal waves and associated moods and emotions. Besides individual perceptions of the coast, different cultural notions and traditions most likely also influence how specific communities interact and experience the coast and its effects (Wheaton et al., 2020).

Emotions at the coast

One dimension pertaining to the therapeutic landscapes concept that has not been specifically looked into is the emotional dimension. Only a handful of studies explicitly focused on emotional processes linked to the coast (Willis, 2015; Jarratt & Gammon, 2016; Jarratt & Sharpley, 2017; Pearce et al., 2017). In these studies, two emotions are prominent, namely the emotions of awe and nostalgia. Awe is an emotion that occurs whenever one perceives something as larger than the self and when one feels the need for

accommodation to assimilate it (Keltner & Haidt, 2003). It is an emotion that is characterized by feelings of a small self, in which one's attention is less focused on the self (Shiota et al., 2007) and one's personal concerns and goals become less significant (Piff et al., 2015). Typical stimuli that elicit awe include art, music, and natural landscapes with panoramic views (Shiota et al., 2007). The coast in particular appears to trigger awe, accompanied with a change in perspective and feelings of relaxation (Willis, 2015; Jarratt & Sharpley, 2017). In a study by Pearce et al. (2017), when asked about what inspires awe at the coast, participants replied with five different facets: marine fauna, aesthetics, ecological phenomena, vast geological landscapes and reflective moments.

The second prominent emotion, nostalgia, is characterized by a sentimental yearning for the past, and although historically considered to be an emotion of negative affect (McCann, 1941), it is increasingly being regarded as ambivalent, thereby containing both positive and negative affect (Sedikides & Wildschut, 2016). Nostalgic experiences are associated with redemption (Wildschut et al., 2006), whereby the narrative progresses from a negative standpoint into a positive one, e.g., taking the good out of the bad (McAdams et al., 2001). In relation to the coast, the study by Jarratt and Gammon (2016) showed that seaside visitors feel nostalgic during their visits to the coast, due to the unchanging and timeless nature of the coast, in contrast to the fast-paced modern world. In addition, nostalgia can be triggered by sensory input (Wildschut et al., 2006), in line with findings that tastes and scents can elicit autobiographical memories (Chu and Downes, 2000). The coast most likely provides sensory stimuli that can lead to nostalgia, such as the scent of the ocean (Reid et al., 2015).

Both awe and nostalgia are considered as complex emotions, namely that they are a combination of two or more emotions. Nostalgia, for example, can be regarded as an aggregate of sadness and happiness (Power, 2006) and awe can be perceived as a mix of fear and happiness (Arcangeli et al., 2020). Moreover, awe and nostalgia are shown to positively affect well-being. Within the context of eudaimonic well-being, which defines well-being with such concepts as autonomy, environmental mastery, personal growth, positive relationships, purpose in life, and self-acceptance (Ryff & Keyes, 1995), both emotions contribute to meaning in life (Routledge et al., 2012; Danvers et al., 2016). Nostalgia has also been shown to enhance self-esteem and social connectedness (Hepper et al., 2012; Reid et al., 2015). Within the context of hedonic well-being, considered as a state of positive affect and absence of negative affect (Kahneman et al., 1999), studies find that nature-induced awe is associated with life satisfaction (Anderson et al., 2018) and is negatively correlated with boredom (Severin et al., 2021). Nostalgia is also shown to buffer against boredom (Van Tilburg et al., 2013) and to generate positive affect (Wildschut

et al., 2006). Considering the positive effects of awe and nostalgia on well-being, it is possible that experiencing these emotions at the coast contributes to the role of the coast as a therapeutic landscape.

An additional mechanism that can pertain to the emotional dimension but does not relate to an emotion *per se* is psychological restoration, defined as a renewal or recovery of depleted physical, psychological, and social resources (Hartig, 2004). More specifically, emotional restoration relates to feeling calm and relaxed as well as feeling refreshed and revitalized. Studies show that visits to natural environments, and particularly the coast, lead to greater emotional restoration (Hartig et al., 1991; White et al., 2013). A prominent theory related to this phenomenon is the stress recovery theory (SRT; Ulrich et al., 1991). The SRT posits that, compared to an urban environment, an environment with natural features facilitates positive affect— notably feelings of interest, pleasantness, and calm, and also reduces both physiological and psychological stress, due to an innate affinity toward nature (Ulrich, 1983). Aquatic features in particular seem to provide greater restoration in terms of relaxation and positive affect (Ulrich, 1981; White et al., 2010). Emotional restoration can therefore also be an important mechanism in the relationship between the coast and well-being.

Present study

The present study aimed to provide an in-depth analysis of how coastal residents experience the emotions they feel at the coast and how they interpret the effect these emotions have on them. To do so, we conducted semi-structured interviews with a group of young Flemish adults who grew up near the Belgian coast and/or were currently residing near the coastline. This particular age group was chosen due to the multiple stressors young adults are exposed to (e.g., instability in work and relationships, transition to living apart from parents, identity exploration) and their resulting mental health implications (Arnett et al., 2014). We subsequently analyzed the interviews with the approach of interpretative phenomenological analysis (IPA; Smith et al., 2009).

Materials and Methods

Our study's aim, design, and analysis plan were preregistered on the Open Science Framework (OSF) registry before data collection².

Participants

² <https://osf.io/tm7pj>

In line with the principles of IPA, which will be discussed further, we recruited a purposive homogeneous sample of eight participants. The authors of IPA consider an acceptable sample size to be between four and ten participants (Smith et al., 2009). Inclusion criteria involved being between 18 and 25 years old and living near the Belgian coast. A description of the eight participants can be found in **Table 1**.³ All participants were from the region of Flanders and therefore the interviews were conducted in Dutch.

Procedure

Two participants were recruited via advertisement of the study in a university school in Ostend, Belgium, whereas the rest of the participants were recruited via word-of-mouth. Participants were notified of the study's inclusion criteria, its aim to explore how coastal residents experience living near the coast, and the registration procedure. Upon registration, participants were asked to fill out an informed consent form. Interviews were then conducted via Skype, during the months of October to December 2020, to respect measures against the COVID-19 pandemic at that time. The interviews lasted between 40 and 60min and were digitally recorded, transcribed and pseudonymized. After the interview, participants received a financial compensation of 15 euros (approximately 17 USD). The study was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University. The semi-structured interviews followed a predetermined interview guideline that consisted of 13 open questions (available at <https://osf.io/v2cax/>). Participants were first asked to introduce themselves and provide insights into their daily routines to put them at ease. They were then asked to describe their relationship with the coast and the impact of living near the coast on their daily lives. Finally, they were asked about the specific emotions they feel at the coast and what effect these emotions have on them. Extra prompts were prepared and sometimes used to facilitate further discussion, such as asking whether the emotions are accompanied with particular physical sensations or thoughts. This guideline helped to steer the conversation toward the questions of interest. Nonetheless, we aimed to leave space for participants to share their story and to bring up new areas that were not considered before. This type of interviewing enables more flexibility to explore participants' interests or concerns and facilitates a rapport between the researcher and participants (Smith and Osborn, 2015). In order to familiarize themselves with this kind of interviewing, each researcher conducted a pilot interview with an external person that was unaware of the study's aim.

³ Each participant's name has been replaced by a pseudonym to protect confidentiality

Table 1*Participant Characteristics*

Participant pseudonym	Sex	Age	Living situation	Studies/work	Extra characteristics
Arne	Male	MV	Grew up and is living near the coast	Student	Diagnosed with Autism Spectrum Disorder
Emma	Female	22	Grew up near the coast and lives inland in student room	Student	
Justine	Female	22	Grew up near the coast and lives inland in student room	Student; on Erasmus in another country	
Noa	Female	22	Grew up and is living near the coast	Temporarily employed; seeking work	Diagnosed as a Highly Sensitive Person
Anna	Female	22	Grew up near the coast and lives inland in student room	Student	
Louis	Male	22	Grew up near the coast and lives inland in student room	Student	
Laura	Female	25	Grew up inland and lives near the coast	Employed	
Victor	Male	21	Grew up and is living near the coast	Student	

Note. MV stands for “missing value”. The participant Arne did not inform us his age.

Qualitative data analysis

The transcribed interviews were analyzed with the use of IPA. The aim of IPA is to investigate in a detailed manner how participants make sense of a specific phenomenon or experience and the meanings that they attach to it. IPA is thus an ideal approach for our study as it focuses on the lived experience of a particular group and is best suited for research questions that are understudied (Peat et al., 2019). IPA is constructed around three principles: phenomenology, hermeneutics, and idiography. Based on phenomenology, IPA researchers strive to look into participants’ subjective experience rather than make an objective statement of the experience itself. However, the principle of hermeneutics shows that access to this experience depends on participants’ interpretation of it as well as the researcher’s interpretation of the participants’ interpretation. In opposition to the nomothetic approach, the last principle, idiography, dictates that IPA researchers prioritize an analysis on a case-by-case basis and therefore avoid

making premature general claims for larger populations. Purposive sampling is thus used to find a “more closely defined group for whom the research question will be significant” (Smith and Osborn, 2015, p. 56).

In our study, we employed IPA using a step-by-step procedure demonstrated in **Table 2** (Smith et al., 2009). Each interview was analyzed individually, before being compared with each other. This individual analysis consisted of first familiarizing oneself with the interview by making descriptive, linguistic, and conceptual notes. An example of a linguistic note was to notice a participant anthropomorphizing the sea (“that is something that the sea never asks”), which indicated perceiving the sea as a powerful entity. We then identified emerging themes based on connections among these interpretative notes, such as “the coast representing home,” or “fascination towards the sea.” These subthemes were subsequently clustered into five or six overarching themes that conceptually differ and that are prevalent in the interview. Each theme or subtheme is illustrated by one or several direct quote(s) of a participant. This process is repeated for each participant, with the conscious effort to put aside the analysis of the previous cases, known as “bracketing” (Peat et al., 2019). The final step involved a group analysis to construct a final table of superordinate themes, based on the themes of each participant. Some themes were found for every participant and thus shifted into superordinate themes, while other themes were clustered to create one new theme. This final table of themes represents the findings of our study.

While conducting IPA, we aimed to respect reflexivity, which is the process of being aware of how the perspectives and beliefs of the researchers might influence the analysis procedure (Dodgson, 2019). The transcripts of the interviews were analyzed by two Master students (EN and LL) and one doctoral student (MS), under the supervision of a professor (AB). Although the authors enjoy visiting the coast, neither of them has or has had a permanent residency near the coast. One of the authors (EN) did live in a coastal city while practicing surfing for 6 months and experienced this very positively. Nonetheless, the analysis process was done in collaboration between the authors. Several meetings took place in which the authors discussed the findings. The first transcript was analyzed by all the authors, with the joint construction of its table of themes. The remaining transcripts were analyzed separately, and the final table of themes was subsequently set up together. In this way, the interpretation of the interviews could not be based on an individual researcher perspective and conscious effort was made to not impose personal feelings toward the coast during these collaborative discussions. According to the framework of Yardley (2000), rigor was achieved by implementing this reflective process, the use of bracketing and pilot interviews, and ensuring a sample that was appropriate for our research question.

Table 2*Step-by-step procedure for interpretative phenomenological analysis*

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1. Read and reread transcript of interview and make descriptive, linguistic, and conceptual notes.
 2. Develop emergent themes based on the notes and the transcript.
 3. Cluster themes together to create a table of overarching themes.
 4. Repeat steps 1-3 for each participant, with the conscious attempt to minimize the influence of the analysis of the previous interviews.
 5. Compare the individual table of themes with each other: similarities, differences, and patterns between transcripts are noted.
 6. Construct a final table of superordinate themes that stems from all participants and includes individual exceptions.
-

Results

The IPA results of our semi-structured interviews consist of five superordinate themes: emotional restoration, awe, nostalgia, emotion regulating strategies, and the coast as a safe haven. The themes are presented in the following sections. We would like to emphasize that the interviews and analysis were conducted in Dutch and therefore all quotes from participants have been translated to English.

Emotional restoration

The coast appears to have an emotionally restorative effect on our participants as they all described feeling calm or revitalized when visiting the coast. This effect was however expressed differently by each participant. Justine, for example, spoke of “feeling reborn” when she is at the coast and claims that spending time at the sea makes her feels more “recharged” and is “more effective than watching a TV series for 20 min.” For Noa, being at the coast calms her down and brings her “peace of mind.” Some participants compared the coast with urban environments, such as Louis who stated that he feels calmer at the coast “because in any case in a city, there is often more movement, more people, and more stimuli.” The feeling of calmness appears to come from the availability of open space and the accompanied opportunities to do physical activity: “by the sea you can just walk or cycle meters on the beach, and you just immediately calm down a bit” (Louis). For other participants, simply seeing the coast brings them a feeling of calmness.

Emma: “I often feel that I only really relax when I have seen the sea. Then, I feel it so almost physically that something falls off of me or something ..., even if it is sometimes only for five minutes just having seen the sea that does a lot, yes that really means a lot.”

The restorative effect of the coast can be especially prominent during certain stressful moments. For example, Anna typically enjoys relaxing near the sea during exam periods. For Emma, going to the coast “always helps” when she “feels a lot.” She adds that although this does not solve anything, “it does help because it calms me down.” Furthermore, in comparison to the other participants, Laura indicated that feeling calm at the coast happens only occasionally for her, notably when she is alone or “when it has been a busy day at work or you have a headache or something.” The feeling of calmness that the coast brings also seems to decrease during the summer due to increased tourism. Laura, for example, expressed that “in the summer I have in any case the opposite I think, then the sea makes me much more nervous than [name of city] would make me.” Tourism therefore seems to reverse the soothing effect of the coast for several participants.

Awe

During the interviews, almost all participants spoke to some extent about an overwhelming effect of the coast on themselves that seems to reflect the emotion of awe. A contrast emerged between awe with a positive valence and awe with a negative valence. Positive awe was expressed by some participants as a fascination for the sea and its natural elements and a respect for its power and grandeur: “the sea is also very fascinating because when you stand by the sea and you listen to the noise that the sea makes, you know that there is an enormous power within it.” (Arne). The interplay between different natural elements and sensory stimuli could make a deep impression on some participants. Justine, for example, was particularly impressed by the vastness of the coast; she stated that the sea is “such a large body of water that we do not control.” The dynamic aspect of the coast was also referred to by some participants, such as the infinite repetitive motions of the waves, the “color changes” of the coast as well as the tidal changes, “the ebb and flow.” Several participants also mentioned the particular beauty of other natural phenomena of the coast such as the “blue algae in the waves,” “waterspouts,” “snow on the beach,” and “beach insects.” Furthermore, the power of the sea was an important element in triggering awe for some participants. A feeling of adrenaline and excitement was described when faced by a stormy sea.

Justine: “When it storms, I love to go for a walk on the beach. Even though they often advise against that (laughs), but uh, I think it’s really cool to see that – yes, I think that’s something really overwhelming, the sea.”

Louis, who works as a beach lifeguard, also described an awareness and appreciation of the dangerous elements of the sea. For Arne, it is the “science” behind the sea that fascinates him, such as the sea’s regulation of temperature, as well as the battle between the sea and manmade constructions at the coast, in which “construction sometimes wins, sometimes loses to nature.”

In contrast to feeling positive awe at the coast, certain participants expressed awe in more negative terms, particularly toward the mystery and the grandeur of the sea. Victor, for example, finds it “frightening” to “go really deep into the water” and Laura expressed displeasure of not being able to “see what’s happening at your feet” when she’s in the water. Both participants also conveyed fear toward the grandeur of the sea, especially during a storm.

Victor: “I find it scary sometimes, because it's so majestic, it's so big, and then when there's a lot of wind and high waves and stuff, I can be impressed by that, and that can instill a certain fear in me.”

This sort of negative awe can perhaps be due to not being able to fulfill the need for accommodation. Indeed, certain participants described trying to understand the grandeur and mystery of the coast. For example, Arne tries to comprehend how the strength of the sea does not break the pier: “how in God’s name is it possible that the pier and the railing all remain standing when those waves crash into them.” Victor also displayed his reflections over the history of the coast and what lies beneath the horizon. Nonetheless, Louis depicted an example of how negative awe can lose its negativity through frequent exposure to the coast:

Louis: “if you often go into the sea and you become a bit used to what those dangers are, or you know what to do and such, ... you do get a little less frightened or something, and it becomes less threatening.”

Louis was therefore able to adapt his mental schemas concerning the threatening elements of the sea and thereby feel less fear.

Moreover, the emotion of awe at the coast appears to have certain effects on the participants. These effects could be in the form of physical sensations or specific feelings that portray an emotional impact upon the participant.

Victor: “you can get a shiver down your spine ... if you’re so impressed by that situation or something. Or I’ll then get a lump in my throat, or there can be once a (laughs) – a tear rolling down ..., I can be caught off-guard like that yes.”

In addition to these physical sensations, awe also seems to lead to a feeling of small self, as stated by Arne: “the grandeur, the greatness of the beach, of nature, of the dike ... and then you just stand there as a small, small dot, yea then you just feel very humble and from there you start thinking about life.” Furthermore, for other participants, the emotion of awe facilitates a feeling of calm, such as for Laura who “calms down” when she “can enjoy the fact that it [the coast] is beautiful.”

Nostalgia

In addition to awe, the coast seems to generate nostalgia in participants by evoking important memories that were created there. All participants described unique memories of the coast throughout their lives. The majority spoke positively of these memories with a nonverbal behavior that portrayed pleasure and gratitude (e.g., laughter, smile). Nonetheless, some participants recalled memories that appeared to be negative. Anna, for example, recounted the death of a family friend who used to take photos of the coast and she thereby sometimes thinks back to that event while at the coast. She further expressed how this makes her feel sad but that “it’s ok” and that being at the coast makes her feel more “calm” because the “sound of the sea is also calming.” Thinking back to this memory is therefore bittersweet as Anna experiences both sadness and a “beautiful” feeling.

A great deal of the memories described by participants were socially-oriented. Examples involve activities with friends and family such as parties in the evenings, walks on the beach, summer vacations, games and watersports. However, some of the memories were not focused on social features and were instead directed toward natural phenomena at the coast. For example, Arne and Noa longed for the winter, and more specifically, snow on the beach.

Arne: “the best memory was when it still snowed at the coast ..., that the beach was sometimes a bit white and so was the dike, yea just these idyllic pictures ..., yes these are the memories I cherish the most about the dike and the sea.”

Additionally, storms at the coast seem to trigger important moments that involve challenging one’s own boundaries. Noa, for example, talked about an enduring memory, when she swam in the sea with her younger brother on a stormy evening, and emphasized the “rush” and adrenaline that she felt. Other memories associated with the coast that were not socially-oriented were memories of daily routines at

the beach such as walking the dog or watching the sunset. Walking at the coast seems to arouse nostalgia in Arne when he thinks about all the “beautiful moments” he spent with his dog at the beach and he wonders “how much longer they can still enjoy” these moments. Justine also expressed missing the coast and her routines there as she was on an Erasmus exchange in a city with a strict lockdown and had no access to the coast at the time of the interview.

The coast appears to play an important role throughout the lives of the participants as they described enduring memories of the coast from their childhood and teenage years. For example, Laura mentioned how she, as a child, did things like “every child”: “sit on the beach and sell those flowers and go look for shells.” Teenage years were then described as “pretty fun days, young teenage days ..., days playing with friends at the beach, playing in the sea” (Noa). Many of these memories were linked to summertime at the coast and its “carefreeness,” which generated nostalgic feelings in several participants, as Emma mentioned missing “the whole summer atmosphere.” However, unlike the rest of the participants, Arne had the least memories of the coast in his childhood. He has autism spectrum disorder (ASD) and is quickly overwhelmed when there are a lot of people; because of increased tourism, he therefore could not spend much time on the beach when he was a child and instead went more often to parks.

Apart from creating important memories, the coast also seems to trigger the reminiscence of these memories. Victor, for example, explained how being at the coast makes him remember a special moment with his friends during high school:

Victor: “I remember that moment sometimes when I go to the beach in the summer, it reminds you of friendship and of the old days. It is unconsciously so that many things directly or indirectly have something to do with the beach, with the proximity of the sea.”

Certain sensory stimuli of the coast were considered to evoke memories such as the scent of the beach that reminds Anna of the summer. For Arne, this effect of reminiscence seems important as he indicated that he “would still visit certain places regularly just to reminisce” if he no longer would live near the coast. Justine also mentioned that the many beautiful memories of the beach “play a part in the fact that she likes being there.” Various feelings seem to accompany the reminiscence of memories at the coast, such as a “feeling of happiness,” “a little homesick,” a feeling of “loss,” or a feeling that time goes quicker.

Emotion regulating strategies

In the interviews, various emotion regulating strategies were depicted, either in relation to the emotions mentioned above, or independently associated with the coast. Although there is clear overlap between them, we describe them separately below.

Reflection and meaning-making

Several participants expressed that the coast is a place where they could stand still and reflect on life, problems, and emotions: “the big questions of life then start to play out” (Arne). For Justine, it is “one of the few moments” that she thinks about her emotions. Victor also benefits from being able “to reflect on his feelings and his emotions” at the coast, because he “maybe sometimes does that too little in his daily life.” He specifies that he is “not consciously” thinking about specific things but that “things are always going through his mind.” In contrast, for Emma and Justine, the coast can also just be a place for them to think of nothing.

Arne emphasized that the possibility of contemplation during his “long walks” on the beach is important to him as it helps him to sort things out and to go over the “mistakes” he might have made during the day, often in the context of his ASD. Regarding these mistakes, Arne displayed signs of meaning-focused coping through acceptance as he says: “I made them [the mistakes] but I’ll make sure I do not make them twice.” The self-reflection that the coast offers can therefore potentially help Arne to open up to unprocessed feelings, such as guilt, shame, or frustration. Another sign of a meaning-making process is the humility and vulnerability that Arne feels when he experiences awe. As he realizes that “we are actually nothing compared to the sea,” he “tries to build a philosophy in his life” in which he is humble both to nature and to other people. Other participants also described meaning-making in terms of putting things in perspective, which helps them to focus on what is truly important to them and also helps to not keep stressing for the less important things in life.

Emma: “I also just realize more what I have, because I can be stressed about things, but in the end it’s not all that important as long as you ... are healthy and as long as your family is okay then, I don’t know, then I can fail as many exams that I want, but that just doesn’t really matter.”

Letting go and exteriorizing emotions

Some participants indicated how they can let go of their emotions at the coast. Two participants alluded to coastal elements facilitating this process. Noa, for example, mentioned “being able to let go of everything for a while” and her emotions could “literally slide into the earth or blow with the wind.” Emma also talked about “how it all blows away from you” with reference to the wind at the coast. In relation to

this, Laura indicated that the coast was the best place for the Dutch practice called “uitwaaien,” which means to go outside in windy weather with the aim to clear one’s mind.

In addition to letting go of emotions, the coast also helps Justine in letting go of overthinking and makes her become more aware of the present moment: “everything else that goes on in your life, then I forget that and then I’m just ... one with nature.” In particular, Justine expressed the importance of the coast at a time when she had to make a crucial decision, stating a constant need to be “preoccupied” with this decision, but being at the beach gave her the permission to temporarily let go of the weight of this decision. The coast therefore offers some participants the chance to get a breath of fresh air and to thereby let go of certain (often difficult) thoughts, feelings or emotions.

The coast was also considered to be a place where emotions could be exteriorized for certain participants, functioning thereby as an “outlet.” Noa spoke most explicitly about this when she stated that the coast is a place where she could express her emotions, including negative emotions: “sometimes I can really let go of my anger or my sadness, so to speak, so that it can really get out.” To exteriorize these emotions, Noa performs actions such as “screaming, crying, or singing.” This exteriorization stops her head from “spinning” and has a positive effect on her: “it calms me down, gives me peace of mind, gives me sometimes just the energy, to keep going.” The use of the coast as an outlet helps Noa to move forward, so that she “no longer has to think about it” and instead think: “tomorrow is a new day.”

Seeking Experiences of Peak Flow

The use of the coast as means of stimulation and seeking peak flow was demonstrated in two participants. Noa, for example, described at length how she uses the coast to pursue a “rush.” During her childhood, the coast gave her a place to “romp,” or in other words to play around in a lively manner, and to “seek out adrenaline rushes.” As Noa grew older, she started to do watersports such as kitesurfing, with which she would seek out “the challenges” and the “combination of wind and sea to then get the feeling thereof.”

Noa: “Feeling for me is really just being able to feel with all the sensors that I have without being directly overwhelmed, so in nature for me there is always a sort of vibe, a fixed wavelength ... with which I can surf along. That also gives a secure peace of mind or a mental calmness.”

This type of experience can be referred to as an experience of peak flow. Noa related this experience to her being a highly sensitive person and thereby demonstrated that doing kitesurfing, or “moving flexibly her legs on the sea, absorbing these shocks,” helps her cope with her high sensitivity.

Arne also displayed how the coast is a place that positively stimulates him. As he described the fascination he feels when he sees the water hit the pier during a big storm, this does not negatively overwhelm him such as other stimuli in his daily life. On the contrary, he actively seeks out this stimulation as he explained how one time during a storm, he climbed over the fence that was used to close off the pier, to look at the water. At that time, he was “really excited” and found that “very pleasant.” Both Noa and Arne thus experience difficulties with processing stimuli but named the coast as a place where they can feel safely stimulated.

Coast as a safe haven

The coast was described by participants in various ways as a safe haven, or in other words, a place where they could feel at ease and feel safe to experience emotions and vulnerability. This was conveyed by three different facets that are described below.

Respite from daily life

Several participants expressed how the coast provides them respite from the hustle and bustle of their daily lives.

Justine: “I find that with many other things in our lives, it is always very busy ..., and by the sea, or the dunes, I find a place where you can once in a while be somewhat stimulus-free and that you return to a moment of zen.”

Coupled with this, Justine described how there is an absence of pressure and expectations at the coast. In her daily life, she feels like she “has to be in a hurry,” that she has things to do and things she should not forget, whereas the coast offers her “some more time to think” and enables her to relax. Arne also mentioned that there is an absence of social pressure and norms at the coast: “by the sea you have time, there is no one who says ‘you have to walk faster’, there is no one who says ‘you have to do this, you still have this much to do’.” Even the feeling of time itself can be absent at the coast, as Noa refers the coast as a “timeless place” and does not feel the need to look at the time when she is there.

Beyond providing respite, the coast also generates a sort of disconnection from reality for various participants. For example, Victor recounted how during his daily drive along the coastal road he can become so “lost in his thoughts” that he does not notice how far he went until he stops at a traffic light. This type of disconnection from reality was described by Emma in relation to the dunes, as she stated that the dunes make one feel really cut off from the rest of the world, in comparison to coastal cities that only have a dike.

Feeling of safety and freedom

An important aspect of the coast as a safe haven is the feeling of safety and freedom that the participants reported experiencing there. In terms of safety, Emma described the sea as a “very safe environment where she feels very good.” Other participants also mentioned “feeling at ease” at the coast, with Justine adding that she “never feels alone,” she “just always feels very reassured by the sea.” This sense of safety could come from the familiarity that participants have in relation to the coast. Some participants expressed how the coast is, and always will be, there for them, as Arne said: “when you are happy, when you are sad, you can always go to the beach.” Justine stated that even when she does not go to the coast, “just the fact that she knows it’s there” is reassuring for her. Additionally, the coast represents “home” for some participants, like for Arne who described the sea as his “homeland.” Justine even went so far to say that she “identifies with” the sea. It is therefore more likely that this familiarity with the coast explains the feeling of safety that participants feel there, rather than the coast itself. Anna even linked the two together by saying: “a sense of safety, yes, just a familiar environment actually.”

In addition to creating a feeling of safety, the coast also represents a place that facilitates emotions and vulnerability. For example, Noa indicated that she and her parents use the coast to have difficult conversations with each other. The coast is thus a setting that makes these conversations easier to have for Noa. Furthermore, Arne expressed how in his daily life, he feels he needs to be as rational as possible, but at the coast “he starts to become emotional,” by reflecting on life and “allowing the peace that the sea indirectly gives you.” This is the “absolute opposite of the feeling” he has during the day. An element that may support this effect on Arne is the simplicity and predictability of the sea, such as the infinite repetition of its waves. The outside world may feel unpredictable to Arne, because of his ASD, and experiencing the natural predictability of the coast may help release the pressure he feels during the day: “The sea that runs its course there, comes and goes, comes and goes. The simplicity.”

Some participants expressed a sense of freedom that they feel at the coast. For example, Louis described the coast as providing the freedom to “do what you want.” This sense of freedom appears to have been accentuated throughout the COVID-19 pandemic for most participants. This could be due to the easy accessibility of a wide-open space, as pointed out by Victor: “we were always lucky here that the sea was close by and the beach is vast, it is large, you can walk there with many people at the same time, without walking on each other’s feet.” Victor also mentioned that due to the diversity of the coast, with the beach, the dunes, and the forest, “you do not have to do the same tour every day,” and this “played a positive role” on him. The coast was therefore perceived as an “extra freedom” during the first-wave lockdown, where the participants could walk or exercise.

The opportunity to be alone

The opportunity to be alone at the coast also contributes to the representation of the coast as a safe haven as it is appreciated by several participants and appears to facilitate the emotion regulating strategies triggered there. For example, Noa and Arne explicitly seek out the coast when there are as few people as possible, as Noa “enjoys the emptiness when there are not many people on the beach” and Arne “just loves when you look over the length of the dike, that you really do not see anyone.” Being alone at the coast may help them cope with the overstimulation that they experience in their daily life. Other participants also mentioned the calming effect of having a “moment for themselves” (Justine), with Louis stating that it is especially “when he’s alone” that “he can really feel at ease.” Additionally, although Laura rarely visits the coast alone, she did indicate that the calming effect of the coast was mostly present when she walked alone.

Discussion

Our qualitative study presents five superordinate themes that represent the emotional experiences generated at the coast for eight Belgian coastal residents.

Emotional restoration

The first theme relates to emotional restoration, as all participants reported feeling calm and/or revitalized when they were at the coast. This is in line with findings of a meta-analysis demonstrating a positive association between larger amounts of blue space within a geographical area and markers of restoration such as stress, anxiety, and depressed mood (Georgiou et al., 2021). For our participants, this feeling of calmness and peace of mind was linked to various coastal elements (e.g., wind, water, open space) and the opportunities for physical activity. This supports the claim that physical activity at the coast enables restoration, as emphasized by the Blue Gym initiative (Depledge & Bird, 2009). The emotional restoration experienced by participants also aligns with the stress recovery theory of Ulrich et al. (1991), as they stated feeling calmer at the coast than in urban environments. Nonetheless, coastal tourism appears to weaken or even reverse the effect of emotional restoration. This issue is referred to in the study by Bell et al. (2015); however, it remains understudied in the current literature. Further research is definitely needed to assess the impact of tourism on the restorative qualities of the coast.

Awe

The second theme that emerged throughout the interviews was the emotion of awe experienced at the coast. Participants described sensations and perceptions that are compatible with the definition of awe

given by Keltner and Haidt (2003). The coast is perceived as larger than one's self, which leads to a need for accommodation in some participants. The power and the grandeur of the sea appear to particularly trigger this perception, but other coastal elements such as the cyclic dynamic of the waves or the mystery beyond the horizon also seem to generate awe. In the study of Pearce et al. (2017), elements that were found to inspire awe at the Australian coast, such as its aesthetic beauty, tidal fluctuations, and vast landscape, were also reported by our participants for the Belgian coast.

Participants who described being unable to comprehend these awe-inspiring phenomena experienced a more negative type of awe with feelings of fear and anxiety. The valence of awe was indeed expressed dimensionally in our interviews and ranged from a fascination toward the power of the sea to unrest or fear toward the potential danger or mystery of the sea. Awe was therefore linked with both positive and negative affect, supporting the notion that it is an ambivalent emotion (Moss and Wilson, 2015). One of our participants demonstrated that frequently interacting with the sea allowed him to be less scared of it. Negatively valenced awe could thus transform into a positive fascination if one were to be more knowledgeable and familiar with the sea, allowing to successfully fulfill one's need for accommodation.

An alternative concept that can be linked to these feelings of fear is the experience of the sublime. According to the philosopher Burke (1757/1990), this emotion is triggered by aesthetic stimuli that convey both power and obscurity, thereby inducing elements of threat and fear. Awe and the sublime are viewed as closely related, with studies suggesting that the sublime can be conceptualized as a threat-based variant of awe (Gordon et al., 2017; Arcangeli et al., 2020). However, recent studies call into question the importance of the fear component in the sublime, with one study demonstrating that awe and the sublime are associated through the dimensions of small self and connectedness instead (Clewis et al., 2021). Further research is needed to clarify the relationship between the sublime and awe and the extent to which the sublime can be linked with experiencing fear at the coast.

Other characteristics of awe appeared in our interviews and can be linked to the facets of awe in the Awe Experience Scale (AWE-S; Yaden et al., 2019). One of these facets is self-diminishment, which refers to the feeling of a small self, and was conveyed by one of our participants, Arne. Self-diminishment has been found to mediate the effect of awe on prosocial behavior (Piff et al., 2015) and humility (Stellar et al., 2018). Our study is consistent with these findings as Arne described feelings of small self that leads him to feel humble toward both nature and other people. Another facet of awe from the AWE-S that was described by our participants was the physical sensations accompanying the experience of awe, such as the "shiver down your spine" described by Victor. Moreover, one aspect of awe that is not included in the

AWE-S, but that was expressed by Arne, is the fascination toward the science behind the sea. Studies have indeed shown that awe is positively associated with scientific thinking, to help fulfill the need for accommodation (Valdesolo et al., 2017; Gottlieb et al., 2018). Overall, the experience of awe at the coast reported by our participants is in line with previous studies demonstrating nature, and more specifically the coast, as an elicitor of awe (Shiota et al., 2007; Anderson et al., 2018; Ballew and Omoto, 2018).

Nostalgia

The third theme identified in the interviews refers to the experience of nostalgia at the coast. This experience is characterized by the coast evoking important memories that were created there throughout participants' lives. The qualitative study of Jarratt and Gammon (2016) presents similar findings as their participants described a nostalgic connection with the coast, primarily through the recollection of childhood memories. It is interesting to note the similarity between the present study and the one of Jarratt and Gammon (2016), considering the age difference (their participants were aged between 55 and 74 years old). This similarity is however in line with previous findings showing that proneness to nostalgia follows a curvilinear trend, namely that it peaks in younger (under 30) and older (over 75) adulthood, (Hepper et al., 2021). This is possibly due to the importance of nostalgia in times of transition (Sedikides et al., 2015), such as transition to university or employment. Nostalgia was stated as a reason to visit the coast in Jarratt and Gammon (2016), much like for our own participants, which leads to the hypothesis that the coast facilitates coping with life transitions through the experience of nostalgia. Further research comparing the effect of the coast on different age groups is needed to test this hypothesis.

Just like with awe, the experience of nostalgia at the coast was sometimes expressed more ambivalently. More recent studies demonstrate that nostalgia is an ambivalent, but predominantly positive, emotion (Wildschut et al., 2006; Sedikides & Wildschut, 2016). Although most of our participants indicated feeling positive affect while recalling memories of the coast, other participants expressed a feeling of loss. This feeling of loss is what differentiates nostalgia from mere reminiscence, which is solely a positive form of recollection (Jarratt & Gammon, 2016).

The noted ambivalence in awe and nostalgia could potentially explain their positive influence on well-being. Indeed, studies have found that ambivalent emotions are more likely to support the fulfillment of psychological needs such as the need for autonomy and relatedness (Moss & Wilson, 2015) and to boost adaptive coping styles and resilience to stress (Braniecka et al., 2014). These findings are based on the coactivation model of Larsen et al. (2003) which stipulates that "taking the good with the bad" enables a person to confront adversity and to transform it into an advantage by engaging with the stressor and making meaning out of it. The bittersweet memory recounted by Anna could very well be an example of

this very coping process. The present study therefore puts forward the hypothesis that the coast generates experiences of awe and nostalgia, which in turn enable coping with various life stressors, and ultimately benefit well-being.

Taking a look at the content of participants' memories evoked by the coast is important to further understand this experience of nostalgia. Most of the memories were centered around a social context, which is consistent with studies portraying nostalgic narratives as often involving social interactions (Wildschut et al., 2006). Nostalgia has also been found to feature momentous events (Wildschut et al., 2006), such as the memory of swimming in the sea during a storm, described by Noa. Interestingly, other elements in nostalgic memories that are not prominently found in the literature were described in our interviews. These elements reflected for example different seasons at the coast (wintertime and summertime) and their associated natural phenomena, as well as simple daily routines at the beach. Therefore, beyond providing the opportunity to create important social memories, the coast can also elicit nostalgia through symbolic interactions with its natural elements.

Emotion regulating strategies

The fourth theme present in the interviews we conducted relates to emotion regulating strategies. Emotion regulation has been defined as “processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions” (Gross, 1998, p. 275). Several emotion regulating strategies that are considered as adaptive have been described by our participants in relation to the coast. Although emotion regulation has been found to be positively associated with nature and to predict nature's restorative outcomes (Johnsen, 2013), to the best of our knowledge, no studies have specifically evaluated emotion regulation in the context of coastal environments.

A first emotion regulating strategy refers to reflecting on life, problems, and emotions while being at the coast. Reflection has been suggested to contribute to active problem-solving and thereby lead to long-term positive outcomes (Arditte & Joormann, 2011). A previous study already found that exposure to nature increases the ability to reflect on a life problem (Mayer et al., 2009). A second strategy, or “family of strategies,” involves meaning-making processes such as acceptance and positive reappraisal, for which numerous psychological benefits have been found (Hayes et al., 1999; Gross & John, 2003). For example, reflection led some participants to be able to accept difficult situations or events, such as Arne accepting the possible “mistakes” he made, often in the context of his autism spectrum disorder (ASD). Other participants displayed positive reappraisal by putting things in perspective, namely to release the stress associated with things considered more trivial. These types of meaning-making processes could

be partly due to the experience of awe and nostalgia triggered by the coast, as awe is associated with more focus on the “bigger picture” and nostalgia is linked with redemptive narratives (Wildschut et al., 2006; Piff et al., 2015). A third emotion regulating strategy refers to participants being able to let go or exteriorize emotions while being at the coast. Participants described being able to get a breath of fresh air, clear their mind, and let go of certain thoughts and emotions. This coincided with a deeper awareness of the present moment, and of feeling more connected to one’s surroundings. Other participants expressed using the coast for emotional exteriorization that ultimately enables them to calm down and have enough energy to move forward. This can be viewed as the opposite of suppression of emotional expression, which is considered as a risk factor for psychological distress (John and Gross, 2004).

If we take a closer look into these emotion regulating strategies, we notice that some of them resemble components of mindfulness. Mindfulness is considered as the nonjudgmental acceptance of thoughts, feelings, and sensations, while keeping a centered awareness of the present moment (Kabat-Zinn, 1990). This is in line with the strategies of acceptance and letting go described by the participants. We are therefore led to the hypothesis that the coast triggers emotional and cognitive processes that facilitate the practice of mindfulness, which could further enhance the benefits of well-being at the coast. Indeed, a study by Nisbet et al. (2019) demonstrates that practicing mindfulness while walking along a canal led to stronger connectedness to nature and reduced negative affect, compared to walking along the same path without mindfulness or walking indoors. Their exploratory analyses also revealed that mindfulness led to a higher experience of awe. Future research should therefore aim to replicate this effect for coastal environments.

The final subtheme identified within emotion regulating strategies involves seeking experiences of peak flow. Although emotion regulation and peak flow are independent constructs, it can be argued that they are positively interrelated (Tavares & Freire, 2016). Experiences of peak flow, typically arising during physical activity, are characterized by a feeling of intense satisfaction, that occurs when a person considers their level of skill as sufficient to meet the perceived challenges of that activity (Pomfret & Bramwell, 2016). An example of such an experience was described by Noa; these experiences have been previously reported to take place at the coast (Bell et al., 2015). In addition to triggering peak flow, the coast also appears to facilitate positive stimulation without directly overwhelming our participants with high sensitivity. A study by Caddick et al. (2015) displays similar findings as it explored the effect of surfing on the well-being of combat veterans experiencing posttraumatic stress disorder (PTSD). Their participants expressed that the sensory experience of surfing at the coast enables them to escape from their usual ruminative thinking that typically overwhelms them. It would be beneficial to conduct further

research into the benefits of peak flow experiences and positive stimulation at the coast for individuals with mental health disorders such as ASD or PTSD.

Coast as a safe haven

The fifth and final theme that emerged from the interviews was the coast as a safe haven. The theme essentially demonstrates that for all participants, the coast represents a safe place where they can feel emotional and vulnerable and have respite from the stressors and pressures of daily life. Participants even described a certain ability to disconnect from reality, by becoming lost in their thoughts. This strongly reflects the concept of “being away” within the attention restoration theory, defined by psychological distance from one’s usual thoughts and concerns that require directed attention (Kaplan & Kaplan, 1989). There therefore seems to be a shift in the content and the type of processing of thoughts, with the coast enabling more “reverie,” or in other words more unconscious musings over one’s life for example (Jarratt & Gammon, 2016).

In relation to this, Noa described a sense of timelessness at the coast, which has been previously linked to the experience of nostalgia, due to the contrast between the permanence of the coast and the fast-paced modern world (Jarratt & Gammon, 2016; Jarratt & Sharpley, 2017). The study of Rudd et al. (2012) demonstrates that the emotion of awe is also found to be associated with an impression of timelessness, as awe increased perceived time availability, which subsequently led to greater life satisfaction. The coast therefore perhaps expands the perception of time through the experience of awe and nostalgia, thereby potentially counteracting “time famine.” Time famine refers to the feeling of having too much to do and not enough time to do it (Perlow, 1999). Investigating this mechanism would be beneficial considering that time famine has been shown to have negative health effects, and is possibly associated with burnout (Lehto, 1998; see also Bell et al., 2017).

An additional aspect of the coast as a safe haven relates to the sense of freedom that some participants associate with the coast. Indeed, the COVID-19 pandemic appeared to strengthen this sense of freedom by providing an accessible open-space with a diverse landscape. This is consistent with findings of a positive relationship between access to the coast and well-being during the first-wave lockdown in Belgium (Severin et al., 2021).

To understand why the coast represents a safe haven for our participants, we can link this to the representation of the coast as “home.” This representation was also demonstrated by Jellard and Bell (2021), who stated that the coast could be considered as a “home away from home” (Gardner, 2011), enabling a feeling of ease, stability, and connectivity with others who share that same space. Moreover, our participants’ representation of the coast strongly reflects the notions of place attachment (i.e., the

emotional bond to a place) and place identity (i.e., the cognitive identification to a place; Jorgensen and Stedman, 2001). Place attachment has been linked to numerous psychological benefits, as well as the emotion of nostalgia (Scannell & Gifford, 2017). Additionally, Korpela (1989) argues that place identity is partly formed by processes of emotion- and self-regulation. For example, the ability to reflect in one's favorite place can help maintain one's sense of coherence and self-esteem, which, in turn, can enable the place to have restorative qualities (Korpela & Hartig, 1996). Further research should aim to assess to what extent attachment or familiarity with the coast generates this representation of safe haven and/or whether there are other mechanisms at play.

One example of such a mechanism could be the opportunity to be alone. Most urban cities in Belgium do not have natural spaces that offer the same level of openness such as the coast. In exception to during summertime, the vastness of the coast therefore allows one to be alone, or to the very least, feel alone. Being alone at the coast was appreciated by most of the participants and appeared to facilitate emotional restoration and emotion regulating strategies. The limited presence of other people most likely enables participants to focus their attention to their natural surroundings and/or to themselves.

Limitations, future directions, and implications

The present study was conducted with the use of the well-validated approach of interpretative phenomenological analysis, that enabled us to explore the lived emotional experience generated at the coast for coastal residents. There are nonetheless certain limitations present in the study. The first limitation arises from implementing the interviews via videoconferencing and not physically face to face. This sometimes led to technical hiccups, which possibly formed miscommunications. Additionally, videoconferencing created a different interview atmosphere, in which, on the one hand, some participants potentially had more difficulty opening up and building a relationship of trust with the interviewer. On the other hand, for other participants, this may have facilitated vulnerable exposure due to the psychological distance created by an online interview (Roesler, 2017).

Furthermore, in exception to Noa, our sample consisted of participants that were students or were permanently employed, indicating a minimum amount of socioeconomic stability. Although our participants expressed a number of stressors in their lives, it would be interesting to analyze how groups that undergo a higher degree of stress, such as patients in a rehabilitation center, or individuals with a lower socioeconomic status, experience their emotions at the coast. Although the association between coastal proximity and mental health is shown to be stronger for those with low household income (Garrett et al., 2019), the mediating role of emotional factors for this group remains unknown.

Nonetheless, two of our participants are highly sensitive, with one of them having autism spectrum disorder. Recruiting participants with these characteristics was not intended but their experiences helped bring more insight to our analysis, in terms of the function of the coast in emotionally coping with such characteristics.

An important element that should also be taken into account is the contextual influence of the COVID-19 pandemic. During the time period of the interviews, Belgium was experiencing an intense second-wave of COVID-19 infections, along with a number of governmental measures such as closing of nonessential stores and restaurants, a curfew, and restricted social contacts. This second-wave seemed to particularly affect young adults as a series of health surveys demonstrated a rise in anxiety, depression, and dissatisfaction with life for those aged between 18 and 24 years old, compared to the first-wave of COVID-19 infections (Berete et al., 2020). The interpretation of our findings is therefore dependent on this context. For example, several participants expressed the negative impact of the pandemic on their daily routines, vacation jobs, and social interactions. In parallel, participants reported frequently visiting the coast during the lockdown. Considering the overall impact of the pandemic on mental health, it is possible that the prominence of engaging in emotion regulation at the coast was enhanced during this particular time period. Additionally, the pandemic enabled more opportunities to be alone, which perhaps reinforced the notion of the coast as a safe haven.

Finally, our findings cannot be generalized to the general population due to the qualitative focus on the subjective experience of our sample of young coastal residents. Nonetheless, our findings represent various hypotheses that should be tested with quantitative methods, such as the elicitation of awe and nostalgia and the use of adaptive emotion regulating strategies at the coast. The interactions between these different emotional processes should also be further investigated.

In addition to these future directions, several theoretical and practical implications can be taken out from our findings. On a theoretical level, we can hypothesize that, due to their beneficial nature, the stated emotions and related emotion regulating strategies elicited by the coast may play a positive role on the well-being of our participants. This could thus indicate an indirect relationship between the coast and well-being. Moreover, our findings demonstrate that coastal residents can experience similar emotional processes as coastal visitors/ tourists, such as the emotions of awe and nostalgia. However, the feeling of safety at the coast is perhaps unique to coastal residents, due to their familiarity with the coast. Our study therefore enriches the literature with a specific look into emotional mechanisms in the relationship between the coast and well-being for coastal residents.

On a practical level, we suggest that we aim to preserve the factors that facilitate the beneficial emotional experiences highlighted in our study. For example, we should promote physical activity at the coast, such as watersports, that enable experiences of peak flow or emotional restoration. We should also promote social interactions but only to a reasonable extent. Based on our interviews, experiencing nostalgia was partly dependent on important social memories created at the coast; however, the opportunity to be alone was also associated with various adaptive emotion regulating strategies. Additionally, mass tourism during the summer has a negative impact on the coast's restorative qualities. Efforts should therefore be made to limit overcrowding, such as optimizing spatial distribution (Basterretxea-Iribar et al., 2019) or instating reservation systems to access the beach. The emotion of awe also depends on natural characteristics such as openness and aesthetic beauty; these elements should therefore be safeguarded, such as by reducing littering at the coast.

Finally, investigating the role of emotional processes triggered by the coast on well-being can bring insight into possible solutions in the prevention of psychological distress and support of mental health. Developing the use of mindfulness at the coast with the elicitation of awe could for example potentially benefit coping with burnout or mood disorders or even other conditions undermining people's well-being. Furthermore, the findings represented in our study could lead to important opportunities for contexts other than mental health. For example, the emotional and restorative experience of the coast could be recalled and utilized to promote training of emotional intelligence. In short, emotional intelligence skills can be divided into four abilities, namely the ability to perceive emotions, to use emotions to facilitate thought, to understand emotions, and to manage emotions (Mayer et al., 2004). Developing these skills has been found to positively affect academic performance, social interactions, and organizational behavior (Mayer et al., 2004). Young adults could particularly benefit from these skills, considering that they experience important transitions within these educational, social, and work contexts (Arnett et al., 2014).

Conclusion

The present study demonstrates that young coastal residents can experience complex emotional processes at the coast, namely the ambivalent emotions of awe and nostalgia, as well as emotional restoration. These emotions appear to be facilitated by the coast's multisensory and symbolic qualities. Furthermore, the coast is featured as a safe place that allows participants to engage in adaptive emotion regulating strategies and to distance themselves from daily life stressors. These findings indicate a potential benefit of these emotional processes on the well-being of our participants. We therefore argue

that the emotional mechanisms highlighted in our study should be considered as possible contributors to the coast's therapeutic potential, alongside the putative physical, social, and cognitive mechanisms.

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Chapter 3

Effects of the Coast on Emotions, Well-Being, and Pro-Environmental Attitudes and Behaviors¹

Abstract

Contact with coastal landscapes has beneficial effects on well-being and environmental engagement. However, experimental analysis of these effects and their underlying emotional mechanisms remains limited. We present two preregistered studies (Study 1: $N = 248$; Study 2: $N = 494$) that evaluated effects of virtual exposure to coastal landscapes (vs. urban landscape) on stress, meaning-focused coping, and pro-environmental attitudes and behaviors. Awe (characterized by feelings of small self), nostalgia, and nature connectedness were investigated as potential mediators. In both studies, coastal landscapes led to higher stress reduction, and higher small self, nostalgia, and nature connectedness. Nostalgia and nature connectedness were significant mediators in Study 2. No significant effects on meaning-focused coping nor pro-environmental attitudes and behaviors were found. Situational (i.e. presence of litter) and individual factors (i.e. income level) were assessed as potential moderators, with Study 1 finding no significant moderation of litter and Study 2 revealing a moderated mediation effect of income. The gathered evidence underscores valuable emotional processes that should be further utilized within nature-based interventions.

¹ Based on Severin, M.I., Pauwels, L., Verheye, J., Loeyts, T., Everaert, G., Buysse, A., & Raes, F. (2024). Effects of the coast on emotions, well-being, and pro-environmental attitudes and behaviors. [Manuscript under review]

Introduction

Blue spaces, especially coastal landscapes, have been demonstrated to significantly enhance health and well-being (Britton et al., 2020; Hooyberg et al., 2020; White et al., 2021). Several mechanisms explaining this contribution have been suggested, primarily within the domains of physical activity, social interactions, restoration, and environmental factors (Elliott et al., 2023; Georgiou et al., 2021). One domain that has received limited research attention pertains to emotional processes. Although studies have looked at the effect of blue spaces on positive and negative affect (e.g., MacKerron & Mourato, 2013; Vert et al., 2020), few studies have evaluated specific, more complex, emotions. Research on emotional processes in blue spaces has hitherto primarily taken a qualitative approach (Bell et al., 2015; Jarratt & Sharpley, 2017; Severin et al., 2022), resulting in a notable absence of quantitative analysis, contrary to research pertaining to green spaces. A multitude of studies have examined the effects of green spaces on positive and negative affect (McMahan & Estes, 2015), as well as on specific emotional states such as awe (Lopes et al., 2020) and nature connectedness (Samus et al., 2022). Investigating emotional processes triggered by coastal landscapes and their impact on well-being is primordial to further comprehend and use the benefits of the coast, such as facilitating its inclusion in therapeutic settings. Reinforcing these emotional processes may also further support connection and engagement with coastal landscapes and encourage place-protective action (Kearns & Collins, 2012). The present paper therefore aims to investigate specific emotional mechanisms underlying the effect of coastal landscapes on well-being and on pro-environmental attitudes and behaviors (PEABs), with two experimental studies. We focus on the emotional states of awe and feelings of small self, nostalgia, and nature connectedness and delineate well-being as stress and adaptive coping.

Studies have demonstrated that exposure to coastal landscapes can reduce both subjective and physiological stress, even more so than green spaces (Hooyberg et al., 2023; White et al., 2013). Beyond reducing stress, natural environments have been demonstrated to foster adaptive coping with challenging and stressful situations, including enhancing the ability to reflect on a life problem (Mayer et al., 2009). Within the broader framework of coping, natural environments are also considered to facilitate emotion regulation (Johnsen, 2011), which can thereby predict restorative outcomes (Johnsen, 2013). A study by Korpela et al. (2018) introduces the term “environmental strategies”, which refers to “the use of specific socio-physical settings and their experiential contents as a common means of affect and stress regulation” (p. 2). The perceived efficacy of environmental strategies was found to be positively related to perceived health and life satisfaction in regulating sadness (Korpela et al., 2018). Coastal landscapes in particular also appear to support adaptive emotion-regulating strategies such as cognitive reappraisal, emotional

exteriorization, and mindful awareness, in young coastal residents. For instance, the coast can function as an outlet in which one can exteriorize one's anger or sadness (Severin et al., 2022). Regarding PEABs, research has indicated a positive effect of nature exposure. A narrative review revealed a positive association between the time spent in nature and PEABs (Deville et al., 2021). Visiting nature has also been positively linked with household pro-environmental behaviors (Martin et al., 2020) and watching a nature video has led to higher sustainable intentions and behavior (Zelenski et al., 2015). Moreover, coastal (vs. inland) residents are more inclined to report pro-environmental behaviors (Alcock et al., 2020), exhibit greater belief in climate change, and express greater support for government regulation of carbon emissions (Milfont et al., 2014).

There is thus considerable research on the effect of nature on well-being and PEABs. However, the scarcity of causal experimental analysis of these effects for coastal landscapes is precisely what we wanted to address with the present studies. Additionally, the benefits of exposure to coastal landscapes is dependent on several situational and individual factors, such as water quality, weather, cultural context, age, gender, and ethnicity (Garrett et al., 2023; White et al., 2020). In our studies, we will investigate two potential moderators of the beneficial effect of the coast, i.e., presence of litter (situational factor) and income level (individual factor). Very few studies have evaluated to what extent litter, specifically plastic, can modulate coastal effects. In Wyles et al. (2016), littered coastal landscapes were linked with lower restorative quality and negative emotions. Nonetheless, participants reported behavioral intentions to actively deal with the litter by removing it. Perceiving litter at the coast might weaken the received well-being benefits but also evoke a stronger desire to protect and preserve the affected environment. In terms of income level, positive effects of the coast appear to be reinforced for people with low income (Garrett et al., 2019; Wheeler et al., 2012). These findings can be framed within the equigenesis theory, which states that natural environments reduce health inequalities by containing health-promoting characteristics that help build resilience (Mitchell & Popham, 2008; Wheeler et al., 2015). Moreover, low socio-economic status has been linked with a higher tendency to experience awe, nostalgia, and nature connectedness (Hepper et al., 2020; Piff & Moskowitz, 2018; Richardson et al., 2022). Perhaps people with low-income experience these emotions more intensely when at the coast, offering an additional pathway through which coastal landscapes can yield benefits for low-income individuals.

Emotional mechanisms

The present paper focuses on three emotional states that are potential mediators of the effect of coastal landscapes on well-being and pro-environmental attitudes and behaviors, i.e., awe, nostalgia, and nature connectedness.

An increasing amount of studies demonstrate the prominence of experiencing awe in natural environments (Anderson et al., 2018; Ballew & Omoto, 2018). Awe typically arises whenever one perceives something as larger than the self, and is accompanied with a need to update one's mental schemas (Keltner & Haidt, 2003). The coast has been described as an awe-inspiring place due to its vastness, beauty, and grandeur (Jarratt & Sharpley, 2017; Pearce et al., 2017; Severin et al., 2022). Moreover, experiencing awe leads to numerous outcomes that benefit well-being, such as a reduction in stress and boredom and an increase in life satisfaction (Bai et al., 2021; Rudd et al., 2012; Severin et al., 2021). A potential pathway underlying these effects is through a diminished sense of self (Monroy & Keltner, 2023). Research indicates that awe can prompt a shift in attention towards larger entities and reduce the significance of one's personal concerns and goals, which, in turn, facilitates a broader perspective on things (Piff et al., 2015; Bai et al., 2021). Awe also appears to benefit pro-environmental behaviors (Chirico et al., 2023; Yang et al., 2018), an effect mediated by feelings of small self (Kaplan et al., 2023) and explained by awe's self-transcendent nature (Zelenski & Desrochers, 2021).

Defined as a sentimental yearning for the past, nostalgia is experienced as a mix of sadness and happiness (Leunissen, 2023). The role of nostalgia in nature has been largely neglected, although a recent study found that adding natural sounds to virtual nature exposure increased the emotions of awe and nostalgia (Smalley et al., 2023). Nostalgic memories are often centered around social interactions (Wildschut et al., 2006), and coastal landscapes are places where important social memories are made throughout one's life (Ashbullby et al., 2013; Severin et al., 2022). Moreover, the coast offers a multitude of sensory stimuli that can elicit nostalgia such as its particular scent (Reid et al., 2015), its aspect of timelessness (Jarratt & Gammon, 2016), and its unique phenomena (Severin et al., 2022). Nostalgia is shown to increase both hedonic and eudaimonic well-being, as well as act as a psychological resource that mitigates against threats to well-being (Hepper & Dennis, 2023). Although a study found that nostalgia can increase recycling intentions and behavior (Zhang et al., 2021), little is known about the extent to which it affects PEABs. Nostalgia has been linked with place attachment (Scannell & Gifford, 2017), which has a moderate positive effect on pro-environmental behavior (Daryanto & Song, 2021).

Importantly, both awe and nostalgia are emotions that potentially boost efficient coping due to their ambivalent nature (Braniecka et al., 2014). According to Larsen et al. (2003), experiencing positive and negative affect simultaneously (i.e. "taking the good with the bad") enables an individual to confront

adversity and to transform it into an advantage via meaning-making processes. In Study 1, we investigate meaning-focused coping, which consists of appraisal-based efforts to find coherence and meaning in a given situation (Park & Folkman, 1997), such as through positive reframing (Riley & Park, 2014). Considering the role of awe in focusing on the “bigger picture” (Piff et al., 2015) and the role of nostalgia in redemptive narratives (Wildschut et al., 2006), we suggest that both emotions can be positively linked with meaning-focused coping. Moreover, in Study 2, we sought to explore whether exposure to coastal landscapes (vs. an urban landscape) led to a more expanded time perception. Studies have found that nature exposure can lengthen subjective time perception (Berry et al., 2015; Davydenko & Peetz, 2017) and coastal landscapes have been described as inducing a sense of “timelessness” (Jarratt & Gammon, 2016; Severin et al., 2022). Both awe and nostalgia appear to influence time perception, as experiencing awe can increase perceived time availability (Rudd et al., 2012) and nostalgia can buffer perceptions of limited time (Hepper et al., 2020).

Conceptualized on both a trait and state level, nature connectedness is characterized by emotional and cognitive bonds to the natural world. An extensive amount of studies have shown an increase in state nature connectedness during nature exposure (Barragan-Jason et al., 2022), with visits to coastal landscapes linked with greater nature connectedness than visits to urban green spaces (Wyles et al., 2019). In a systematic review, Barragan-Jason et al. (2023) demonstrate a positive impact of nature connectedness on pro-environmental values and behaviors and found a positive correlation with mental and physical health. Experiencing nature connectedness also partially mediated the effect of nature exposure on positive affect and the ability to reflect on a life problem (Mayer et al., 2009).

Study 1

In Study 1, we investigated whether exposure to coastal landscapes (vs. an urban landscape) leads to higher stress reduction, a higher likelihood to adopt a meaning-focused coping style, and higher pro-environmental attitudes. Furthermore, we aimed to evaluate whether the emotional states of awe and feelings of small self, nostalgia, and nature connectedness positively mediate these effects of coastal landscapes, as well as whether the presence of litter (specifically plastic) moderates these effects. We used an online experimental design with six conditions that differed on two factors, namely environment type and presence of plastic. Participants were randomly assigned to watch a video-clip of either: (1) a beach with a sunset, (2) coastal dunes, or (3) an urban street. Each video-clip either contained plastic or not. We used two different types of coastal landscapes to assess whether the mediation of awe would be stronger for the sunset condition (vs. dunes), as sunsets are shown to be more awe-inspiring than blue-

skies (Smalley & White, 2023). Before watching the video-clip, participants were asked to recall a stressful moment and report their stress level. After watching the video-clip, participants again reported their stress level, as well as the emotions they felt while watching the video-clip, how they would cope if they were confronted again with the stressful moment, and their level of pro-environmental attitudes.

Methods

The study's experimental design and data analysis plan were preregistered in the Open Science Framework (OSF) registry prior to data collection (<https://osf.io/qwkvc>).

Participants

Based on a power analysis to detect medium effect sizes with .80 power, using the *pwr* package in R, our preregistered sample size was set to $N = 210$. A total of 251 first-year psychology students completed the online experiment, resulting in about 40 participants per condition. Three participants were excluded due to scoring either one or two on a 5-point Likert scale asking to what extent participants followed instructions. The majority of participants identified as women (82.7%), were 18 years old (65.7%; $M = 18.97$, $SD = 2.93$), and graduated from general secondary school (91.1%).

Measures

All scales included in the study were in Dutch, either translated with the use of independent back-translation or were empirically validated translations. The survey was administered on the Limesurvey platform (Limesurvey GmbH) and is open access (<https://osf.io/xkz5n>).

Covariates. At the beginning of the survey, we measured several variables that potentially needed to be controlled for, in order to assess the unique effect of environment type and/or plastic. Included variables were: age, gender, educational attainment, subjective health, dispositional awe and nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty. More detail concerning the measurement of these covariates can be found in Supplementary Materials (Table S1).

Manipulated variables. To increase participants' pre-stress level, participants were asked to mentally visualize a recent stressful moment for one minute. Participants had to concentrate on the feelings of stress they experienced in their body and mind. We then evaluated their mental visualization with three statements that had to be rated on a scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*): "I had the feeling I was mentally reliving this moment", "I visualized the moment in great detail", and "I saw the moment as it truly happened" ($\alpha = .66$).

The video-clips were recorded with a Canon EOS60D in automatic settings, set on a tripod. The video-clips of the coastal landscapes were recorded at a beach in De Haan, Belgium and those of the urban landscape were recorded at a street in Ghent, Belgium (**Figure 1**). For the video-clips where plastic was present, ten plastic items (e.g., plastic bottles, cans, industrial packaging) were randomly spread out across the landscape. Each video-clip was two minutes-and-a-half long and included audio to enhance immersion. The video-clips are open access (<https://osf.io/bsfdx/>).

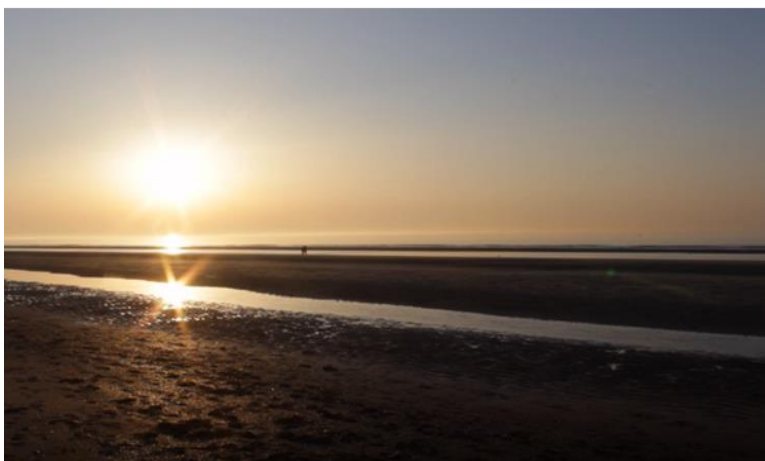
Potentially mediating emotional states. Feelings of small self was measured with five items representing small self as a sense of vastness vis-à-vis the self (e.g., “I feel the presence of something greater than myself”) and five items showcasing small self as a sense of self-diminishment (e.g., “I feel insignificant in the grand scheme of things”; Piff et al., 2015). The items were rated on a scale from 1 (*strongly disagree*) to 7 (*completely agree*) and displayed excellent reliability ($\alpha = .93$). Considering the high correlation between awe and small self in our sample ($r = .42$), we decided to solely consider feelings of small self as a potential mediator. A single-item was used to measure awe and nostalgia, in which participants rated to what extent they experienced these emotions while watching the video, on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*). The emotions of amusement, fear, gratitude, compassion, sadness, contentment, pride, and relaxation were included in the list as filler items. For state nature connectedness, we employed the state version of the Connectedness to Nature Scale (CNS; Mayer et al., 2009), consisting of 13 items (e.g., “Right now, I’m feeling a sense of oneness with the natural world around me”), rated on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*). The items presented good reliability ($\alpha = .87$).

Outcomes. To measure stress reduction, participants reported their subjective stress level before and after watching the video-clip, on a scale ranging from 1 (*not stressed at all*) to 10 (*very stressed*), with 5 labelled as *moderate*. Stress reduction was computed as the difference between pre-stress and post-stress. For meaning-focused coping, participants were asked to think back to the stressful moment they had previously mentally visualized and evaluate how they would react if they would be confronted with that moment again. We used the brief COPE inventory (Carver, 1997) to assess coping styles and combined the two items related to positive reframing (e.g., “I try to see it in a different light, to make it seem more positive”) and the two items related to acceptance (e.g., “I accept the reality of the fact that it has happened”), to create a measure of meaning-focused coping (Riley & Park, 2014). Items were rated on a scale from 1 (*I wouldn’t do this at all*) to 4 (*I would do this a lot*) and the aggregated index had acceptable reliability ($\alpha = .66$). To measure pro-environmental attitudes, we used the abbreviated New Ecological Paradigm scale (NEP; Cordano et al., 2003; Dunlap et al., 2000). The scale contains eight items (e.g., “When

humans interfere with nature it often produces disastrous consequences”), rated on scale from 1 (*strongly disagree*) to 7 (*strongly agree*), and showed acceptable reliability ($\alpha = .79$).

Figure 1

Screenshots of the Video-Clips of the Urban Landscape (top image), the Coastal Landscape with Dunes Including Plastic (middle image), and the Coastal Landscape with a Sunset (bottom image)



Procedure

Participants were recruited on a voluntary basis via the participant pool of the Faculty of Psychology and Educational Sciences of KU Leuven, Belgium. The study's aim was advertised as investigating individual reactions to the environment. Upon opening the link to the online experiment, participants gave their informed consent. The survey typically took 20 minutes to complete and compensation was provided through university credits. Participants were thanked and debriefed if desired. The study was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University with protocol number 2020/76.

Statistical Analysis

The effect of environment type and plastic on meaning-focused coping and pro-environmental attitudes was tested with two-way ANCOVA models, as pre-registered. Only covariates that were linearly related to the dependent variable and that did not violate the homogeneity of regression slopes assumption were included in the analysis. Due to the low variability in terms of age, gender, and education, we did not include these socio-demographic variables as potential covariates. To test whether small self, nostalgia, and nature connectedness influenced meaning-focused coping and pro-environmental attitudes, we used one-tailed Pearson correlations, as pre-registered.

For the outcome of stress reduction, we assessed the total effect of environment type on stress reduction and then employed a structural equation modeling approach to look further into mediation and moderation effects. We first conducted a basic mediation model to test for mediation of small self, nostalgia, and nature connectedness in the effect of coastal landscapes on stress reduction. We then conducted four moderated mediation models in which moderation of plastic for each pathway was tested (the fourth model tested for simultaneous moderation in all pathways). We utilized the *lavaan* package (Rosseel, 2012) in R, with maximum likelihood estimation and a bootstrap sample of size 5000 to obtain confidence intervals. Covariates that had a significant effect on either stress reduction or any of the potential mediators were included in the models. Environment type was dummy coded and “urban landscape” was used as reference category. In contrast to what was preregistered, we chose to analyze the effects on stress reduction using structural equation modeling. This decision was made to maintain consistency in the chosen models throughout the paper and to facilitate a comparison of the results between Study 1 and Study 2. The results from the preregistered analyses regarding stress can be found in the Supplementary Materials (Tables S2 – S7). All pairwise comparisons are Bonferroni-corrected.

Results

We first checked for sufficient manipulation of the pre-stress levels. The mean pre-stress was above moderate ($M = 5.94$) and was higher than pre-stress levels found in similar experiments that did not manipulate stress beforehand ($M = 3.90$ in Hooyberg et al., 2023; $M = 3.77$ in Chapter 4). Results display a high level of mental visualization ($M = 3.52$), that positively correlated with the pre-stress levels ($r = .45$, $p < .001$). The better participants mentally visualized a past stressful moment, the higher their stress level before watching the video-clip. This is in line with what we can expect from a successful manipulation of pre-stress.

Mediators of the effect of coastal landscapes on stress reduction

A one-way ANCOVA displayed a significant total effect of environment type on stress reduction, $F(2, 240) = 5.75$, $p = .004$, partial $\eta^2 = .046$. Pairwise comparisons indicated higher stress reduction for coastal dunes ($M = 2.36$, $p = .017$) and for sunset ($M = 2.47$, $p = .007$), compared to the urban street ($M = 1.50$). Looking further into mediation effects, results of the path analysis indicated a non-significant direct effect of both coastal landscapes on stress reduction, while adjusting for subjective health, dispositional nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty. Both coastal landscapes had a significant positive effect on small self, nostalgia, and nature connectedness. In terms of the effect of the emotions on stress reduction, no significant effects were found. Overall mediation effects of small self, nostalgia, and nature connectedness were not observed (**Table 1**).

Moderated mediation models of plastic in the effect of coastal landscapes on stress reduction

The four moderated mediation models indicated that the presence of plastic did not significantly moderate the effect of environment type on the emotions (Model 1) nor stress reduction (Model 3). Plastic did not significantly moderate the effect of the emotions on stress reduction (Model 2), nor all three pathways simultaneously (Model 4; see Supplementary Table S8). Chi-squared difference tests comparing the first three moderated mediations models with the basic mediation model did not show a better fit of the moderated mediation models for the data (**Table 2**).

Effect of coastal landscapes and plastic on meaning-focused coping and pro-environmental attitudes

Adjusting for dispositional awe, dispositional nostalgia, and meaning in life, the interaction between environment type and plastic on meaning-focused coping was not significant, $F(2, 239) = 0.55$, $p = .577$. Main effects of environment type, $F(2, 239) = 1.77$, $p = .172$, and plastic, $F(1, 239) = 0.92$, $p = .338$, on meaning-focused coping were also non-significant. Regarding pro-environmental attitudes, when adjusting for subjective health, dispositional awe, engagement with natural beauty, and trait nature connectedness, the interaction between environment type and plastic was not significant, $F(2, 238) =$

0.45, $p = .641$. Main effects of environment type, $F(2, 238) = 1.36$, $p = .259$, and plastic, $F(1, 238) = 1.12$, $p = .29$, on pro-environmental attitudes were also non-significant.

Table 1

SEM Mediation Model of Small Self, Nostalgia, and Nature Connectedness in the Effect of Coastal Landscapes on Stress Reduction, with Urban Landscape as Reference

Outcome	Predictor	Effects Pathway	Estimate ^a	SE	95% CI
Stress reduction ^b	Coastal dunes	direct	0.510	0.35	[-0.186, 1.196]
		indirect via small self	0.175	0.13	[-0.046, 0.441]
		indirect via nostalgia	0.215	0.19	[-0.132, 0.580]
		indirect via nature connectedness	-0.041	0.11	[-0.265, 0.176]
	Beach with sunset	direct	0.609	0.37	[-0.108, 1.318]
		indirect via small self	0.187	0.14	[-0.047, 0.480]
		indirect via nostalgia	0.210	0.18	[-0.129, 0.569]
		indirect via nature connectedness	-0.037	0.10	[-0.252, 0.159]
	Small self	direct	0.218	0.14	[-0.059, 0.490]
	Nostalgia	direct	0.094	0.08	[-0.059, 0.253]
Nature connectedness	direct	-0.086	0.22	[-0.515, 0.364]	
Small self ^b	Coastal dunes	direct	0.804***	0.17	[0.463, 1.125]
	Beach with sunset	direct	0.859***	0.19	[0.486, 1.236]
Nostalgia ^b	Coastal dunes	direct	2.279***	0.22	[1.837, 2.717]
	Beach with sunset	direct	2.228***	0.25	[1.725, 2.714]
Nature connectedness ^b	Coastal dunes	direct	0.477***	0.12	[0.248, 0.715]
	Beach with sunset	direct	0.431**	0.13	[0.191, 0.685]

^a Unstandardized coefficients

^b Adjusted for subjective health, dispositional nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty

** $p < .01$

*** $p < .001$

Table 2*Chi-Square Difference Tests for the Basic Mediation Model versus the Moderated Mediation Models*

	χ^2 difference	df difference	<i>p</i>
Mediation model			
Vs. Model <i>a</i> -path moderation	6.220	6	.399
Vs. Model <i>b</i> -path moderation	5.545	3	.136
Vs. Model <i>c'</i> -path moderation	0.411	2	.814

Influence of emotions on meaning-focused coping and pro-environmental attitudes

Feelings of small self is shown to have a significant positive correlation with meaning-focused coping ($r = .11, p = .035$), but not with pro-environmental attitudes ($r = .04, p = .264$). Nostalgia did not significantly correlate with neither meaning-focused coping ($r = .06, p = .158$), nor pro-environmental attitudes ($r = .07, p = .119$). Nature connectedness is shown to have a significant positive correlation with meaning-focused coping ($r = .20, p < .001$) and with pro-environmental attitudes ($r = .17, p = .003$). Note that these correlations are one-tailed.

Discussion

Taken together, the results from Study 1 did not demonstrate a mediational role for small self, nostalgia, and nature connectedness in the effect of coastal landscapes on stress reduction. Although both coastal landscapes triggered these emotions, the experience of these emotions was not linked with a higher stress reduction. These findings could be due to a lack of statistical power. The preregistered sample size was based on a power analysis of an ANOVA model, to detect a significant total effect with six conditions, and not on a structural equation model to detect significant indirect effects.

Furthermore, the presence of plastic did not significantly moderate the effect of environment type on stress reduction, emotions, meaning-focused coping, and pro-environmental attitudes, nor did it affect the relationship between the emotions and stress reduction. This could be due to the plastic not being salient enough in the videos. To investigate this, we conducted a post-study in which 60 adults watched either the sunset video with plastic, the dunes video with plastic, or the urban video with plastic. Participants were then asked to rate to what extent did they notice the plastic, as well as other elements present or not present in the video, on a scale from 1 (*I did not notice it at all*) to 4 (*I noticed it a lot*). A Kruskal-Wallis test indicated a significant difference in the extent of noticing plastic between the videos,

$H(2) = 8.61, p = .014$. Participants who watched the dunes plastic video noticed significantly more the plastic ($M = 3.40$) than those who watched the sunset plastic video ($M = 2.45; p = .021$). From this we can infer that plastic was not salient enough in the sunset video, however the high mean scores for the dunes and urban videos ($M = 3.30$) implies a sufficient salience of plastic in these environments. The absence of a moderating effect of plastic on nature connectedness and pro-environmental attitudes is in line with findings from Menzel et al. (2023), in which neither nature connectedness nor plastic-related problem awareness, intentions and policy support were affected by presence of plastic during a forest walk.

Finally, exposure to both coastal landscapes did not significantly affect meaning-focused coping nor pro-environmental attitudes. These variables reflect moderately stable dispositions, therefore they might not be so easily influenced by virtual exposure (Kesenheimer & Greitemeyer, 2021; Mayer et al., 2009; Nielsen & Knardahl, 2014). In accordance with what we expected, meaning-focused coping was found to be positively correlated with small self and nature connectedness, constituting a novel finding in the literature. In contrast, nostalgia did not correlate with meaning-focused coping, although a potential relationship should be examined in further research. Pro-environmental attitudes positively correlated with nature connectedness as expected but did not correlate with small self nor nostalgia. We suggest that the link between small self, nostalgia and pro-environmental attitudes is more indirect and specific to certain contexts. For example, nostalgia could be associated with environmental concern solely towards a particular familiar place, through the process of place attachment.

Study 2

In Study 2, our objective was to replicate the experimental design of Study 1, but with a larger and more socio-demographically diverse participant group. Our specific focus was on low-income groups, aiming to investigate whether exposure to coastal landscapes results in greater stress reduction and increased pro-environmental behavior, compared to an urban landscape. Additionally, we sought to examine the potential mediating roles of small self, nostalgia, and nature connectedness in these effects. The effect of plastic litter was not investigated in this study. Therefore, participants were randomly assigned to one of three conditions that differed solely according to environment type (i.e. beach with a sunset, coastal dunes, or an urban street). The same set-up as in Study 1 was employed: participants recalled a stressful moment, reported their stress level, watched the video-clip, reported again their stress level, and reported the emotions they felt while watching the video-clip. Participants subsequently completed the Work for Environmental Protection Task that measured their pro-environmental behavior, unlike in Study 1 where we looked at pro-environmental attitudes. We chose pro-environmental behavior as an outcome

because, contrary to pro-environmental attitudes, several experimental studies have shown it can be affected by virtual nature exposure (Ibanez & Roussel, 2022). In this study we also explored whether exposure to coastal landscapes (vs. an urban landscape) leads to a more expanded time perception, as well as a stronger likelihood to be associated with certain emotion-regulating strategies.

Methods

The study's experimental design and data analysis plan were preregistered in the Open Science Framework (OSF) registry prior to data collection (<https://osf.io/89uja>).

Participants

A power analysis for structural equation modeling to detect a significant mediation effect with .80 power, using the *pwrSEM* rShiny app (Wang & Rhemtulla, 2021), determined a required sample size of 700 participants. Our preregistered sample size was set to $N = 500$ to be in line with cost effectiveness. A total of 531 adults living in Belgium took part in the online experiment, of which 37 were excluded due to scoring either one or two on a 5-point Likert scale asking to what extent participants followed instructions. The final sample size amounted to 494 participants ($n = 172$ in urban condition, $n = 158$ in dunes condition, $n = 164$ in sunset condition). The sample was well distributed in terms of age, gender, and educational attainment (**Figure 2**). In terms of income, 60.6% of participants can be considered to have low-income, as their individual income was less than €2000 net per month, which is on average equivalent to a gross income of €2650. This threshold was chosen as it represented 20% of full-time workers in Belgium in 2020 (*Salaires Mensuels Bruts Moyens | Statbel, 2022*). Additionally, the poverty line in 2020 was €1293 net per month for a person living alone. Almost all participants had Belgian ethnicity (95.3%) and were living inland (97.8%).

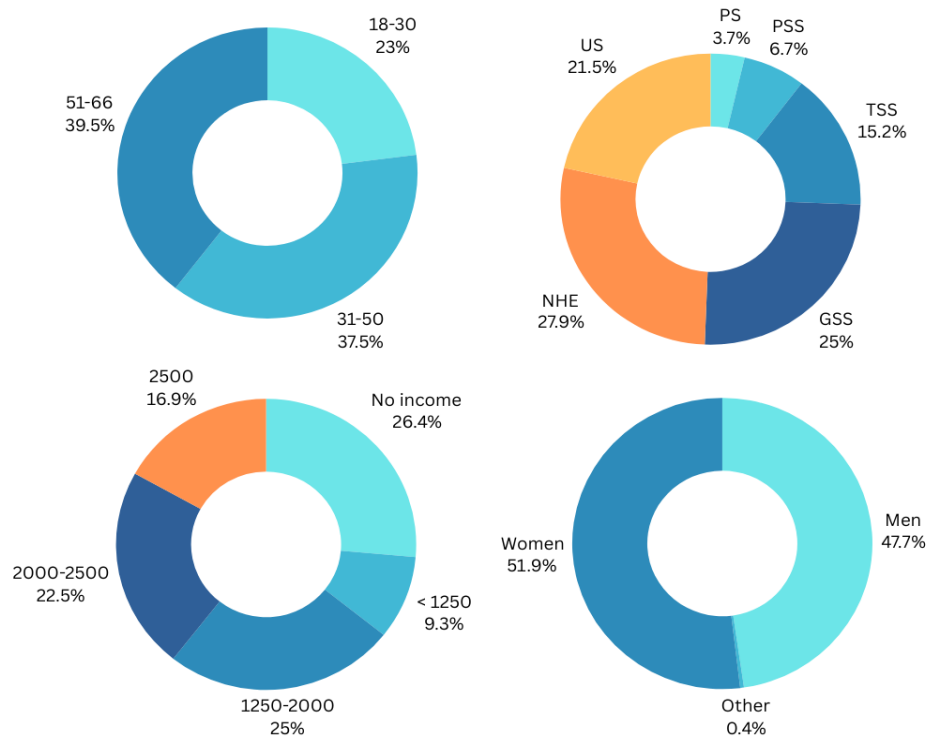
Measures

The majority of the measures were the same as in Study 1, with a few changes detailed here below. The survey was administered on the Qualtrics platform (Qualtrics XM) and is open access (<https://osf.io/6wa35>).

Additional covariates. Ethnicity, residential coastal proximity, and familiarity with the landscape were added as potential covariates. The scale used to measure dispositional nostalgia was changed to a shorter scale with three items, as we considered the original scale difficult to comprehend. More detail regarding the measurement of these additional covariates can be found in Supplementary Materials (Table S9).

Figure 2

Frequency Distribution of Age (top left), Educational Attainment (top right), Individual Income (bottom left), and Gender (bottom right)



Note. PS = primary school; PSS = professional secondary school; TSS = technical secondary school; GSS = general secondary school; NHE = non-university higher education; US = university school.

Pro-environmental behavior as an outcome. Pro-environmental behavior was measured with a behavioral paradigm called the Work for Environmental Protection Task (WEPT; Lange & Dewitte, 2022). The paradigm consisted of a number screening task, in which participants had to identify numbers with a first even digit and a second odd digit (e.g., “25” or “83”), amongst a row of 50 numbers. Participants were first presented with a familiarization trial. They were then informed that they could voluntarily complete up to eight pages of 50 numbers and that for each page completed, we would donate one tree (equivalent to €0.10) to an environmental organization (i.e., Eden Reforestation Project). Pro-environmental behavior was thus operationalized as the number of WEPT pages completed and reflected how much cognitive effort a participant was willing to make for an environmental cause. A WEPT page was considered completed when the amount of time a participant spent on the page was not more than two standard

deviations below the sample mean for that page (1% of completed pages were excluded based on this criterion). The WEPT is a reliable and valid tool to experimentally analyze pro-environmental behavior (Lange & Dewitte, 2023), and is uncorrelated with socioeconomic status (Bosshard et al., 2024). After the WEPT, we included two exploratory items measuring environmental concern, i.e. “Right now I want to do something to protect the environment” and “Right now I am very concerned about the environment”, rated on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

Exploratory variables. We used three items to measure subjective time perception, based on Repke et al. (2018): (1) How quickly has time seemed to pass since the study started? (scale from 1 = *time passed really slowly* to 7 = *time passed really quickly*), (2) How many minutes would you estimate have elapsed since the study started?, and (3) How does time feel for you at this moment? (scale from 1 = *time feels constricted* to 7 = *time feels expanded*). The reliability of the index of the three items was unacceptable ($\alpha = .005$), therefore the items were analyzed separately. Another exploratory variable was the extent to which participants considered coastal landscapes to be a place where they could engage in certain adaptive emotion-regulating strategies. To measure this, we created a scale with 12 items based on the emotion-regulating strategies that were reported in a qualitative study assessing how coastal residents experienced emotional processes at the coast (Severin et al., 2022). The scale reflected strategies such as reflection, acceptance, cognitive reappraisal, exteriorization, and mindful awareness (e.g., “The kind of environment I saw in the video is a place where I can let my feelings and emotions be as they are”). Items were rated on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*) and can be found in Supplementary Materials.

Procedure

Participants were recruited via an online citizen panel (i.e., Bpact) in which residents in Belgium can sign up and participate in studies in exchange for financial compensation. The advertisement of the study was targeted as much as possible to members earning a gross income of less than €2650 and/or having low educational attainment. After clicking the link to the online experiment, participants gave their informed consent. The survey typically lasted from 25 to 35 minutes, depending on how many trials of the WEPT the participant completed. Participants were compensated through Bpact and received a debriefing if desired. The study was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University with protocol number 2023-018A.

Statistical Analysis

As pre-registered, we employed structural equation modeling for path analysis to test the effects of environment type on stress reduction and pro-environmental behavior, as well as the mediation effects of feelings of small self, nostalgia, and nature connectedness. We utilized the *lavaan* package (Rosseel, 2012) in R, with maximum likelihood estimation and a bootstrap sample of size 5000 to obtain confidence intervals. Environment type was dummy coded and “urban landscape” was used as reference category. Covariates that had a significant effect on either the outcome variable or any of the potential mediators were included in the models. Due to the low variability in terms of ethnicity and residential coastal proximity, we did not include these socio-demographic variables as potential covariates. In order to include gender as a potential covariate, we had to make the variable binary, thereby excluding the two participants who chose “other” from the analysis. Familiarity with the landscape could not be included as a potential covariate as it was shown to significantly differ between the conditions and was thereby not independent of the experimental effect.

Results

We first checked if the manipulation of pre-stress levels was sufficient. Similar to Study 1, results show a high level of mental visualization of a past stressful moment ($M = 3.36$), that positively correlated with moderate pre-stress levels ($M = 5.06$; $r = .49$, $p < .001$), again in line with what we can expect from a successful manipulation of pre-stress.

Mediators of the effect of coastal landscapes on stress reduction and pro-environmental behavior

A one-way ANCOVA displayed a significant total effect of environment type on stress reduction, $F(2, 480) = 8.82$, $p < .001$, partial $\eta^2 = .035$. Pairwise comparisons indicated higher stress reduction for coastal dunes ($M = 1.70$, $p < .001$) and for sunset ($M = 1.60$, $p = .002$), compared to the urban street ($M = 0.78$). Adjusting for gender, dispositional nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty, results of the path analysis indicated a non-significant direct effect of both coastal landscapes on stress reduction. Both coastal landscapes had a significant positive effect on small self, nostalgia, and nature connectedness. Nostalgia and nature connectedness, but not small self, had significant positive effects on stress reduction. Nostalgia and nature connectedness were shown to fully mediate the effect of coastal landscapes on stress reduction² (**Table 3**).

² A post-hoc exploratory structural equation model including only small self as a mediator displayed significant mediation of small self in the effect of both coastal landscapes on stress reduction ($Estimate = 0.279$, $SE = 0.09$, $p = .002$ for dunes; $Estimate = 0.262$, $SE = 0.08$, $p = .001$ for sunset).

Table 3

SEM Mediation Model of Small Self, Nostalgia, and Nature Connectedness in the Effect of Coastal Landscapes on Stress Reduction, with Urban Landscape as Reference

Outcome	Predictor	Effects Pathway	Estimate ^a	Std. Error	95% CI
Stress reduction ^b	Coastal dunes	direct	0.112	0.27	[-0.427, 0.635]
		indirect via small self	-0.054	0.09	[-0.244, 0.139]
		indirect via nostalgia	0.317**	0.12	[0.089, 0.557]
		indirect via nature connectedness	0.536**	0.16	[0.224, 0.874]
	Beach with sunset	direct	0.054	0.28	[-0.495, 0.626]
		indirect via small self	-0.050	0.09	[-0.232, 0.132]
		indirect via nostalgia	0.335**	0.12	[0.096, 0.592]
		indirect via nature connectedness	0.485**	0.15	[0.206, 0.789]
	Small self	direct	-0.062	0.11	[-0.278, 0.155]
	Nostalgia	direct	0.172**	0.06	[0.050, 0.291]
	Nature connectedness	direct	0.423***	0.12	[0.183, 0.663]
	Small self ^b	Coastal dunes	direct	0.862***	0.14
Beach with sunset		direct	0.810***	0.14	[0.540, 1.088]
Nostalgia ^b	Coastal dunes	direct	1.840***	0.18	[1.499, 2.189]
	Beach with sunset	direct	1.945***	0.19	[1.577, 2.303]
Nature connectedness ^b	Coastal dunes	direct	1.267***	0.13	[1.007, 1.527]
	Beach with sunset	direct	1.147***	0.13	[0.893, 1.408]

^a Unstandardized coefficients

^b Adjusted for gender, dispositional nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty

** $p < .01$

*** $p < .001$

A total of 2410 WEPT pages were completed, thereby contributing to a donation of €241 to the Eden Reforestation Project. A one-way ANCOVA indicated that the total effect of environment type on WEPT performance was not significant, $F(2, 480) = 0.58, p = .558$. Path analysis displayed a non-significant

direct effect of both coastal landscapes on WEPT performance while adjusting for age, dispositional nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty. Neither of the three emotions significantly affected WEPT performance. Mediation effects were therefore not observed (**Table 4**). WEPT performance was shown to be significantly correlated with both items measuring environmental concern (item 1: $r = .20, p < .001$; item 2: $r = .11, p = .014$). However, these two items did not significantly differ between environment types either (item 1: $F(2, 491) = 0.37, p = .688$, item 2: $F(2, 491) = 0.42, p = .658$).

Table 4

SEM Mediation Model of Small Self, Nostalgia, and Nature Connectedness in the Effect of Coastal Landscapes on Pro-Environmental Behavior, with Urban Landscape as Reference

Outcome	Predictor	Effects Pathway	Estimate ^a	Std. Error	95% CI
WEPT performance ^b	Coastal dunes	direct	0.240	0.41	[-0.567, 1.047]
		indirect via small self	-0.145	0.16	[-0.476, 0.159]
		indirect via nostalgia	0.028	0.17	[-0.324, 0.379]
		indirect via nature connectedness	-0.233	0.25	[-0.725, 0.259]
	Beach with sunset	direct	-0.034	0.41	[-0.854, 0.756]
		indirect via small self	-0.137	0.15	[-0.442, 0.157]
		indirect via nostalgia	0.029	0.19	[-0.345, 0.401]
		indirect via nature connectedness	-0.212	0.23	[-0.654, 0.237]
	Small self	direct	-0.167	0.18	[-0.518, 0.178]
	Nostalgia	direct	0.015	0.09	[-0.181, 0.206]
	Nature connectedness	direct	-0.185	0.19	[-0.569, 0.204]

Note. WEPT = Work for Environmental Protection Task

^a Unstandardized coefficients

^b Adjusted for age, dispositional nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty

Exploratory analyses

One-way ANOVAs did not display significant differences between environment types for neither of the three items measuring time perception (Supplementary Table S11). To investigate the emotion-regulating strategies associated with the coast, we first looked at the internal consistency and reliability of our scale. Looking at responses from participants who watched the coastal videos, the scale presented excellent reliability ($\alpha = .93$). A principal component analysis indicated that one factor could be extracted, if item 3 (i.e., “The kind of environment I saw in the video is a place where I simply think of nothing”) were to be removed (see factor loadings in Supplementary Table S10). Furthermore, participants in the coastal conditions (vs. urban) reported significantly higher scores on all items ($p < .001$ for each item), with a higher overall mean of the emotion-regulating strategies scale ($p < .001$ for dunes and sunset). More detail can be found in the Supplementary Table S11.

We additionally explored whether individual net income moderated any of the mediation pathways of small self, nostalgia, and nature connectedness in the effect of environment type on stress reduction. We employed Model 59 from the PROCESS macro program in SPSS (Hayes, 2022) that simultaneously evaluates moderation of income in all three mediation pathways. Five covariates were included in the model, namely, gender, dispositional nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty. Results demonstrated no significant moderation of income in the *a-path* (effect of environment type on emotions) for neither emotion. Income was however found to moderate the *c'-path* (effect of environment type on stress reduction), $F(8, 444) = 2.38, p = .016$. For participants earning no income, the relative conditional direct effect of the sunset landscape on stress reduction is negative, compared to the urban landscape ($\beta = -1.542, p = .007$). In contrast, for participants earning between €1250 to €2000, the relative conditional direct effect of the coastal dunes landscape on stress reduction is positive, compared to the urban landscape ($\beta = 1.275, p = .020$). In terms of the *b-path* (effect of emotions on stress reduction), income is found to significantly interact with the emotion of nostalgia, $F(4, 444) = 3.24, p = .012$. Conditional effects show a significant positive effect of nostalgia on stress reduction for participants earning no income ($\beta = 0.480, p < .001$). Moreover, the findings revealed a significant moderated mediation effect of income wherein nostalgia positively mediated the effect of both coastal landscapes on stress reduction, only for participants earning no income. To summarize, among participants with no income, watching the coastal videos resulted in less stress reduction than watching the urban video. However, it was observed that the greater their experience of nostalgia while watching the coastal videos, the more their stress levels decreased. This indicates a potential buffering effect of nostalgia.

Discussion

In Study 2, nostalgia and nature connectedness, but not small self, are shown to positively mediate the effect of coastal landscapes on stress reduction. Although both coastal landscapes do trigger small self, this emotional state did not significantly affect stress reduction. Looking further into the correlations between small self and stress reduction for each environment type, we see a significant negative correlation in the group exposed to an urban landscape ($r = -.22, p = .004$), thereby potentially hindering the overall effect of small self on stress. This could reflect the negative side of small self, translated through feelings of powerlessness, that does not benefit well-being (Gordon et al., 2016). Furthermore, neither exposure to coastal landscapes nor the emotions affected pro-environmental behaviors. This might be attributed to limited variability in WEPT performance, as a large portion of participants completed the maximum number of pages (43.7%). The WEPT typically consists of 15 pages (Lange & Dewitte, 2022). However, in the interest of making our study as short as possible, we reduced the number of pages to eight. Another possibility could be that, akin to Study 1, virtual exposure is not sufficient to impact pro-environmental behaviors nor environmental concern. Indeed, in Lange & Truysens (2022), evidence of the effect of virtual nature exposure on WEPT performance is mixed.

Our exploratory analyses revealed that exposure to coastal landscapes (vs. an urban landscape) did not significantly lead to a more expanded time perception, similar to Repke et al. (2018). This could be due to the low reliability of the separate time perception items, in contrast to the measurement of time perception in other studies (e.g., Rudd et al., 2012). Moreover, exploratory analyses demonstrated that coastal landscapes were considered to be a place where one can engage in various adaptive emotion-regulating strategies, such as reflection, acceptance, cognitive reappraisal, exteriorization, and mindful awareness. Further research should experimentally test whether exposure to the coast can potentially facilitate the use of these strategies.

Finally, the exploratory analysis of moderation of income in the mediation pathways of small self, nostalgia, and nature connectedness in the effect of environment type on stress reduction revealed two important findings. First, the positive effect of exposure to coastal landscapes on stress reduction was not more pronounced for those with low income, and was even negative for those with no income. This is contradictory to the equigenesis theory but supports findings from recent studies that challenge the assumption that coastal exposure buffers income-related health inequalities (Elliott et al., 2023; Geiger et al., 2023). Nonetheless, we should note that income was assessed by individual income and not household income. It is possible that in the group with no income, a certain percentage still benefited from a moderate to high household income. A one-way ANOVA did however display a significant difference in

quality of life between income groups, $F(4, 478) = 3.29, p = .011$, with those with no income ($M = 4.86, p = .043$) and those earning less than €1250 ($M = 4.72, p = .029$) showing lower quality of life than those earning more than €2500 ($M = 5.24$).

The second main finding pertains to nostalgia potentially buffering against the negative effect of coastal exposure on stress reduction for those with no income. Considering that the majority of our sample were inland residents, we initially speculated that the participants with no income had less capabilities to frequently visit the coast. Watching the video-clip of the coast perhaps generated feelings of sadness which hindered stress reduction but these feelings might have been attenuated by nostalgic memories of the coast. In our sample, visit frequency to the coast did not differ between income groups, $F(4, 314) = 0.75, p = .556$. However, participants with no income did report higher feelings of sadness ($M = 2.60$) after being exposed to the coast, than participants earning more than €2500 ($M = 1.90$), with a marginally significant difference, $p = .056$. Further research should therefore investigate the emotional mechanisms underlying the moderation effect of income level on coastal benefits.

General Discussion

The present research aimed to assess specific emotional mechanisms in the effect of coastal landscapes on well-being and pro-environmental attitudes and behaviors (PEABs) with the use of two online experimental studies. Well-being was defined in terms of stress and adaptive coping. In both studies, participants were randomly assigned to watch a video-clip of either a beach with a sunset, coastal dunes, or an urban street. In Study 1, the sample consisted of first-year university students whereas Study 2 had a larger and more socio-demographically diverse sample.

Results from both studies demonstrated that exposure to both coastal landscapes (vs. an urban landscape) led to more stress reduction, further supporting the notion that the coast has restorative properties. Both studies also revealed a positive effect of coastal landscapes on experiencing feelings of small self, nostalgia, and nature connectedness, providing empirical evidence to the prominence of these emotional states in relation to the coast. In Study 1, neither small self, nostalgia, nor nature connectedness significantly mediated the effect of coastal landscapes on stress reduction. However, in Study 2, nostalgia and nature connectedness did emerge as significant mediators. This could potentially be due to a stronger statistical power in Study 2 or due to the different socio-demographic characteristics between the two studies. For instance, the benefits of nostalgia on stress reduction perhaps relied on specific socio-demographic traits, as the exploratory analysis in Study 2 indicated a positive effect of nostalgia on stress reduction only for those with no income, whereas in Study 1 no effect was found in a

relatively homogenous sample. In both studies, small self was not found to be a significant mediator. In Study 2, the effects of small self might have been overshadowed by nostalgia and nature connectedness, due to a possible overlap between the three emotional states.

In Study 1, exposure to coastal landscapes did not significantly lead to a higher likelihood to adopt meaning-focused coping, whereas in Study 2, coastal landscapes were considered to be a place where one can engage in various adaptive emotion-regulating strategies. Although meaning-focused coping and adaptive emotion-regulation are different constructs, there was considerable overlap in how they were measured. For instance, both included the strategy of acceptance, either towards a particular situation or towards one's emotions, and the strategy of reappraisal, either in the form of positive reframing or in the form of putting things into perspective. We can therefore argue that although a virtual exposure of the coast through the means of a video-clip was unable to affect meaning-focused coping, it is still possible that being at the coast in real life can facilitate adaptive coping towards a challenging situation or help regulate one's emotions, as shown in Severin et al. (2022). Regarding the emotions, both small self and nature connectedness, but not nostalgia, positively correlated with meaning-focused coping in Study 1, providing further support for their beneficial role in adaptive coping (Braniecka et al., 2014; Mayer et al., 2009).

Neither of the two studies found a significant effect of exposure to coastal landscapes on pro-environmental attitudes (Study 1) and behaviors (Study 2). In terms of pro-environmental attitudes, we suggest that the exposure was not immersive enough, as positive effects of nature have been demonstrated via real or virtual reality exposure (Chan et al., 2023; Deville et al., 2021). In Lange and Truysens (2022), it is suggested that the effect of virtual nature exposure on pro-environmental behaviors could be small and thus difficult to detect. Another possibility would be that exposure to virtual nature would have greater effects on pro-environmental behavior if the exposure represented destroyed nature (e.g. beach full with plastic), such as in Klein and Hilbig (2018) and Yu et al. (2023). There would need to be a strong salience of plastic however, as our results in Study 1 did not show a moderating effect of plastic on pro-environmental attitudes.

Based on previous studies (Smalley & White, 2023), we expected the video-clip of the beach with a sunset to generate more awe (and thereby small self) and to have stronger effects on stress due to its idyllic setting, compared to the video-clip of coastal dunes. Nonetheless, in both studies, coastal dunes had the same positive effects on stress reduction and emotions as the beach with a sunset. Coastal dunes also have high aesthetic appeal (Richardson & Nicholls, 2021) and therefore a stronger contrast might have been found between a beach with a sunset and a beach with a blue-sky.

Limitations, Future Directions, and Implications

The present studies enabled to experimentally test the effect of coastal landscapes on well-being and PEABs, as well as the emotional mechanisms of small self, nostalgia, and nature connectedness. Significant effects in Study 1 were replicated in a larger and more diverse sample in Study 2, thereby enhancing the generality of our findings.

Certain limitations are however to be noted. First, both studies were conducted online and thus not in a fully controlled setting. Although measures were taken to ensure that the participants followed instructions (e.g. for the video-clip, participants could only continue to the next page after a certain amount of time; participants who indicated that they did not follow instructions were excluded), we could not prevent possible distractions from the environment while participants completed the study. Nonetheless, participants may have felt more comfortable to experience emotions within their everyday setting, then in a laboratory. Second, single-item measures, which are considered to be more prone to measurement error, were used to assess subjective stress and nostalgia. Single-items are, however, shown to be in good agreement with multiple-item scales assessing mood and health (Verster et al., 2021), have been widely used to evaluate distinct emotions (Piff et al., 2015; Rudd et al., 2012), and can present greater face validity (Wanous et al., 1997). Third, the generality of our findings is constrained to the specific coastal landscapes shown in our video-clips, and we cannot exclude other particularities of the coast that potentially affect our measured outcomes in real life. Future research should evaluate the extent to which other contextual factors (e.g. presence of people, meteorological conditions, manmade elements such as windmill farms) can impact the emotional experiences triggered by the coast.

The results from this paper have several theoretical and practical implications. Study 2 presents a novel finding of nostalgia and nature connectedness mediating the effect of coastal landscapes on stress reduction, within an experimental framework. The importance of nature connectedness has been highlighted in previous work (Martin et al., 2020; Wyles et al., 2019), but few studies have investigated the role of nostalgia at the coast. This emotion is frequently experienced in daily life (Wildschut et al., 2006) and is beneficial for maintaining and restoring our well-being (Hepper & Dennis, 2023). Demonstrating that the coast triggers this emotion, which consequently reduces stress, provides a gateway to further understand how the coast enhances our well-being. Furthermore, our findings imply that it would be beneficial to utilize coastal landscapes as a way to optimize clinical interventions such as reminiscence-based interventions (Hallford et al., 2022). Another important finding from our studies is that coastal landscapes, with or without a sunset, can generate feelings of small self, a main characteristic of awe. Promoting these feelings of small self with the use of the coast in therapeutic settings is likely to

boost adaptive coping such as meaning-focused coping. Importantly, our findings also signify that for those who lack easy or feasible access to coastal areas, virtual exposure through a video-clip is effective in reducing stress and fostering valuable emotional states. Overall, the present paper showcases coastal landscapes as a strong contender for the implementation of nature-based therapies, providing support for ‘blue prescription programs’ (Alejandre et al., 2023).

In conclusion, the present study demonstrated nostalgia and nature connectedness as positive mediators in the effect of coastal landscapes on stress reduction. Our findings offer insight into the emotional processes that play a significant role in how the coast benefits well-being and should be further emphasized in future research.

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Chapter 4

Effect of Coastal Walks and Engagement Interventions on Well-Being and Pro-Environmental Behavior¹

Abstract

The present study assessed the effect of real-life exposure to a coastal (vs. urban) landscape on well-being and pro-environmental behavior, and compared differential effects of engagement interventions. Participants ($N = 77$; 22 – 78 years old) walked along the beach or in an urban street, and followed instructions according to a specific engagement level. Group differences were not significant, although effect sizes for worry reduction (highest in mind-wandering group) and increase of positive and low-arousal positive mood (highest in mindful engagement group) were small-to-medium, suggesting a need for replication with a larger sample size. Additional exploratory analyses revealed a stronger experience of awe, nature connectedness, and adaptive emotion-regulating strategies during mindful engagement. Our study highlights the need to consider under what conditions benefits from coastal exposure can be optimized.

¹ Based on Severin, M.I., Mertens, L., Gündüz, O., Van der Gucht, K., Everaert, G., Buysse, A., & Raes, F. (2024). Effect of coastal walks and engagement interventions on well-being and pro-environmental behavior. [Manuscript under review]

Introduction

The body of evidence supporting the positive impact of nature exposure on well-being and pro-environmental behaviors has consistently grown in recent years (World Health Organization, 2023; Rosa & Collado, 2019). The majority of the evidence stems from correlational research (e.g., Alcock et al., 2020; Garrett et al., 2019; Hooyberg et al., 2020; Martin et al., 2020; White et al., 2021). Experimental studies testing the effects of exposure to nature remain limited and typically focus on virtual, and not real-life, exposure (Hooyberg et al., 2023; Klein & Hilbig, 2018; Lange & Truyens, 2022; Tanja-Dijkstra et al., 2018). The aim of the present paper is to address this gap, with a specific focus on coastal landscapes. Although coastal landscapes are shown to have superior benefits on well-being in comparison to other blue or green space types (Garrett et al., 2023; MacKerron & Mourato, 2013), very few experimental studies assess real-life exposure effects of the coast. Although investigating real-life exposure presents methodological difficulties (e.g., issues of standardization and confounding factors), it would also boost the ecological validity of coastal benefits and it generally leads to greater effects on well-being compared to virtual exposure (Browning et al., 2020; Mayer et al., 2009). The current paper hereby presents an experimental study investigating the effects of real-life exposure to a coastal (vs. urban) landscape on well-being (characterized as stress, mood, and worry) and pro-environmental behavior.

To better understand the impact of exposure to coastal landscapes on well-being and pro-environmental behavior, research has explored individual and situational factors that may moderate these effects (Garrett et al., 2023; White et al., 2020). One factor that is increasingly prominent in the literature is the manner in which individuals interact or engage with the environment during exposure, whereby heightened engagement typically enhances the restorative outcomes of nature (Kaplan, 2001). Evaluating various engagement interventions that potentially strengthen the effects of coastal landscapes can enable to maximize the coast's therapeutic potential. An additional aim of this paper is therefore to examine differential effects of three types of engagement interventions, namely mindful engagement (Lymeus et al., 2018), mind-wandering (Macaulay et al., 2024), and distraction, during exposure to a coastal landscape on well-being and pro-environmental behavior.

Engagement interventions in nature

When evaluating how and why exposure to nature affects well-being and pro-environmental behavior, one must consider how the individual is experiencing the environment. A person could for example be fully attentive to their environment or the environment could merely be a backdrop to their inner thoughts and emotions. Manipulating an individual's engagement level with the environment has been

shown to influence the benefits experienced in terms of well-being (Korpela et al., 2017) and connection to nature (Lumber et al., 2017), which is a strong predictor of pro-environmental behavior (Barragan-Jason et al., 2023). For example, Duvall (2011) manipulated engagement through awareness-enhancing tasks such as focusing on sensory experiences or imagining the environment differently, which led to increased effects on mood and sustained attention.

More recently, researchers have begun to integrate principles of mindfulness as a form of engagement with nature. Being mindful involves being aware of the present moment and accepting without judgement one's thoughts, feelings, and sensations (Kabat-Zinn, 1990). Mindfulness is increasingly practiced in both non-clinical and clinical populations (Querstret et al., 2020; Sverre et al., 2023). Studies have shown that natural environments are conducive to mindful engagement (Brymer et al., 2021), and that a state of mindfulness mediates the effect of nature on positive mood and eudaimonic well-being (Stewart & Haaga, 2018). Building upon this, interventions that boost mindful engagement in nature induce a positive change in mood and an increase in nature connectedness, both in adults (Nisbet et al., 2019) and in children (Barrable et al., 2021). Three key mechanisms have been suggested to explain these effects, namely perceptual sensitivity, decentering, and non-reactivity (Macaulay et al., 2022b). Specific focus on coastal landscapes is more limited, although Severin et al. (2022) demonstrated that certain emotion-regulating strategies associated with the coast resembled components of mindfulness, such as acceptance, letting go, and increased awareness of the present moment.

An alternative form of engagement that has not received as much attention is mind-wandering. Mind-wandering has been typically conceived as task-unrelated and/or stimulus-independent thought (Smallwood & Schooler, 2015). Unlike rumination, whereby the content of thoughts tends to fixate upon a specific topic, thoughts can shift freely between topics during mind-wandering (Christoff et al., 2016). In terms of the effects on well-being, results have been mixed, with some studies showing a negative effect on mood (Killingsworth & Gilbert, 2010), while other studies display a positive effect on mood (Franklin et al., 2013), as well as on creativity (Baird et al., 2012). Seli et al. (2015) distinguish between spontaneous and deliberate mind-wandering, with the former being positively associated with depression, stress, and anxiety and the latter being negatively associated (Seli et al., 2019). Moreover, deliberate mind-wandering was found to be positively linked with a specific component of mindfulness (i.e., non-reactivity to internal experiences; Seli et al., 2015). Although mindfulness and mind-wandering are considered to be opposing constructs (Schooler et al., 2014), it is possible that mindfulness and deliberate mind-wandering may be complementary processes instead.

In the context of mind-wandering in natural environments, perhaps seeking out nature to deliberately mind-wander might enhance the environment's restorative outcomes (Macaulay et al., 2024). Williams et al. (2018) suggested that restoration may be reinforced by gently shifting between internal mind-wandering and external fascination with nature. This is supported by a recent study wherein instructing participants to intentionally engage in mind-wandering during an outdoor walk resulted in reduced negative affect (Macaulay et al., 2022a). With regards to coastal landscapes, participants in Severin et al. (2022) reported experiences that resemble mind-wandering such as getting lost in their thoughts, feeling cut off from the rest of the world, and reflecting on inner thoughts and emotions.

In consideration of these findings, we therefore suggest that inducing both mindful and mind-wandering processes through engagement interventions can enhance the effects of the coast on well-being. In terms of pro-environmental behavior, we can expect an enhancement through mindful engagement but not through mind-wandering. To our knowledge, there is no indication in the literature that mind-wandering could lead to a higher connection with nature or pro-environmental behavior.

Exploratory associations with emotions and emotion-regulating strategies

To understand why mindful engagement and mind-wandering might boost the effects of coastal landscapes on well-being and pro-environmental behavior, we investigate specific emotions that might be associated with these forms of engagement. In terms of mindful engagement, we can consider awe and nature connectedness. Experiencing awe leads to a reduced focus on the self (i.e. feelings of small self; Piff et al., 2015), which partly explains how awe benefits well-being (Monroy & Keltner, 2023). Being in a state of awe can be closely linked with mindfulness as one is typically engrossed in the moment and can experience a shift in perspective (Thompson, 2022). Nisbet et al. (2019) demonstrated a higher experience of awe after mindful engagement in a blue space, compared to mere exposure to that blue space. Moreover, nature connectedness is shown to positively mediate the effect of awe on pro-environmental behavior (Yang et al., 2018), as well as the influence of mindfulness and awe on climate change action (Wang et al., 2022).

Regarding mind-wandering, we examine the emotion of nostalgia as potentially having a positive association with this mental state. Nostalgia is defined as a sentimental yearning for the past and can function as a psychological resource by buffering against threats to well-being (Hepper & Dennis, 2023). Although mind-wandering is shown to be more frequently future-oriented (Cole & Kvavilashvili, 2019), there are indications that mind-wandering triggered by environmental stimuli is more likely to be past-

oriented (Maillet et al., 2017). We propose that reminiscence of past events during mind-wandering might evoke nostalgic feelings.

Research has demonstrated that awe, nostalgia, and nature connectedness can be associated with coastal landscapes (Jarratt & Gammon, 2016; Severin et al., 2022; Wyles et al., 2019), and that these emotions mediate the well-being benefits of the coast (Severin et al., under review) or nature in general (Anderson et al., 2018). We propose that mindful engagement in coastal landscapes might enhance effects on well-being and pro-environmental behavior due to a higher experience of awe and nature connectedness, and that mind-wandering at the coast might enhance effects on well-being due to a higher experience of nostalgia.

An additional factor worth investigating is the emotion-regulating strategies associated with mindful engagement and mind-wandering at the coast. To illustrate, Severin et al. (2022) found several emotion-regulating strategies linked with the coast, namely self-reflection, acceptance of emotions, awareness of present moment, putting stressors into perspective, letting go, clearing one's mind, feeling respite, and emotional exteriorization. Acceptance of emotions and awareness of present moment are core tenets of mindfulness (Chambers et al., 2009). Putting one's stressors into perspective and letting go can be seen as a form of decentering (Baer, 2009), through which psychological distance from one's thoughts and emotions is created. Regarding mind-wandering, deliberate mind-wandering is positively linked with self-reflection (Vannucci & Chiorri, 2018), whereby attending to one's inner thoughts and feelings might be beneficial to well-being in certain contexts (MacIsaac et al., 2023). Mindful engagement and mind-wandering at the coast might therefore enhance effects on well-being through adaptive emotion-regulating strategies.

Present Study

The present study aimed to investigate the effects of real-life exposure to a coastal (vs. urban) landscape on well-being and pro-environmental behavior, as well as compare the effects of various forms of engagement during exposure to a coastal landscape. In line with previous research testing the effects of real-life exposure in a blue space (e.g., Gidlow et al., 2016; Nicolosi et al., 2021; Vert et al., 2020), we conducted an experiment in which participants were asked to do a 20-minute guided walk in either an urban street or at a beach. Following the guidelines of Macaulay et al. (2022a) and Nisbet et al. (2019), we designed three types of engagement interventions to reflect diverse engagement levels. Participants doing the beach walk were instructed to either: (1) be mindful of their surroundings (mindful engagement), (2) let their mind wander (mind-wandering), or (3) engage in mental visualization exercises

(distraction). Participants walking in an urban street received the same instructions as the distraction group at the beach.

We used stratified block randomization to assign the participants to a group; participants were stratified according to whether they were a coastal or inland resident. Before and after the walk, participants reported their subjective stress, mood, and level of worry. After the walk, we measured pro-environmental behavior using a behavioral paradigm. We expected that walking at the beach (vs. an urban street) would lead to higher stress and worry reduction, a more positive change in mood, and higher pro-environmental behavior. We also expected that mindful engagement, mind-wandering, and distraction at the coast will have differential effects on stress and worry reduction, mood change, and pro-environmental behavior.

Furthermore, an exploratory aim of the study was to assess differences in awe (characterized by small self), nostalgia, nature connectedness, and emotion-regulating strategies between the four groups and to determine potential mediation of these variables in the effect of environment type and/or engagement level on stress, mood, worry, or pro-environmental behavior. These exploratory measures were assessed after the walk.

Methods

The study's experimental design and data analysis plan were preregistered in the Open Science Framework (OSF) registry before data collection (<https://osf.io/tseb4>).

Participants

Using the *pwr* package in R for the power analysis, the preregistered sample size was set to $N = 180$ to detect medium effect sizes with .80 power. Due to limited time availability and the requirements to be at a specific place, we recruited 82 adults from the general public. Five participants in the mindful engagement group were excluded as they stated having previously followed a mindfulness training. Our final sample size was $N = 77$, with about 20 participants per group. In our sample, 58.4% of participants identified as women and 35.1% identified as men (6.5% gave no response). The mean age was 53 years old (26% aged 22-35, 16.9% aged 36-59, and 50.6% aged 60-78). The largest educational attainment groups were those who graduated from non-university higher education (41.6%) and university school (27.3%). Within each group, there was 17 to 25% of participants who were inland residents and 75 to 83% who were coastal residents.

Measures

Participants completed three questionnaires. The first questionnaire (Q1), completed on average six days before the experiment, contained measurements of covariates. The second (Q2) and third (Q3) questionnaires, given right before and after the walk, measured the outcomes of stress, mood, and worry. Q2 and Q3 also included a measurement of attitudes towards car use, public transport use, and walking, taken from Kroesen and Chorus (2018), to act as a filler scale. The emotions of awe, nostalgia, and nature connectedness, as well as adaptive emotion-regulating strategies and pro-environmental behavior, were measured in Q3. In each questionnaire, participants were asked to compose a unique participant code, consisting of their birth month, followed by the first two letters of their first name and surname. This code enabled us to link the participant data from each questionnaire. The study was conducted in Dutch. We employed either empirically validated translations or translated the scales using independent back-translation. All questionnaires were administered on the Qualtrics platform (Qualtrics XM) and are open access (<https://osf.io/nka29>).

Covariates

The included variables that most likely affected the outcomes of well-being, pro-environmental behavior, and emotions, and that potentially needed to be controlled for, were: age, gender, educational attainment, subjective health, mindfulness skills, trait mind-wandering, trait repetitive negative thinking, dispositional awe and nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty (see Table S1 in Supplementary Materials for more detail).

Environment type and engagement level manipulation

Participants exposed to a coastal landscape walked at the Oosteroever beach in Ostend, Belgium. On the right side of the sandy beach there was a concrete walking path (although participants walked on the sand) and dunes with patches of vegetation (**Figure 1**). Participants exposed to an urban landscape walked along an avenue in Ostend. The avenue contained a tram-line, a wide double-sided road, and a walking path next to residential buildings. Although natural elements were avoided as much as possible, there was a line of trees next to the walking path. Maps illustrating the walking routes can be found in Supplementary Materials (Figure S1).

Instructions for mindful engagement and mind-wandering were developed based on previous engagement interventions conducted in natural environments (Nisbet et al., 2019; Macaulay et al., 2022a). Participants in the mindful engagement group were instructed to be aware of their surroundings and to curiously observe what they see, feel, hear, or smell in the present moment. They were encouraged to use the stimuli in the environment to bring their attention back to the here and now, if ever their

thoughts started to wander. Participants in the mind-wandering group were instructed to let their thoughts run free and to lose themselves in them. We specified that there was no need to focus on a particular aspect of the environment or on the present moment. Brief reminders of the instructions were given to participants every five minutes during the walk (**Figure 2**). For the distraction groups, we designed four neutral mental visualization exercises. Participants were asked to visualize themselves cooking a meal, everything they had done that day from the moment they woke up, everything they planned to do the rest of that day, and finally a journey that they regularly take in their daily life. A different exercise was given every five minutes during the walk (with the first one given when the walk started). All instructions designed for this study are open access (<https://osf.io/nka29>).

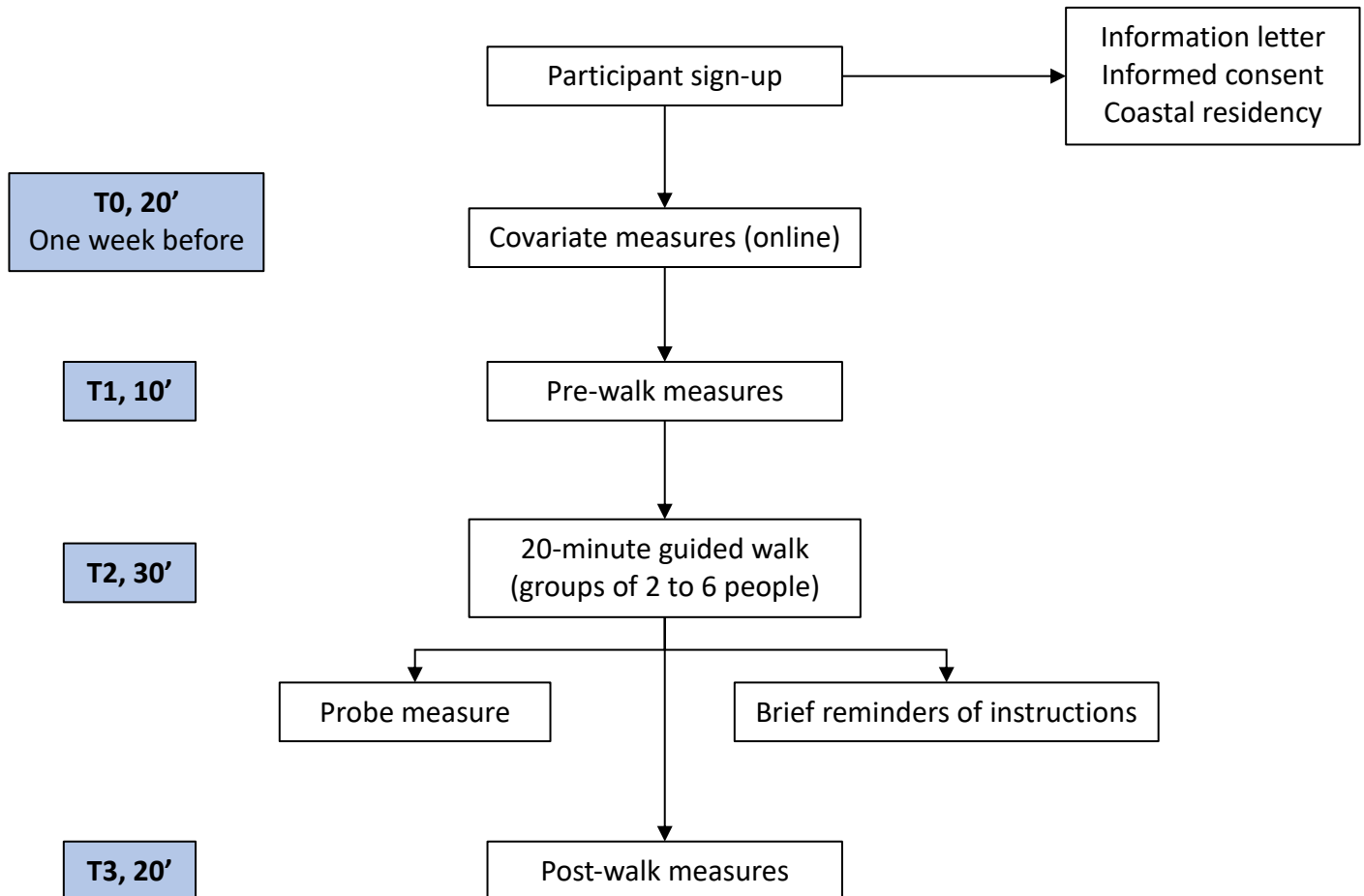
Figure 1

Pictures of the Exposed Urban Landscape (top image) and the Exposed Coastal Landscape (bottom image)



Figure 2

Flow Diagram of the Experiment, Including the Brief Reminders of the Instructions for each Engagement Level Group



Brief reminders of instructions:

- Distraction group:

e.g. *“Visualize everything you did today, from the moment you woke up to the moment you came to participate in this study. How did you wake up? Did you have breakfast? And if you had breakfast, what did you eat? How did you come here? Go through each step in detail.”*

- ” Mind-wandering group:

“Just let your mind wander. There is no need to focus on any particular aspect of your environment or on anything happening right now. Let your imagination run wild.”

- ” Mindful engagement group:

“Be aware of your surroundings and curiously observe with all your senses. If your thoughts start to wander, that's okay, just observe and gently bring your attention back to the here and now without judgement.”

Outcomes

Subjective stress was measured on a scale ranging from 1 (*not stressed at all*) to 10 (*very stressed*), with 5 labelled as *moderate*, in response to “How stressed are you right now?”. To evaluate mood, we used the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988; Engelen et al., 2006), that contains 10 positive mood adjectives (e.g. “excited”, “inspired”, “attentive”) and 10 negative mood adjectives (e.g., “distressed”, “irritable”, “jittery”), rated on a scale from 1 (*very slightly or not at all*) to 5 (*extremely*). The aggregated indexes for positive mood (pre-walk: $\alpha = .87$; post-walk: $\alpha = .93$) and negative mood (pre-walk: $\alpha = .82$; post-walk: $\alpha = .78$) presented good reliability. Four extra adjectives that represent low-arousal positive mood were added to the PANAS (i.e., “calm”, “relaxed”, “content”, “peaceful”; McManus et al., 2019) and showed good reliability (pre-walk: $\alpha = .83$; post-walk: $\alpha = .89$). Worry was assessed with a scale ranging from 1 (*not at all*) to 10 (*very*), with 5 labelled as *moderate*, in response to “In the past 5 minutes, to what extent were you worrying?”. Changes in stress, mood, and worry, were computed as the difference between the pre and post-measurements.

To measure pro-environmental behavior, we employed the Work for Environmental Protection Task (WEPT; Lange & Dewitte, 2022). In this behavioral paradigm, participants are presented with a number screening exercise, whereby they are requested to identify numbers with a first even digit and a second odd digit (e.g., “61” or “47”) from a series of 50 numbers. After a familiarization trial, participants are informed that they can continue the exercise on a voluntary basis and that for each completed page of 50 numbers (maximum of eight pages), we would donate one tree, equivalent to €0.10, to an environmental organization (Eden Reforestation Project). The number of completed WEPT pages represented how much cognitive effort a participant was willing to invest for an environmental cause. A WEPT page was deemed completed when the time spent by a participant on the page did not exceed two standard deviations below the sample mean (all completed pages passed this criterion).

Probe variable

To determine the level of attention towards the environment, participants had to rate to what extent they were paying attention to their surroundings, on a scale from 1 (*not at all*) to 10 (*very*), with 5 labelled as *moderate*. Participants were signaled every five minutes during the walk to answer the question on a flashcard. The variable was thus assessed at three specific timepoints and was measured in accordance with the probe-caught method, commonly used to collect mind-wandering data (Weinstein, 2018).

Exploratory variables

The emotion of awe, characterized by feelings of small self, was measured with ten items representing a sense of vastness vis-à-vis the self (e.g., “I feel the existence of things more powerful than myself”) and a sense of self-diminishment (e.g., “In the grand scheme of things, my own issues and concerns do not matter as much”; Piff et al., 2015). Participants rated these items on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*). The aggregated index presented excellent reliability ($\alpha = .91$). The emotion of nostalgia was embedded in a list of emotions (e.g. amusement, fear, compassion, pride, awe), that were measured on a scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*), in response to “During the walk, I experienced...”. State nature connectedness was assessed through the state version of the Connectedness to Nature Scale (CNS; Mayer et al., 2009), comprising of 12 items (e.g., “At the moment, I’m feeling that the natural world is a community to which I belong”). Items were rated on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*) and demonstrated excellent reliability ($\alpha = .94$).

To measure the extent to which participants engaged in adaptive emotion-regulating strategies during the walk, we utilized the 12-item scale developed in Chapter 3, with the removal of item 3 (“I simply think of nothing”), due to its low factor loading. Example items are: “During the walk, I could let my feelings and emotions be as they are”, “During the walk, I was more aware of the present moment”, and “During the walk, I could let out my anger or my sadness”. Items were rated on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*) and showed good reliability ($\alpha = .86$).

Procedure

The study was conducted from May 22nd to June 9th 2023. Both the coastal walks and urban walks had an equal share of cloudy and sunny days, with the average temperature ranging from 13°C to 22°C (more detail in Supplementary Materials, Table S2). We recruited Dutch-speaking adults from the general public through advertisement in social media, local newsletters, neighborhood events, and word-of-mouth. The advertised aim of the study was to investigate how people react to their environment. Participants could click on a link that led them to an information letter and an informed consent form. After giving consent, participants indicated whether they lived in a coastal municipality and gave their e-mail address. Participants were asked to reserve a time slot for their participation and received a link to the first online questionnaire (Q1) one week prior.

On the day of the experiment, Experimenter 1 met participants in the coastal groups in a classroom near the beach (i.e., ‘Duin en Zee’) and those in the urban group in a meeting room parallel to the avenue (i.e., ‘InnovOcean Campus’). After completing the pre-walk questionnaire (Q2), Experimenter 2 handed to each participant a set of four flashcards, according to the participant’s assigned group.

Experimenter 1, unaware of the group assignment, then led the participants to the starting point of the walk, whereby participants read the first flashcard, containing the instructions they should follow during the walk. Every five minutes during the walk, the participants were signaled to stop, answer the question measuring the probe variable on a flashcard, and subsequently read the brief reminder of the instructions on the back of the card. Each walking group had two to six participants, similar to Pasanen et al. (2018) and Triguero-Mas et al. (2017). The coastal walking groups had a balanced number of engagement levels. Participants were instructed to keep distance from each other and avoid communication. At the end of the walk, the participants were guided back to the meeting point where they completed the post-walk questionnaire (Q3) and were debriefed afterwards. The experiment typically took one hour and participants were compensated with 10€. We also conducted a lottery in which one participant won 100€, two participants won 50€, and three participants won 20€. The study was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University with protocol number 2023-034.

Statistical Analysis

As pre-registered, the effect of environment type and engagement level was first tested with one-way ANCOVAs for the outcomes of stress and worry reduction, change in positive and negative mood, and pro-environmental behavior. The studentized residuals of all outcomes (except for change in positive mood) did not have a normal distribution. Considering the small sample size per group ($\sim n = 20$), non-parametric tests were conducted instead. We used the Kruskal-Wallis test to compare the mean ranks between the groups for each outcome. Effect sizes were based on the eta-squared measure for non-parametric tests (η^2 ; Tomczak & Tomczak, 2014). The results from the preregistered ANCOVA analyses can be found in Supplementary Materials (Table S3). All pairwise comparisons are Bonferroni-corrected.

Results

Manipulation check

Manipulation of engagement level was checked by testing differences in the probe variable between the groups. A one-way ANOVA found no significant difference in the aggregated mean probe variable between the groups, $F(2, 54) = 1.73, p = .187, \eta^2 = .060$. Looking at each measurement of the probe variable separately, there is a significant group difference for the first probe measurement (i.e., five minutes after beginning of the walk), $F(2, 54) = 3.76, p = .03, \eta^2 = .122$. Participants in the mindful engagement group reported higher attention towards the environment ($M = 8.11$) than those in the distraction group ($M =$

6.26, $p = .037$). The second and third probe measurement did not display significant group differences. We note that in the mindful engagement group, the probe variable decreases in the second measurement (-8.9%), then increases in the third measurement (+6.1%), suggesting a difficulty of the participants to maintain awareness towards their surroundings but a willingness to do so.

Effect of environment type and engagement level on stress, worry, mood, and pro-environmental behavior

Figure 3 illustrates the descriptive distribution of each outcome per group. The Kruskal-Wallis tests did not demonstrate significant group differences in the distribution of neither stress nor worry reduction. No significant group differences were found in changes in positive or negative mood, nor in low-arousal positive mood (**Table 1**). Results therefore do not show support for an effect of environment type nor engagement level on the well-being outcomes, although it is important to note that the effect sizes for worry reduction and increase of positive and low-arousal positive mood were small-to-medium. We observed higher mean ranks of worry reduction in the distraction urban and mind-wandering groups. For increase of positive mood, we detected higher mean ranks in all three coastal groups, with the highest in the mindful engagement group. We also observed higher means ranks of increase of low-arousal positive mood in the mind-wandering and mindful engagement groups.

In terms of pro-environmental behavior, a total of 384 WEPT pages were completed and thus a donation of €38,40 was made to the Eden Reforestation Project. A Kruskal-Wallis test did not display a significant group difference in the distribution of WEPT performance, $H(3) = 1.15$, $p = .766$, $\eta^2 = -.025$ (**Figure 4**). Considering the negative effect size, results show no indication of an effect of environment type nor engagement level on pro-environmental behavior.

Exploratory analyses

Differences in the experience of awe, nostalgia, nature connectedness, and emotion-regulating strategies (ERS) between the groups were assessed with one-way ANCOVAs. Covariates included in the models were linearly related to the dependent variable and did not violate the homogeneity of regression slopes assumption.

No significant group differences in the experience of awe (characterized by small self), nor nostalgia (adjusting for subjective health and dispositional nostalgia) were found, although effect sizes were medium-to-large (**Table 2**). We observed higher mean awe (small self) in all three coastal groups and higher mean nostalgia in the mind-wandering and mindful engagement groups. Post-hoc analyses revealed a significant group difference with a large effect size for the emotion of awe measured by a

single-item (similar to nostalgia), when adjusting for age and mindfulness skills. Pairwise comparisons indicated higher awe in the mind-wandering ($p = .003$) and mindful engagement groups ($p = .003$), compared to the distraction urban group.

Figure 3

Boxplots of Stress and Worry Reduction (top) and Mood Change (bottom) per Group

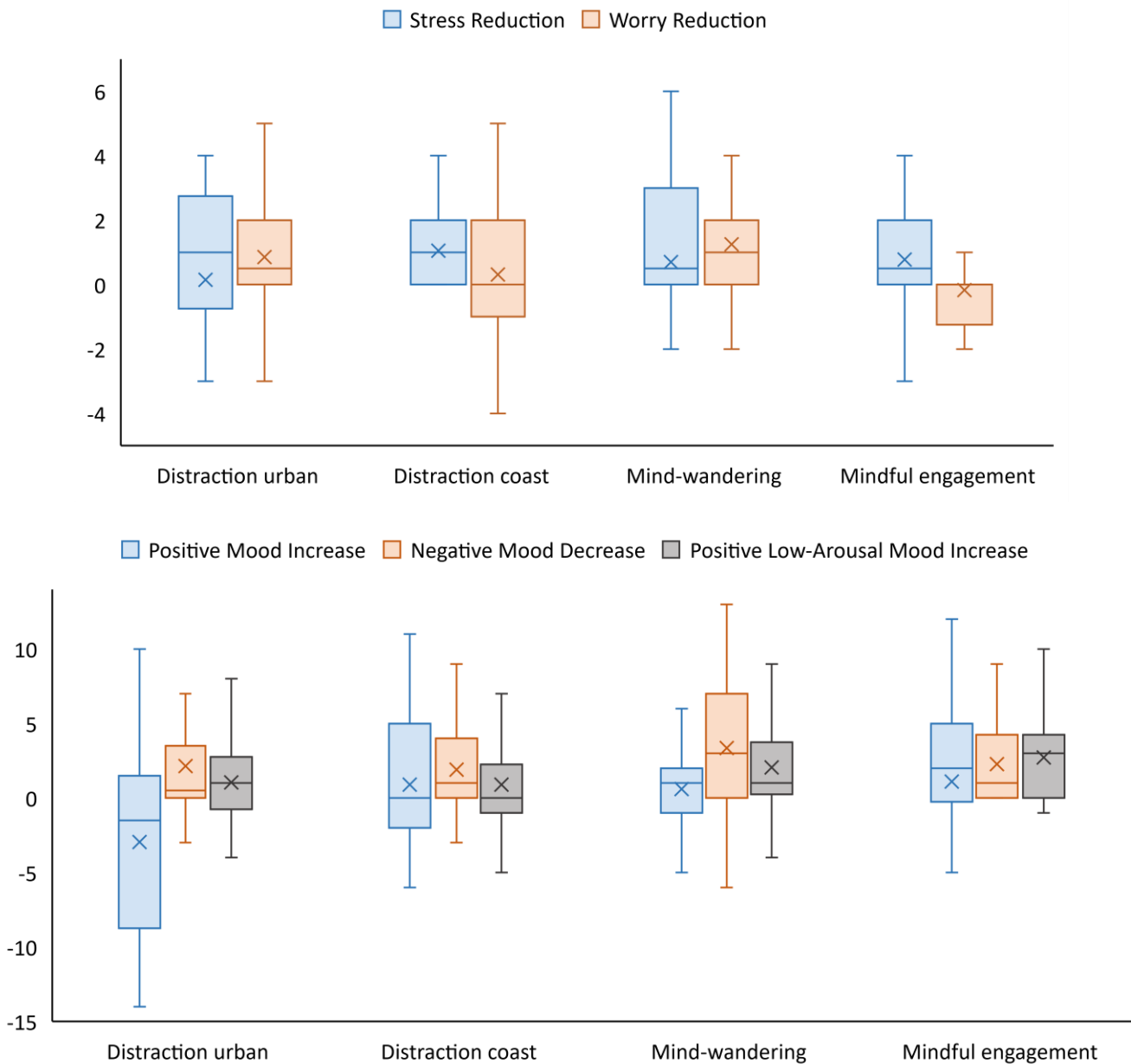


Table 1

Kruskal-Wallis H Test in the Effect of Environment Type and Engagement Level on Stress, Worry, and Mood

Outcome	Group	Mean rank	<i>H</i>	<i>df</i>	<i>p</i>	η^2
Stress reduction	DU	38.45	0.25	3	.969	-.038
	DC	40.03				
	MW	40.25				
	MF	37.14				
Worry reduction	DU	44.03	6.18	3	.103	.044
	DC	35.47				
	MW	45.18				
	MF	30.28				
Positive mood increase	DU	28.78	6.44	3	.092	.047
	DC	41.45				
	MW	40.33				
	MF	46.31				
Negative mood reduction	DU	34.33	2.22	3	.528	-.011
	DC	37.71				
	MW	44.48				
	MF	39.47				
Low-arousal positive mood increase	DU	34.60	5.36	3	.147	.032
	DC	31.47				
	MW	41.33				
	MF	46.72				

Note. DU = distraction urban group, DC = distraction coastal group, MW= mind-wandering group, MF = mindful engagement group

Adjusting for subjective health, dispositional awe, trait nature connectedness, and meaning in life, nature connectedness was significantly different between the groups, with a large effect size. Participants in the mindful engagement group displayed higher nature connectedness than those in the distraction

urban group ($p = .009$). For the outcome of emotion-regulating strategies, a significant group difference with a large effect size was found, while adjusting for subjective health. Pairwise comparisons indicated higher ERS in the mindful engagement group, compared to the distraction urban group ($p = .013$).

To further investigate potential mediation effects of these exploratory measures on well-being and pro-environmental behavior, we first assessed two-tailed Pearson correlations between the potential mediators and the outcomes. Increase in low-arousal positive mood had a significant positive correlation with awe (small self; $r = .26, p = .023$), nature connectedness ($r = .29, p = .012$), and emotion-regulating strategies ($r = .44, p < .001$). Additionally, stress reduction was significantly correlated with awe (small self; $r = .26, p = .024$). We subsequently performed a series of path analyses through structural equation modeling in consideration of these four positive correlations. We employed the *lavaan* package (Rosseel, 2012) in R, with maximum likelihood estimation and a bootstrap sample of size 5000 to obtain confidence intervals. The group variable was dummy coded and “distraction urban” was used as reference category. From the four models, one demonstrated significant mediation. Adjusting for age, subjective health, and meaning in life, emotion-regulating strategies fully mediated the effect of mindful engagement on increase of low-arousal positive mood, compared to the distraction urban group, $Estimate = 1.494, SE = 0.62, p = .016, 95\% CI = [0.511, 2.968]$. As the total effect of environment type and engagement level on low-arousal positive mood was not significant, we must interpret this result with caution.

Figure 4

Boxplot of the Total Number of Completed Pages of the Work for Environmental Protection Task per Group

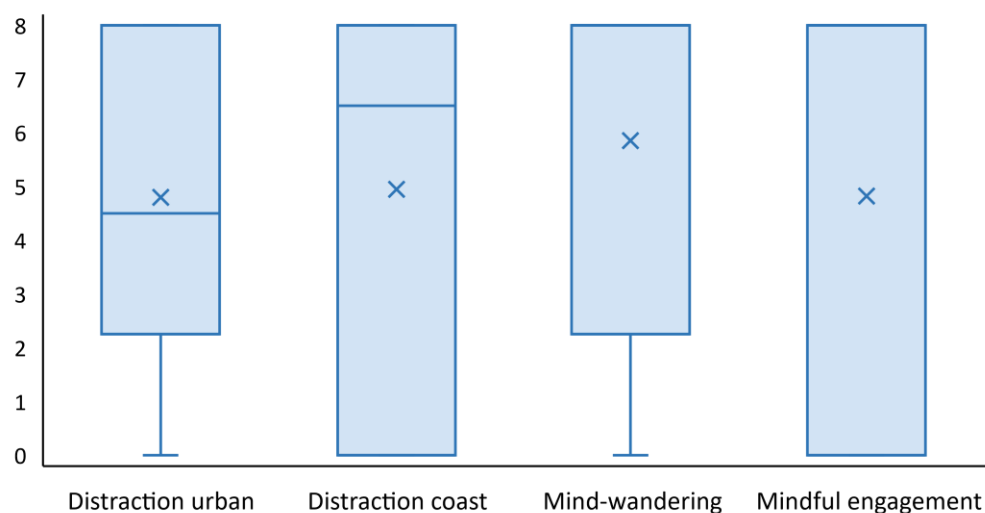


Table 2

Estimated Marginal Means and One-Way ANCOVAs in Awe, Small Self, Nostalgia, Nature Connectedness, and Emotion-Regulating Strategies

Variable	Distraction urban		Distraction coast		Mind-wandering		Mindful engagement		<i>F</i>	η_p^2
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>		
Awe (small self)	2.96	1.01	3.85	1.40	3.82	1.14	3.81	1.39	2.41	.094
Awe ^a	3.23	0.32	4.36	0.35	4.95	0.34	4.98	0.35	6.28***	.227
Nostalgia ^b	3.20	0.37	3.51	0.41	4.30	.039	4.42	0.40	2.39	.099
Nature connectedness ^c	3.48	0.28	3.98	0.32	4.51	0.30	4.89	0.31	4.26**	.173
Emotion-regulating strategies ^d	3.89	0.21	4.38	0.24	4.48	0.22	4.91	0.24	3.51*	.139

Note. Awe (small self) was not adjusted for any covariate, therefore means and standard deviations are reported.

^a Adjusted for age and mindfulness skills

^b Adjusted for subjective health and dispositional nostalgia

^c Adjusted for subjective health, dispositional awe, trait nature connectedness, and meaning in life

^d Adjusted for subjective health

* $p < .05$

** $p < .01$

*** $p < .001$

Discussion

The present study investigated the effect of real-life exposure to a coastal landscape (vs. urban landscape) on well-being and pro-environmental behavior. The differential effects of three levels of engagement, namely distraction, mind-wandering, and mindful engagement, during exposure to a coastal landscape were also assessed. Although effects of environment type and engagement level on well-being and pro-environmental behavior were not significant, our findings revealed small-to-medium effect sizes in terms of worry reduction (highest in mind-wandering group) and increase of positive and low-arousal positive mood (highest in mindful engagement group). Considering these effect sizes and that our sample size did not reach the required amount, a main interpretation of the non-significant findings is low statistical power. Within the literature on nature and well-being benefits, effect sizes are typically small but are comparable to other factors such as gender and socio-economic status (Martin et al., 2020; Severin et al.,

2021; White et al., 2013). Our small-to-medium effect sizes indicate that the cumulative effect of coastal walks on well-being could be substantial, especially in terms of increasing positive mood as all three coastal groups had higher mean ranks than the urban group.

For the outcomes of reduction of stress and negative affect, effect sizes were negative (see Metsämuuronen, 2023 and Okada, 2017, for explanation regarding negative effect sizes). This could be due to a low baseline ($M = 3.77$ for pre-stress; $M = 14.99$ for pre-negative mood), resulting in little room for improvement. In line with the Stress Recovery Theory (SRT; Ulrich, 1983), greater effects might have emerged if stress or a negative mood had been induced in participants, through means of a stress task or a stress recall procedure as in Severin et al. (under review). Furthermore, a negative effect size was found for pro-environmental behavior. This may be related to the narrow variability in WEPT performance, with a considerable number of participants completing the maximum amount of pages (46.8%). Although the WEPT is typically employed with 15 pages of the number-screening exercise, we had reduced the number of pages to eight to limit the total time spent on the experiment. In Vlasceanu et al. (2024), the WEPT was also reduced to eight pages and no effects of pro-environmental behavioral interventions on the WEPT were found.

Regarding the non-significant effect of environment type, an additional interpretation is related to the location of the urban walk, which was set in a coastal city and was therefore in proximity to the coast. We initially intended to conduct the urban walk in a city further inland. However, during participant recruitment, it became evident that coastal residents were less willing to travel to another city for the experiment. This would have created a sampling bias if only coastal residents participated in the coastal walks and only inland residents participated in the urban walks. We therefore decided to set both locations at the same coastal city and to stratify the participants according to their residency. It is possible that participants doing the urban walk were indirectly exposed to coastal elements such as sea breeze and coastal bird sounds, thereby creating less of a disparity between the coastal and urban landscapes.

With regards to the lack of differential effects of engagement level, we offer three additional explanations. First, apart from in the beginning of the walk, participants in the mindful group did not significantly pay more attention to their surroundings compared to the other groups. Successfully manipulating a state of mindfulness with a brief intervention has also proven to be difficult in similar studies (Macaulay et al., 2022a; Unsworth et al., 2016). Maintaining a state of awareness of the present moment typically requires more practice and is challenging for novice use of mindfulness (Zhang et al., 2023). Second, our probe measure only reflected awareness of one's surroundings and thus did not include aspects of curious observation and decentering. Perhaps participants in the mindful group

experienced these other aspects of mindfulness to a higher degree than other participants. Third, positive effects of mindfulness on well-being outcomes such as stress and mood may potentially only appear in the later stages of mindfulness practice (Nyklíček, 2011). Indeed, both in Macaulay et al. (2022a) and Nisbet et al. (2019), brief mindful engagement interventions in nature did not lead to a greater increase of positive affect.

No significant effects on well-being were found for mind-wandering, although the reduction in worry and in negative affect were highest in the mind-wandering group, in accordance to findings from Macaulay et al. (2022a). Even though evidence for the benefits of mind-wandering on mood are mixed, deliberate mind-wandering in natural environments appears to enhance restoration (Macaulay et al., 2024) and should be further investigated.

Our exploratory analyses demonstrated a significant effect of mindful engagement at the coast on nature connectedness, in line with findings from Barrable et al. (2021) and Nisbet et al. (2019). Experiencing nature connectedness was significantly higher in the mindful group (vs. distraction urban), and not in the other coastal groups (i.e., distraction coast and mind-wandering), suggesting that engaging mindfully at the coast is a prerequisite to completely feel connected to nature. For the emotions of awe (small self) and nostalgia, group differences were not significant, although effect sizes were medium-to-large, suggesting a low statistical power. All three coastal groups had the highest mean for awe (small self), and the mind-wandering and mindful engagement groups had the highest mean for nostalgia. In contrast to awe characterized as small self, post-hoc analyses displayed a significant group difference for the single-item measurement of awe. Although both measures were significantly correlated ($r = .39, p < .001$), participants' interpretation of 'awe' could be associated with other facets that are distinct from a feeling of small self (e.g., altered time perception, feelings of connection, perceived beauty; Yaden et al., 2019). The single-item awe was significantly higher in the mindful group, similar to Nisbet et al. (2019) and now applied in the context of coastal landscapes. Awe was also significantly higher in the mind-wandering group, indicating that deliberate mind-wandering can be conducive to feelings of fascination towards one's environment, in between moments of self-reflection, as suggested in Williams et al. (2018).

A prominent finding from our exploratory analyses relates to the significant effect of mindful engagement on adaptive emotion-regulating strategies. Experiencing for example acceptance and openness towards one's emotions, or being able to clear one's mind, was higher in the mindful group (vs. distraction urban), and not in the other coastal groups, indicating a unique effect of mindful engagement. Moreover, emotion-regulating strategies were shown to mediate the effect of mindful engagement on the increase of low-arousal positive mood, thereby highlighting an important mechanism through which

mindful engagement at the coast benefits well-being. This mediation effect should be interpreted with caution however, due to the non-significant total effect of mindful engagement.

The current study differs from previous work in that participants are guided by an experimenter during the walk and a comparison was made between walks in a coastal and an urban landscape. An important limitation of this study is the low statistical power, as recruitment of participants proved to be challenging. The study should therefore be replicated with a larger sample or be conducted with a within-subjects design, as in Gidlow et al. (2016) and Yin et al. (2023). Another limitation involves a common constraint of *in situ* experiments, namely low standardization. Efforts were made to minimize this constraint by considering situational factors such as weather, tide, and external events that could vary between walking groups. Experimenters adhered to a standardized script when communicating with participants, and each walking group maintained a balanced level of engagement. Finally, to measure stress and worry, we employed single-item measures. Although single-items are considered to be less reliable, they appear to align well with multiple-item scales in the context of mood and health (Verster et al., 2021).

Conclusion

Evaluating the impact of brief engagement interventions in coastal landscapes on the general public can contribute to a greater understanding of the role of the coast in maintaining or boosting well-being. Despite non-significant findings regarding the effect of real-life exposure to the coast and engagement level, considerable effect sizes in terms of worry reduction and increase in positive and low-arousal positive mood suggest a need for replication with a larger sample size. Moreover, we found unique effects of mindful engagement at the coast on valuable emotions, such as nature connectedness and awe. These findings advance our understanding of underlying mechanisms of the well-being benefits of mindful engagement. These mechanisms should be further emphasized when integrating mindfulness in coastal landscapes. Considering that its use at the coast was also found to be linked with adaptive emotion-regulating strategies, future research should investigate the cumulative benefits of mindful engagement interventions at the coast within clinical and non-clinical settings.

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Chapter 5

Impact of the Citizen Science Project COLLECT on Ocean Literacy and Well-Being within a North/West African and South-East Asian Context¹

Abstract

Plastic pollution is both a societal and environmental problem and citizen science has shown to be a useful tool to engage both the public and professionals in addressing it. However, knowledge on the educational and behavioral impacts of citizen science projects focusing on marine litter remains limited. Our preregistered study investigates the impact of the citizen science project Citizen Observation of Local Litter in coastal ECosysTems (COLLECT) on the participants' ocean literacy, pro-environmental intentions and attitudes, well-being, and nature connectedness, using a pretest-posttest design. A total of 410 secondary school students from seven countries, in Africa (Benin, Cabo Verde, Côte d'Ivoire, Ghana, Morocco, Nigeria) and Asia (Malaysia) were trained to sample plastics on sandy beaches and to analyze their collection in the classroom. Non-parametric statistical tests ($n = 239$ matched participants) demonstrate that the COLLECT project positively impacted ocean literacy (i.e., awareness and knowledge of marine litter, self-reported litter-reducing behaviors, attitudes towards beach litter removal). The COLLECT project also led to higher pro-environmental behavioral intentions for students in Benin and Ghana (implying a positive spillover effect) and higher well-being and nature connectedness for students in Benin. Results are interpreted in consideration of a high baseline in awareness and attitudes towards marine litter, a low internal consistency of pro-environmental attitudes, the cultural context of the participating countries, and the unique settings of the project's implementation. Our study highlights the benefits and challenges of understanding how citizen science impacts the perceptions and behaviors towards marine litter in youth from the respective regions.

¹ Based on Severin, M.I., Akpetou, L.K., Annasawmy, P., Asuquo, F.E., Beckman, F., Benomar, M., Jaya-Ram, A., Malouli, M., Mees, J., Monteiro, I., Ndwiga, J., Neves Silva, P., Nubi, O.A., Sim, Y.K., Sohau, Z., Shau-Hwai, A.T., Woo, S.P., Zizah, S., Buysse, A., Raes, F., Krug, L.A., Seeyave, S., Everaert, G., Mahu, E., & Catarino, A.I. (2023). Impact of the citizen science project COLLECT on ocean literacy and well-being within a north/west African and south-east Asian context. *Frontiers in Psychology, 14*, 1130596. doi: 10.3389/fpsyg.2023.1130596

Introduction

The accumulation of plastic litter in the environment, and its impact on ecosystem services (e.g., fisheries, tourism, maritime transportation) and human well-being is a concern of public interest. Economic activities of local populations, such as fisheries or seafood sales, can be affected indirectly by potential effects of litter on fish stocks (e.g., due to ghost fishing gear) or by consumers perception of shellfish as unsafe items for purchasing, due to the presence of microplastics (Van Cauwenberghe & Janssen, 2014). Furthermore, there is growing evidence that direct and/or indirect exposure to coastal environments can benefit various aspects of well-being (e.g., social relationships, restoration from stress and attentional fatigue, positive emotions; Hooyberg et al., 2020; White et al., 2020; Severin et al., 2021b, 2022). However, the presence of marine litter can negatively impact these benefits by reducing the coast's restorative and recreational qualities and inducing negative moods (Wyles et al., 2016; De Veer et al., 2022). Marine litter can also disrupt the aesthetic experience of the coast by diminishing its scenic quality (Rangel-Buitrago et al., 2018), thereby reducing the chances of people spending time in (littered) coasts (Tudor and Williams, 2006) and negatively affecting the tourism industry (Williams et al., 2016; Krelling et al., 2017). In terms of risks of marine litter on human health, a recent report by the World Health Organization (WHO) concludes that although the evidence remains insufficient, a reduction in exposure would greatly benefit humans and the environment (World Health Organization, 2022).

To tackle the problem of plastic pollution, action needs to be taken at both collective and individual levels, and citizen science can be a useful tool to engage both the general public and STEM (science, technology, engineering, and mathematics) professionals. Global, national and local authorities recognize the urgency to mitigate this issue and various community initiatives frequently take place aiming at protecting natural and recreational areas, such as beach “clean-up” activities, where plastic items are manually collected (Jorgensen et al., 2021). Examples of such beach clean-ups include the Ocean Conservancy's International Coastal Cleanup that engages volunteers and organizations to remove debris from beaches and waterways worldwide (Ocean Conservancy, 2022), and “Clean up the Med,” a nationwide campaign of voluntary beach clean-ups in Greece (Kordella et al., 2013). Citizen science goes a step beyond by actively involving citizens in the scientific research process, which can promote action by first, addressing data gaps in marine litter distribution and abundance to develop effective mitigation measures, and second, increasing public awareness of plastic pollution and encouraging individual action to reduce plastic littering (Thiel et al., 2011; Hidalgo-Ruz and Thiel, 2013).

The individual level, with a focus on the citizen participation, is however often neglected in the literature. Despite the growing number of citizen science projects focused on plastic pollution

(Rambonnet et al., 2019), only a small percentage evaluate their effectiveness in impacting awareness and sustainable action on their participants (Severin et al., 2023). Including this evaluation is nonetheless essential to understand each project's benefits and challenges presented to the public, thereby maximizing its full potential to address plastic pollution on a local and global scale (Kelly et al., 2022). Moreover, as stated in Pahl and Wyles (2017), understanding the perceptions, decisions, and actions of humans is a central ingredient in undertaking the issue of plastic pollution. Additionally, there is a strong underrepresentation of African countries within citizen science projects, accompanied with a lack of socio-economic and socio-demographic diversity (Kawabe et al., 2022; Severin et al., 2023). In this paper, we investigate the impact of the Citizen Observation of Local Litter in coastal ECosysTems (COLLECT) project on the participants' ocean literacy, pro-environmental intentions and attitudes, and well-being. Ocean literacy was conceptualized as awareness and knowledge of marine plastic litter, self-reported litter-reducing behaviors, and attitudes towards beach litter removal.

The COLLECT project

The COLLECT project (2021–2022) was a citizen science initiative with the aim of obtaining data on the abundance and distribution of coastal plastic litter in seven countries in North and West Africa (Benin, Cabo Verde, Côte d'Ivoire, Ghana, Morocco, Nigeria) and South-East Asia (Malaysia). The project consisted of training students from secondary schools (11–18 years old) in sampling and analyzing macro-, meso- and microplastic in sandy beaches. Students went to the beach during two different seasons (wet-autumn and dry-spring) and sampled plastic following a standard operating procedure (SOP). They then analyzed the samples in the classroom. Prior to the field activities, the students were given an information session which consisted of presenting the project and providing background information on plastic pollution and guidelines for field sampling. COLLECT's methodology followed best practices of citizen science initiatives on plastic litter assessments in aquatic areas (Rambonnet et al., 2019; Barnardo and Ribbink, 2020; De Rijck et al., 2020). The project was overseen by the Partnership for Observation of the Global Ocean (POGO)², a well-established network of oceanographic research institutes that collaborate to promote and execute global ocean observations via innovation, capacity building, outreach, and advocacy (Miloslavich et al., 2019; POGO, 2021). In each country, the project was undertaken by local researchers who were affiliated within member institutions of the POGO. More detailed information regarding the full methodology of the project can be found in Catarino et al. (2023).

² <https://pogo-ocean.org>

Prevalence and impacts of litter in the participating countries

Currently, littoral countries in Africa are leaders in the world's urbanization rates (Saghir and Santoro, 2018), and there are concerns over a parallel drastic increase in the production and release of municipal solid waste in these areas (Yoshida, 2018) potentially accumulating on the coast (Ryan, 2020). In Africa, the total mismanaged plastic waste in 2010 was estimated to be 4.4 million metric tons, and is estimated to reach 10.5 million metric tons in 2025 (Jambeck et al., 2018). Strict policies on plastic imports and on the ban on single-use plastic items have demonstrated efficiency in the reduction of plastic consumption, such as in the case of Rwanda (Babayemi et al., 2019), however the effectiveness of such measures without a complete life-cycle approach is not yet clarified (The Economist, 2019). For example, according to the LitterBase (Bergmann et al., 2017)³, marine litter data is scarce for most of the coastal areas in Africa. The situation is similar in Malaysia, as it is one of the leading countries regarding the generation of plastic waste as well as the consumption of single-use plastics (Chen et al., 2021). More than 0.94 million metric tons of mismanaged plastic waste is generated per year, of which an estimated 0.14–0.37 million metric tons consist of plastic marine debris (Jambeck et al., 2015). Key components constraining waste management include an inconsistent application of policy initiatives and a lack of public awareness and interest in household recycling (Chen et al., 2021). Marine litter data also remains lacking in Malaysia (Fauziah et al., 2021). The project COLLECT aimed to address this data gap and provide baseline data, crucial to propose solutions and mitigation measures for the reduction of coastal debris impacts in emerging economies and vulnerable coastal communities.

According to a review by Arabi et al. (2023), there is limited information regarding the social, economic, and health impacts of marine litter in the participating countries, with most of the literature focusing on South Africa. Arabi et al. (2023) demonstrate that the presence of marine litter reduces the aesthetic value of popular tourist beaches in Benin and Côte d'Ivoire, and that unclean beaches were one of the main concerns of coastal residents in Ghana (Van Dyck et al., 2016). In Nigeria, perceived major impacts of marine litter also include aesthetic impairment, as well as health issues and economic downscale (Nubi et al., 2019). Furthermore, marine litter is shown to directly affect the tourism industry, particularly in the African Small Island Developing States (SIDS; including Cabo Verde). SIDS tourism 1 <https://pogo-ocean.org> 2 litterbase.awi.de depends on “beautiful,” clean beaches, but are the most disproportionately affected by marine litter, and therefore necessitate continuous cleaning of the beaches at a high economic cost (Arabi et al., 2023). In 2015, the economic cost of damage from marine litter to

³ <https://litterbase.awi.de/>

fisheries, aquaculture, marine transport, shipbuilding and tourism in the APEC (Asia-Pacific Economic Cooperation) region, including Malaysia, was estimated at 11.2 billion USD (McIlgorm et al., 2020). Finally, the participating countries are also faced with the health risks presented by marine litter through the consumption of seafood containing microplastics, as shown in Malaysia (Karbalaie et al., 2019), and potential injuries due to sharp plastic fragments or discarded fishing nets in the water (Van Dyck et al., 2016; Arabi et al., 2023).

The impacts of citizen science on participants

The goal of increasing ocean literacy in the global population is to enable a positive behavior change towards the ocean and its resources, according to the revised roadmap for the United Nations (UN) Decade of Ocean Science for Sustainable Development (Intergovernmental Oceanographic Commission, 2018). Ocean literacy has been broadly defined up to now as “an understanding of the ocean’s influence on you and your influence on the ocean” (Schoedinger et al., 2005, p. 1). There is however a growing consensus that ocean literacy should not only pertain to understanding of ocean-related topics, but should further include attitudes, behaviors, and level of connectedness to the ocean (Kelly et al., 2022). A recent study demonstrated that ocean literacy consisted of six sub-dimensions: knowledge of ocean-related topics, personal interest in ocean-related aspects, ocean stewardship, ocean as an economic resource, ocean-friendly behavior, and willingness to act responsibly towards the ocean (Paredes-Coral et al., 2022). One conceptual approach that can be utilized to achieve positive behavior change towards the ocean is the Theory of Change model (Connell and Kubisch, 1998). This approach consists of first determining an end objective and then identifying the different steps needed to be reached to obtain this objective. Ashley et al. (2019) demonstrated how the theory of change model can be applied to evaluate ocean literacy initiatives targeting specific behavior change. The identified steps predicting the targeted behavior change were: awareness and knowledge of the issue, attitudes (concern) and self-efficacy (belief that one’s own actions will be beneficial) towards the issue, and interpersonal communication about the issue with friends and family. The ocean literacy initiatives were found to positively impact every step of the theory of change model, as well as the intended behavior change. The study thereby displayed the effectiveness of the included predictors of behavior change and their relevance within the ocean literacy framework (Ashley et al., 2019).

Citizen science projects related to marine litter are found to positively impact components of ocean literacy (Hartley et al., 2015; Yeo et al., 2015; Wyles et al., 2017; Locritani et al., 2019; Rayon-Viña et al., 2019; Wichmann et al., 2022). Hartley et al. (2015) assessed the effect of an educational

intervention on young school children and demonstrated that following the intervention, children reported more concern towards marine litter, had better knowledge of its causes and consequences, and engaged in more sustainable actions aimed at reducing marine litter. Locritani et al. (2019) used the same questionnaire as Hartley et al. (2015), with adolescents, and found similar results with exception to lower variation in problem awareness and perceived negative impacts of marine litter. This was likely to be related to a higher baseline awareness and knowledge of plastic pollution. Similarly, a study by Wichmann et al. (2022) reported a high baseline problem perception and involvement towards marine plastic litter in Chilean school children and did not find any significant effects of the citizen science initiative on their participants, except for an increase in perceived negative impacts. In addition to the high baseline causing little room for improvement, the authors suggested that citizen science alone is not enough to generate pro-environmental behavior change, but would benefit from the inclusion of educational modules that teach participants strategies and skills to empower them for environmental protection (Wichmann et al., 2022). More research is therefore needed to better understand how citizen science can be optimized in its potential to impact ocean literacy.

In addition to benefiting ocean literacy, participating in citizen science initiatives may lead to a positive “spillover effect” (i.e., an indirect side effect of an intervention), in which engaging in one pro-environmental behavior might encourage further engagement in other pro-environmental behaviors (Thøgersen & Ölander, 2003). This was demonstrated in the study by Wyles et al. (2017), in which participating in a beach clean-up led to increased intentions to engage in other, more generic, pro-environmental behaviors. Indeed, a recent Bayesian meta-analysis based on environmental interventions found small positive spillover effects for sustainable intentions, however no spillover effects were found for sustainable behaviors (Geiger et al., 2021). Although spillover effects are generally considered in terms of intentions and behaviors, we would like to explore whether they could apply in terms of attitudes as well. More specifically, if citizen science can impact attitudes regarding a particular issue (e.g., marine litter), perhaps this can also increase pro-environmental attitudes in general.

It has been further demonstrated that citizen science initiatives positively impact well-being and nature connectedness (Koss & Kingsley, 2010; Yeo et al., 2015; Wyles et al., 2017). In the study by Wyles et al. (2017), after participating in a beach clean-up, students reported feeling a more positive mood and higher eudaimonic well-being. In this context, eudaimonic well-being was referred to the meaningfulness of the activity and whether it was in line with one’s personal values. Moreover, Koss and Kingsley (2010) investigated the well-being of volunteers of a marine monitoring program and found that volunteering created personal satisfaction, feelings of enjoyment, and feeling pride in themselves. It is important to

note however that the presence of litter in coastal environments can diminish the restorative qualities of the coast and induce a negative mood (Wyles et al., 2016). Nonetheless, Wyles et al. (2017) speculate that although the littered environment is less restorative, the activity (e.g., beach cleaning) itself may counteract the potential negative effects by benefiting hedonic and eudaimonic well-being. With regards to nature connectedness, the volunteers in Koss and Kingsley (2010) reported an increased sense of connection to nature, which was linked with a desire to protect the coastal environment. This is in line with findings of a positive relationship between connectedness to nature and pro-environmental behavior (Martin et al., 2020). Additionally, Wyles et al. (2019) demonstrate that exposure to coastal environments was associated with higher nature connectedness. We can thus speculate that interacting with the coast can boost connectedness with nature, which in turn can facilitate positive behavior change.

Present study

The aim of the present study was to assess the impact of the citizen science intervention in the project COLLECT (Citizen Observation of Local Litter in Coastal ECosysTEms), by evaluating shifts in participants' ocean literacy, pro-environmental intentions and attitudes, and well-being. To achieve this, students were asked to complete a survey both before (pre-survey) and after (post-survey) the project activities, using a within-subject design. Ocean literacy was conceptualized based on previous studies evaluating citizen science initiatives (Hartley et al., 2015; Wyles et al., 2017; Locritani et al., 2019; Lucrezi & Digun-Aweto, 2020) and the predictors of behavior change from the Theory of Change model used in Ashley et al. (2019). More specifically, to assess ocean literacy we measured awareness and knowledge of marine plastic litter, self-reported litter-reducing behaviors, and attitudes towards beach litter removal. Pro-environmental behavioral intentions and attitudes were included to assess potential spillover effects. Finally, we evaluated hedonic and eudaimonic well-being, as well as nature connectedness.

Methods

The current study's experimental design and data analysis plan were preregistered in the Open Science Framework (OSF) registry before data collection (Severin et al., 2021a)⁴.

Participants

A total of 410 secondary school students from seven different countries took part in the surveys evaluating the impact of COLLECT. About half of the participants identified as female (49.5%), and 43% identified as

⁴ <https://osf.io/vb8tx>

male (7.5% gave no response). The mean age was 15.8 years old ($SD = 2.19$), with the youngest participant being 11 years old and the oldest being 22 years old. The majority of participants (72.4%) were between 14 and 18 years old. **Table 1** depicts the distribution of participants according to country, along with socio-demographic characteristics. There was an important gap in sample size between the countries as certain countries (e.g., Cabo Verde) typically have very low attendance of secondary school students compared to other countries which usually have 50 students per class (e.g., Nigeria). A total of 171 students could not be matched due to missing pre- ($n = 72$) or post-surveys ($n = 99$). Matched pre- and post-surveys that were therefore included in the analysis represent 58% of the total sample size ($n = 239$). Various factors can explain this attrition such as students not attending class at both time points, mistyped identification codes, or schools not being able to finish the sampling activities due to time constraints.

Table 1*Participant Characteristics*

Country (total sample; matched pre- and post-surveys)	School	Age distribution	Gender distribution ^a
Benin ($n = 66$; $n = 65$)	Lycée Technique Coulibaly	$M = 17.6$, $SD = 1.91$, $min = 12$, $max = 22$	Female = 39.4% Male = 60.6%
Cabo Verde ($n = 29$; $n = 16$)	Escola Salesiana de Artes e Ofícios	$M = 16.8$, $SD = 1.05$, $min = 16$, $max = 20$	Female = 79.3% Male = 13.8%
	Liceu Ludgero Lima		
Côte d'Ivoire ($n = 29$; $n = 11$)	Collège les Oliviers de Port Bouet	$M = 17.4$, $SD = 1.57$, $min = 14$, $max = 21$	Female = 58.6% Male = 34.5%
Ghana ($n = 67$; $n = 34$)	O'Reilly Senior High School	$M = 17$, $SD = 1.18$, $min = 15$, $max = 21$	Female = 40.3% Male = 55.2%
Malaysia ($n = 64$; $n = 37$)	Prince of Wales Island International School	$M = 14.6$, $SD = 1.54$, $min = 12$, $max = 18$	Female = 45.3% Male = 54.7%
Morocco ($n = 59$; $n = 1$)	Lycée des Sportifs	$M = 15.8$, $SD = 2.06$, $min = 12$, $max = 21$	Female = 40.7% Male = 22%
	École IBN Batouta		
Nigeria ($n = 96$; $n = 75$)	Riverside College	$M = 14$, $SD = 1.81$, $min = 11$, $max = 21$	Female = 59.4% Male = 38.5%
	University of Calabar International Secondary School		

^a Remaining percentage (to total 100%) corresponds to missing data.

Measures

The pre- and post-assessment survey contained a series of questions divided into three main topics: awareness and knowledge of marine litter, attitudes and behaviors towards marine litter and the environment, and well-being, including nature connectedness. Questions regarding socio-demographics (i.e., gender, age) and visit frequency to the beach were also included. Additionally, the post-survey contained questions measuring satisfaction towards the COLLECT project. The survey was written in English (applied in Ghana, Malaysia, and Nigeria) and then translated to French (applied in Benin, Côte d'Ivoire, and Morocco) and Portuguese (applied in Cabo Verde). The survey language was in accordance with the school language of each country, with exception to the Moroccan schools who employed Spanish, however the students also spoke French. All surveys are open access⁵. When possible, we used translated scales that had already been validated in empirical studies. All other translated items or scales were reviewed by two independent native speakers. To ensure that the survey questions were not too difficult to comprehend or answer, we piloted the survey with the students from Nigeria, from the University of Calabar International Secondary School. The students could indicate when they did not understand the question and could give general feedback. The schools conducted the survey in paper format, with the exception of the school in Malaysia that used an online version of the survey on the Limesurvey platform (Limesurvey GmbH)⁶.

Awareness and knowledge of marine litter

Awareness of marine litter was represented by participants' problem awareness and concern regarding marine litter, and their perceived impacts and causes of marine litter. Questions were adjusted from Hartley et al. (2015) and Locritani et al. (2019) and were reworded in the format of five-point Likert agreement scales to create consistency in response options throughout the survey. Problem awareness of marine litter was measured with the statement "Litter on the beach and in the sea is a problem." Two extra items measuring awareness were included: "litter on the beach and in the sea is a future environmental threat rather than a present one" (based on Hartley et al., 2018) and "litter on the beach and in the sea in our country is more problematic than in other neighboring countries." Concern towards marine litter was measured with the statement "I am worried about the problems that litter on the beach and in the sea might cause." Participants then rated their agreement to whether impacts of marine litter on marine wildlife, tourism, human health, fishing activities, and the appearance of the coast were "bad."

⁵ <https://osf.io/7e3su/>

⁶ www.limesurvey.org

Finally, participants rated their agreement to whether marine litter was due to people dropping litter on the beach, not enough bins, businesses and fishing activities, too much packaging that is difficult to recycle, and rivers discharging waste into the sea.

Knowledge of marine litter was measured by asking participants the estimated degradation time of plastic bottles, similar to Hartley et al. (2015). Response options were less than 1 year, 1–10 years, 10–50 years, 50–100 years, or more than 100 years. Ten to fifty years and 50–100 years were considered as correct responses (Edge et al., 1991; Allen et al., 1994). We also included four multiple choice questions to assess perceived salience of marine plastic. Three questions were based on those used in Wyles et al. (2017), i.e., “what do you think was the most common type of litter found on the coastline near you in 2020?,” “over the last 10 years, plastic bottles found on the coastline near you have increased by...,” and “on average in 2020, how many pieces of litter were found per meter on the coastline near you?” The fourth question consisted of asking participants what percentage of marine litter they thought was plastic, as done in Hartley et al. (2015), with response options being 0–10%, 10–25%, 25–50%, 50–75%, or 75–100%.

Attitudes and behaviors towards marine litter and the environment

Attitudes towards marine litter were specifically targeted towards beach litter removal and were measured with items taken from Lucrezi and Digun-Aweto (2020), with a five-point Likert agreement scale. Examples are: “collective activities are important to keep the beach litter-free” and “everyone is responsible for removing litter from the beach, including me.” An additional item was also included: “only those who originally pollute the beach are responsible for removing litter from the beach.” As stated in Lucrezi and Digun-Aweto (2020), perceiving others such as the local government to be responsible for removing litter can be negatively linked to participation in beach litter removal campaigns. In contrast, perceived personal responsibility can encourage such participation and also reflects the notion of perceived behavioral control, i.e., “it is up to me whether I do this rather than other people or contextual factors.” This is regarded as one of the best direct predictors of behavior change (Klößner, 2013; Ashley et al., 2019). Furthermore, pro-environmental attitudes in general were measured with the revised version of the ten-item New Ecological Paradigm scale (NEP; Dunlap et al., 2000), that is adapted for children and adolescents (Manoli et al., 2007), with a five-point Likert agreement scale. We used the multidimensional purpose of the NEP scale to evaluate three factors, i.e., the extent to which one endorses the rights of nature (Rights of Nature; e.g. “plants and animals have as much right as people to live”), recognizes the possibility of an eco-crisis (Eco-Crisis; e.g. “if things do not change, we will have a big disaster in the environment soon”), and rejects human exemptionalism (Human Exemptionalism; e.g.

“people are clever enough to keep from ruining the earth”; reverse-coded). In our sample, all three factors present low reliability scores for the pre-survey (Cronbach’s alpha=0.24 for Rights of Nature, 0.49 for Eco-Crisis, and 0.33 for Human Exemptionalism) and for the post-survey (Cronbach’s alpha=0.13 for Rights of Nature, 0.60 for Eco-Crisis, and 0.37 for Human Exemptionalism).

Behaviors towards marine litter were measured with items displaying litter-reducing behaviors, used in Hartley et al. (2015) and Locritani et al. (2019). Participants rated how often in the past week they “disposed of litter properly,” “picked up litter on the beach,” “bought goods with less packaging,” “encouraged family and friends to do any or all of the things above,” and “avoided using plastic bags in the supermarket” (added item), using a Likert scale from 1 (*never*) to 5 (*a great deal*). To evaluate pro-environmental behavioral intentions, participants had to rate how often in the future they will engage in participation in beach clean-ups (based on Wyles et al., 2017), and other more generic pro-environmental behaviors, namely buying products with less packaging, recycling, and re-using plastic bags. Response options were *never, rarely, occasionally, a moderate amount, and a great deal*.

Well-being and nature connectedness

Participants’ well-being was assessed with the Short Warwick Edinburgh Mental Well-Being Scale (SWEMWBS; Stewart-Brown et al., 2009), which is a seven-item scale that measures both eudaimonic and hedonic well-being. Eudaimonic well-being refers to living in accordance with one’s true self (Waterman, 1993) and is typically conceptualized with six dimensions, namely autonomy, environmental mastery, personal growth, positive relationships, purpose in life, and self-acceptance (Ryff & Keyes, 1995). Hedonic well-being is defined as a state of positive affect and absence of negative affect (Kahneman et al., 1999), and is often measured by life satisfaction and happiness. The SWEMWBS was developed by the Universities of Warwick, Edinburgh, and Leeds in conjunction with NHS Health Scotland. Participants had to rate the frequency of certain thoughts and feelings experienced in the past week, with response options going from 1 (*never*) to 5 (*always*). The SWEMWBS is shown to have acceptable reliability in our sample, as Cronbach’s alpha was 0.73 for the pre-survey and 0.80 for the post-survey. To measure specifically hedonic well-being, participants were also asked to rate their happiness with a ten-point scale going from *extremely unhappy* to *extremely happy*. Nature connectedness was assessed with the use of the Nature Connection Index (NCI; Richardson et al., 2019). The NCI is a six-item scale that measures a person’s sense of connection with nature, using items such as “being in nature makes me very happy” or “I feel part of nature.” Participants responded with a seven-point Likert agreement scale. The NCI is suitable for both children and adults and is found to have good reliability in our sample. Cronbach’s alpha was 0.86 for the pre-survey and 0.89 for the post-survey.

In the post-survey, participants were also asked to indicate how satisfied they were with the general COLLECT project with a ten-point scale going from *very unsatisfied* to *very satisfied*, such as in Wyles et al. (2017). The meaningfulness of the COLLECT project was measured with participants rating to what extent the project was worthwhile and meaningful to them, using a scale from 1 (*not at all*) to 5 (*extremely*; based on Wyles et al., 2017). Finally, participants also had to select three adjectives that they thought best described the COLLECT project, from the following list: inspiring, boring, informative, pointless, enjoyable, tiring, motivating, frustrating, gratifying, and challenging.

Procedure

School recruitment was largely based on ongoing collaborations between the member institutes of POGO and science teachers. The headteacher of each school received an official invitation letter from POGO, outlining the project and the activities that would take place. The science teacher selected which classes of students would participate, with no prior knowledge of the content of the surveys and their aim. Parents of the participating students then received an information letter (Catarino et al., 2023). The headteacher and the parents of all underage students were requested to give their informed consent for the student to participate in COLLECT and to take part in the surveys. We also required their consent to take photos or video recordings of the students and to use them for educational and outreach purposes. In addition, all students that were 16 years old or older were required to give their personal informed consent to participate in the surveys.

The pre-survey was handed out to the students during the information session, before the presentation of the project, and typically took about 15min to complete. The survey contained first a short introduction, informing the students that the aim of the survey was to understand the different impacts of the project. Students were then asked to compose a unique participant code that would enable to link their answers from the pre- and post-surveys, without direct identification of the student. The code consisted of their birth month, followed by the first two letters of their first name and surname. The post-survey was completed approximately 1month later, allowing at least 1week to pass after the classroom processing of the sampled plastic. It is important to note that in Cabo Verde, Côte d'Ivoire and Morocco, the post-surveys were completed at the end of the second season (i.e., spring), 5/6months after completion of the pre-surveys. A debriefing of the project's results will be provided to the students and teachers in the format of flyers or visually attractive posters. The collection and analysis of the surveys has been approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University (ref: 2021/65).

Statistical analysis

Due to the use of ordinal data, we evaluated the effects of the COLLECT project on the participants with Wilcoxon's matched-pairs signed ranks test, which is a non-parametric statistical method that can determine whether there is a median difference between paired observations. If the assumption that the distribution of differences is symmetrically shaped was violated, then a sign test was employed instead. To evaluate differences between perceived impacts, perceived causes, self-reported litter-reducing behaviors, and attitudes towards beach removal at baseline, we used a Friedman test with pairwise comparisons. We analyzed the intervention effects for each country separately due to unequal group sizes and heterogeneity of covariances. Results from the Moroccan schools could not be included in the analyses because only one participant completed both pre- and post-surveys, due to the disruptions imposed by COVID-19 restrictions in place. For each significant effect we examined whether there was an influence of age, gender, or visit frequency to the beach. We used Spearman correlations to evaluate the relationships between age, coastal visit frequency, and the shift in variables from pre- to post-surveys. For any effects of gender, we used Mann–Whitney *U*-tests to compare the shifts in variables from pre- to post-surveys between men and women. The effects of gender on results from Cabo Verde and Côte d'Ivoire could not be assessed due to a low percentage of men who completed both pre- and post-surveys (6 and 18% respectively).

Results

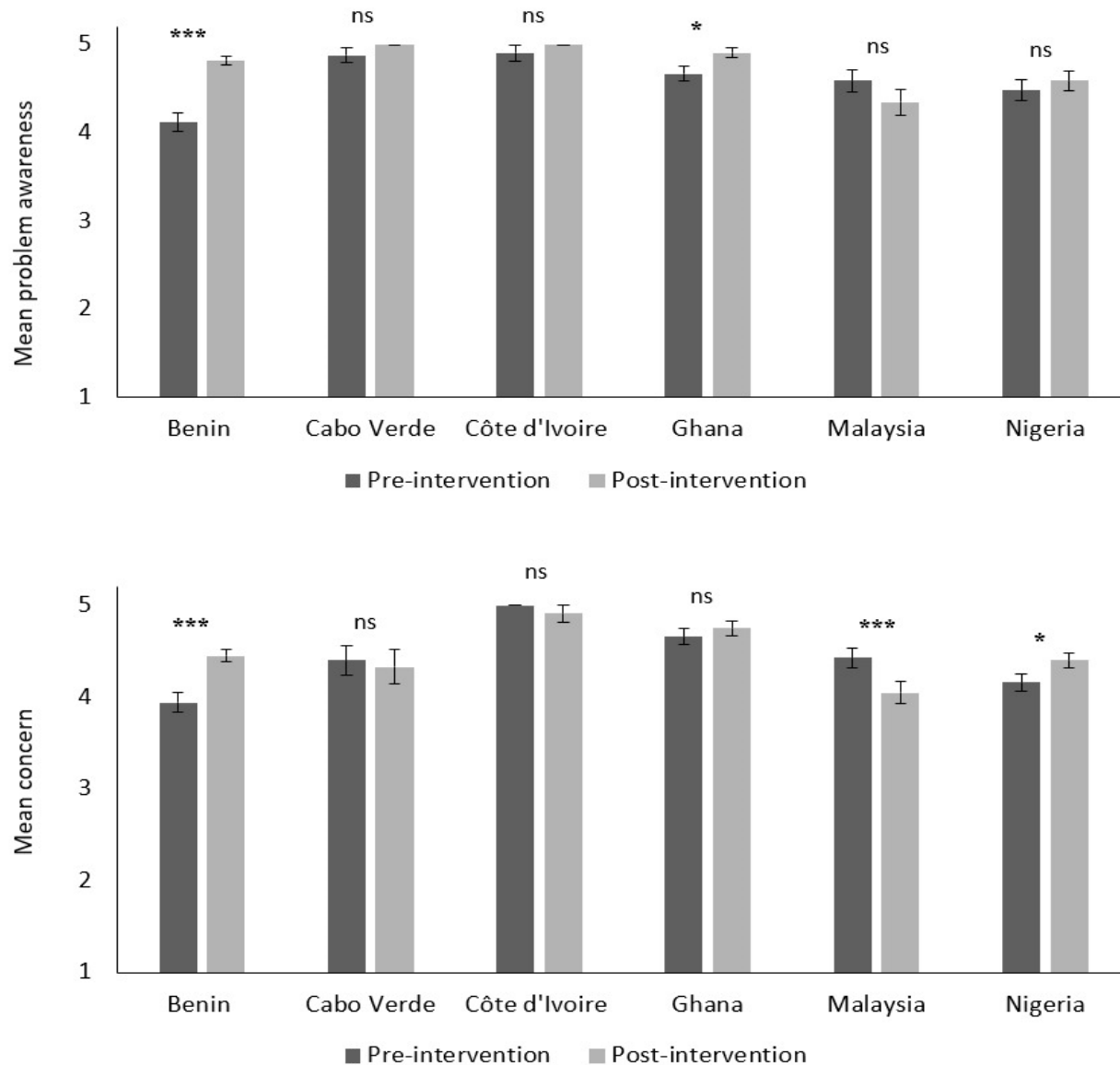
Awareness and knowledge of marine litter

Problem awareness and concern

Results demonstrate a high perception of marine litter as a problem at baseline in all participating countries ($M = 4.53$). This perception significantly increased at post-intervention in Benin (+14%; $p < .001$) and Ghana (+4.8%; $p = .021$; **Figure 1**). Students also considered marine litter to be more problematic in their own country than in other neighboring countries ($M = 3.42$), with a significant increase at post-intervention in Benin (+9.2%; $p = .013$). Nonetheless, students perceived marine litter as a future environmental threat rather than a present one ($M = 3.69$) and this did not significantly change at post-intervention for any of the countries. In terms of concern towards marine litter, a high baseline was reported overall ($M = 4.34$). At post-intervention, concern significantly increased in Nigeria (+4.8%; $p = .011$) and Benin (+10.2%; $p < .001$). In contrast, students in Malaysia reported a significantly lower concern at post-intervention (−7.6%; $p < .001$; **Figure 1**).

Figure 1

Student's Perceptions of Marine Litter as a Problem (top graph) and Concern towards Marine Litter (bottom graph) per Country, at Pre- and Post-Intervention (1 – 5 scale: strongly disagree–strongly agree)



Note. Error bars represent standard error. * $p < .05$; *** $p < .001$; ns = not significant

Perceived impacts and causes

Baseline responses indicated that students perceived marine litter as adverse for marine wildlife ($M = 4.57$), tourism ($M = 4.14$), human health ($M = 4.49$), fishing activities ($M = 4.22$), and the appearance of the coast ($M = 4.29$). As Friedman tests demonstrated that these impacts were perceived differently at

baseline for each country, Bonferroni-corrected pairwise comparisons were performed to evaluate these differences. Marine litter was perceived as having greater negative impacts on marine wildlife and human health than on the appearance of the coast, tourism, and fishing activities in Nigeria, Benin, and Cabo Verde. No significant differences were found between the perceived impacts in Côte d'Ivoire and Ghana. In Malaysia, negative impacts of marine litter were perceived to be greater on marine wildlife in comparison to tourism, human health, and fishing activities. A more detailed analysis of each country is available in Supplementary Materials. Furthermore, perceptions of the negative impacts on marine wildlife increased significantly at post-intervention in Benin ($p < .001$). Perception of the negative impacts on tourism also significantly increased after the intervention, in Nigeria ($p = .041$), Benin ($p < .001$), and Cabo Verde ($p = .004$). Additionally, a significant increase was found in perceived negative impacts on fishing activities in Benin ($p < .001$), and on the appearance of the coast in Nigeria ($p = .041$) and Benin ($p < .001$). In contrast, a significant decrease in perceived negative impacts on fishing activities was found in Malaysia at post-intervention ($p = .045$). This shift in perception was found to significantly differ according to gender ($p = .01$), with males reporting a decreased perception (-13.6%) and females reporting a slightly increased perception (+2.2%).

In regard to perceived causes, students perceived, at baseline, that marine litter is due to people dropping litter ($M = 4.37$), not enough bins ($M = 3.32$), businesses and fishing activities ($M = 3.54$), too much packaging ($M = 3.54$), and rivers discharging wastes into the sea ($M = 3.34$). For every country, Friedman tests indicate that these causes were perceived differently at baseline, thus we conducted Bonferroni-corrected pairwise comparisons to assess these differences. A common difference found in all countries was that people dropping litter was perceived as a greater cause of marine litter than all other causes. In Malaysia and Nigeria, product packaging and businesses and fishing activities were perceived to contribute more to marine litter than the lack of bins, whereas in Benin, product packaging and lack of bins were perceived as greater causes than businesses and fishing activities. Additionally, a lack of bins was perceived as a greater cause than rivers discharging wastes into the sea, in Ghana and Benin. A more detailed analysis of each participating country can be found in the Supplementary Materials. Post-intervention responses indicate significant increases for every perceived cause of marine litter, with the exception of lack of bins for which there were no significant changes. The perception of people dropping litter as a cause of marine litter significantly increased in Benin ($p = .017$) and Nigeria ($p = .031$) but decreased in Malaysia ($p = .003$). The perception of the role of businesses and fishing activities also significantly increased in Benin ($p = .008$), Cabo Verde ($p = .005$), and Ghana ($p = .026$). Students' perceptions about the extent that too much product packaging contribute to marine litter significantly

increased in Benin ($p = .014$), Cabo Verde ($p = .019$), Côte d'Ivoire ($p = .032$), and Ghana ($p = .018$). Finally, the perception of rivers discharging wastes into the sea as a cause of marine litter significantly increased in Côte d'Ivoire ($p = .035$) and Ghana ($p = .004$). Visit frequency to the beach was found to negatively correlate with the difference between pre and post-intervention perceptions of rivers discharging wastes into the sea in Ghana ($r_s = -.387$, $p = .029$), meaning that those who visit the beach more frequently tended to have decreased perceptions after taking part in COLLECT.

Knowledge of marine litter

A higher percentage of students in Ghana (+23%) and Côte d'Ivoire (+12%) stated the correct response to the degradation time of a plastic bottle after taking part in COLLECT. This was not the case in other countries, as there was an increase in the percentage of students responding “more than 100 years” instead. In terms of perceived plastic salience, results indicate that students had a high perception of plastic salience at baseline. The majority (70%) of students considered plastic to represent more than 50% of marine litter at baseline. This perception significantly increased at post-intervention in Benin ($p = .002$). About 83% of the students responded that plastics constituted the most common type of litter found on their local coastline and the percentage remained similar at post-intervention (85%). About 64% of the students believed that plastic bottles had increased between 35-75% over the last ten years. No significant changes concerning that assumption were found in either of the countries at post-intervention. Finally, about 33% of the students responded that on average there were between two to five pieces of litter per meter found on their local coastline, and 48.5% responded there were five pieces or more. Students in Benin perceived a significantly greater number of litter pieces per meter at post-intervention ($p = .014$).

Attitudes and behaviors towards marine litter and the environment

Attitudes towards beach litter removal

At baseline, students reported low agreement that only those who originally pollute the beach are responsible for removing beach litter ($M = 2.42$), moderate agreement that it is the responsibility of the local government ($M = 3.25$) and the local community ($M = 3.73$) for removing beach litter and high agreement that everyone is responsible for beach litter removal, including themselves (i.e., collective responsibility) ($M = 4.39$). They also reported high agreement that collective activities are important to keep the beach litter-free ($M = 4.29$). Friedman tests demonstrate significant differences between these items, at baseline, in every country. We therefore performed Bonferroni-corrected pairwise comparisons to evaluate these differences. In all countries, beach litter removal was more perceived to be everyone's responsibility, rather than the responsibility of only the original polluters. Collective responsibility was

also more perceived than the responsibility of the local government, in all countries except for Benin. In Nigeria and Ghana, collective responsibility was more perceived than the responsibility of the local community as well. A more detailed analysis of each country can be found in the Supplementary Materials. Furthermore, post-intervention responses in Benin indicate a significantly increased perception that the local community is responsible for beach litter removal ($p = .007$) whereas responses in Malaysia indicate a significantly decreased perception ($p = .032$). This contrast is also shown in regards to the perception that collective activities are important to keep the beach litter-free, i.e., increased perception in Benin ($p < .001$) and decreased perception in Malaysia ($p = .029$). Finally, students in Benin also reported a significantly increased perception of collective responsibility towards beach litter removal at post-intervention ($p < .001$).

Pro-environmental attitudes

With regard to pro-environmental attitudes, students reported a high endorsement of the rights of nature ($M = 3.91$), a high recognition of the possibility of an eco-crisis ($M = 4.08$), and a low rejection of human exemptionalism ($M = 2.73$), at baseline. No significant changes at post-intervention were found in the endorsement of the rights of nature in any of the countries. A significant increase in the recognition of the possibility of an eco-crisis was found in Benin (+5.8%; $p = .001$), accompanied with a contrasting significant decrease in the rejection of human exemptionalism (-4.9%; $p = .045$). It is important to keep in mind however that the three factors describing pro-environmental attitudes presented low reliability scores.

Self-reported litter-reducing behaviors

Baseline responses indicate that students reported a moderate frequency of buying goods with less packaging ($M = 2.81$), avoiding the use of plastic bags in the supermarket ($M = 2.67$), and encouraging family and friends to engage in these actions ($M = 2.78$). A low frequency was reported in terms of picking up litter on the beach ($M = 1.92$), and a moderate frequency was reported in terms of disposing litter properly ($M = 3.54$). For every country, a Friedman test demonstrates significant differences between these behaviors at baseline, thus we conducted Bonferroni-corrected pairwise comparisons to assess these differences. Students reported significantly greater levels of appropriate litter disposal than picking up litter on the beach (all countries), buying goods with less packaging (Nigeria and Malaysia), avoiding plastics bags (Nigeria, Cabo Verde, and Ghana), and encouraging family and friends to act (Nigeria, Benin, and Malaysia). Buying goods with less packaging and encouraging family and friends to act were performed more frequently than picking up litter on the beach in Nigeria, Benin, Côte d'Ivoire, and Ghana. Additionally, these actions were performed more frequently than avoiding the use of plastic bags in

Nigeria. A more detailed analysis of each country can be found in the Supplementary Materials. After participating in COLLECT, students in Benin reported a significantly higher frequency of appropriate litter disposal ($p < .001$), of encouragement of family and friends ($p < .001$), and of buying goods with less packaging ($p < .001$). This increase in buying goods with less packaging was found to be positively correlated with coastal visit frequency ($r_s = .284, p = .022$). Furthermore, at post-intervention students in Nigeria ($p < .001$), Benin ($p < .001$), and Ghana ($p = .005$) reported a significant increase in picking up litter on the beach. Finally, a significant increase in avoiding the use of plastic bags in the supermarket was also reported by students in Benin ($p < .001$), Cabo Verde ($p = .039$), and Ghana ($p = .001$). **Table 2** illustrates the pre- and post-intervention means of each self-reported litter-reducing behavior, per country.

Pro-environmental behavioral intentions

At baseline, students reported moderate intention to participate in future beach clean-ups ($M = 3.40$), to buy products with less packaging ($M = 3.53$), to recycle ($M = 3.82$), and to re-use plastic bags ($M = 3.57$). After participating in COLLECT, the intention to participate in future beach clean-ups significantly increased for students in Benin (+13.4%; $p = .001$) and Ghana (+9.6%; $p = .019$). Nonetheless, the change in intention to participate in beach clean-ups was found to be negatively correlated with age in Benin ($r_s = -.248, p = .046$) and to be positively correlated with age in Ghana ($r_s = .357, p = .049$). Older students in Benin therefore expressed less willingness to participate in beach clean-ups at post-intervention, whereas older students in Ghana expressed more willingness. Furthermore, students in Benin reported a significant increase in the intention to buy products with less packaging (+9.2%; $p = .003$), to recycle (+12.8%; $p = .002$), and to re-use plastic bags (+9.8%; $p = .008$). However, the shift in intention to re-use plastic bags was found to significantly differ according to gender ($p < .001$), with males reporting an increased intention (+20.6%) and females reporting a slightly decreased intention (-6.2%), at post-intervention (**Figure 2**).

Well-being and nature connectedness

Differences between pre- and post-intervention mean scores of well-being were evaluated with a paired samples t-test for each country. Only students in Benin reported a significant increase in well-being after participating in COLLECT (+6.4%; $p < .001$; **Figure 3**). Change in happiness was assessed with a Wilcoxon's matched-pairs signed ranks test for each country. In parallel with well-being, students in Benin demonstrated a significant increase in happiness at post-intervention (+12.3%; $p < .001$). Furthermore, at baseline, students displayed an average of 60.78 ($SD = 25.8$) on an index going from 0 to 100 for nature connectedness. Differences between pre- and post-intervention mean scores of nature connectedness

were evaluated with a paired samples t-test for each country. A significant increase in nature connectedness was found for students in Benin at post-intervention (+18.9%; $p < .001$), whereas a significant decrease was found for students in Malaysia (-8.3%; $p = .007$; **Figure 3**).

Satisfaction with COLLECT

Students reported high satisfaction with the COLLECT project, with average scores above nine (out of ten), with the exception of students in Nigeria ($M = 7.86$) and in Malaysia ($M = 6.65$). Students from all countries considered the COLLECT project to be highly worthwhile and meaningful to them (average scores above four, out of five), with the exception of Malaysia ($M = 3.35$). More than 50% of the adjectives used to describe the COLLECT project referred the project to be “motivating”, “informative”, “inspiring”, and “enjoyable”. About 15% referred the project to be “challenging”, “gratifying”, and “tiring”. Finally, 6% of the adjectives attributed the project as “boring” and “frustrating”, and 2% as “pointless”.

Students and/or teachers also had the option to fill in a feedback form evaluating their thoughts and opinions regarding COLLECT. When asked how we could improve the project, teachers from Morocco and Nigeria responded with a common opinion, namely that the project should be expanded in some way (e.g. by increasing the number of participants or schools involved, or replicating the project several times). One teacher in particular expressed a need for “more education, especially among the younger generation, on recycling and renewable energy”. Teachers also reported several aspects of the project that they liked or appreciated, namely the “hands-on” experience of the field activities and the efficiency and coordination of the project. When asked to what extent the project influenced interest in science and a pursuit in a scientific career, about half of the students from Cabo Verde replied positively, e.g. “I've always had this curiosity to work in the scientific field and this project gave me the inspiration I needed to really want to continue with this career”. The learning outcomes of the project reported by the students from Cabo Verde included: how to differentiate the types of plastic, how to sample and analyze plastic, the presence of microplastics, how to work as a team, the impacts of plastic on nature and humans, and the importance of reducing plastic consumption. The project was a learning experience for the teachers as well, as teachers stated learning about the presence of plastics that are “too small to see with the naked eye”, the methodology for plastic sampling, and the negative effects of plastic waste on the ecosystem and humans.

Table 2

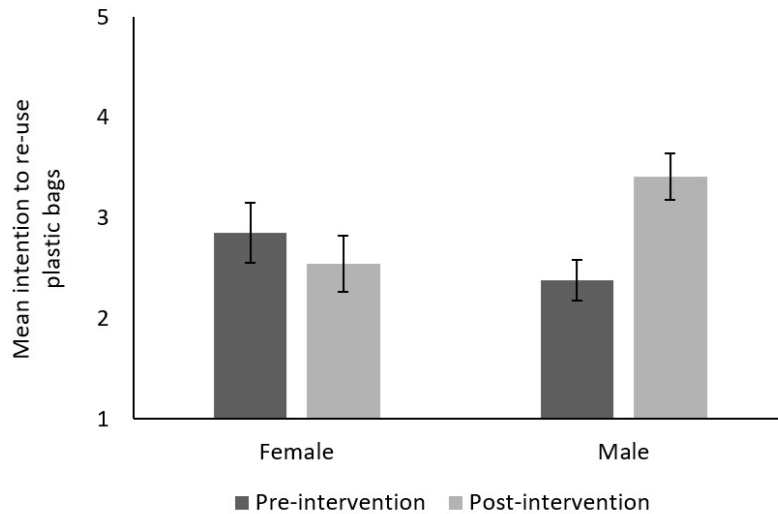
Means (and SD) for Self-Reported Litter-Reducing Behaviors per Country, at Pre- and Post-Intervention (1 – 5 scale: never–a great deal)

Self-reported litter-reducing behaviors, per country	Pre-intervention M (SD)	Post-intervention M (SD)
Benin		
Disposed of litter properly	2.92 (1.39)	3.74 (1.25)***
Picked up litter on the beach	1.32 (0.78)	2.56 (1.03)***
Bought goods with less packaging	2.28 (1.02)	3.37 (1.19)***
Avoided using plastic bags in the supermarket	2.31 (1.10)	3.34 (1.18)***
Encouraged family and friends to act	1.91 (1.01)	3.46 (1.26)***
Cabo Verde		
Disposed of litter properly	3.93 (1.27)	4.36 (0.84)
Picked up litter on the beach	2.64 (1.28)	3.00 (0.96)
Bought goods with less packaging	2.92 (0.64)	2.92 (0.76)
Avoided using plastic bags in the supermarket	2.50 (1.02)	3.36 (1.08)*
Encouraged family and friends to act	3.14 (1.23)	3.86 (1.10)
Côte d'Ivoire		
Disposed of litter properly	3.36 (1.63)	3.64 (1.36)
Picked up litter on the beach	2.27 (1.42)	3.09 (1.14)
Bought goods with less packaging	3.09 (1.22)	3.55 (1.04)
Avoided using plastic bags in the supermarket	2.91 (1.22)	3.55 (1.51)
Encouraged family and friends to act	3.70 (1.49)	3.90 (1.29)
Ghana		
Disposed of litter properly	3.91 (1.23)	4.19 (1.03)
Picked up litter on the beach	2.48 (1.02)	3.38 (1.15)**
Bought goods with less packaging	3.43 (1.01)	3.70 (1.12)
Avoided using plastic bags in the supermarket	2.81 (1.51)	3.52 (1.36)**
Encouraged family and friends to act	3.48 (1.21)	3.87 (1.10)
Malaysia		
Disposed of litter properly	3.92 (0.98)	3.89 (0.87)
Picked up litter on the beach	2.24 (1.16)	2.35 (0.92)
Bought goods with less packaging	2.84 (1.09)	3.05 (0.99)
Avoided using plastic bags in the supermarket	3.78 (1.29)	3.65 (1.18)
Encouraged family and friends to act	2.62 (1.16)	2.54 (1.17)
Nigeria		
Disposed of litter properly	3.85 (0.96)	3.87 (1.15)
Picked up litter on the beach	1.49 (0.85)	2.30 (1.13)***
Bought goods with less packaging	2.73 (1.06)	2.95 (1.24)
Avoided using plastic bags in the supermarket	1.97 (1.13)	2.03 (1.10)
Encouraged family and friends to act	2.69 (1.30)	2.84 (1.30)

Note. * $p < .05$; ** $p < .01$, *** $p < .001$. Post-intervention means in bold are significantly higher compared to pre-intervention means

Figure 2

Mean Behavioral Intention to Re-Use Plastic Bags in Benin, per Gender, at Pre- and Post-Intervention (1 – 5 scale: never–a great deal)



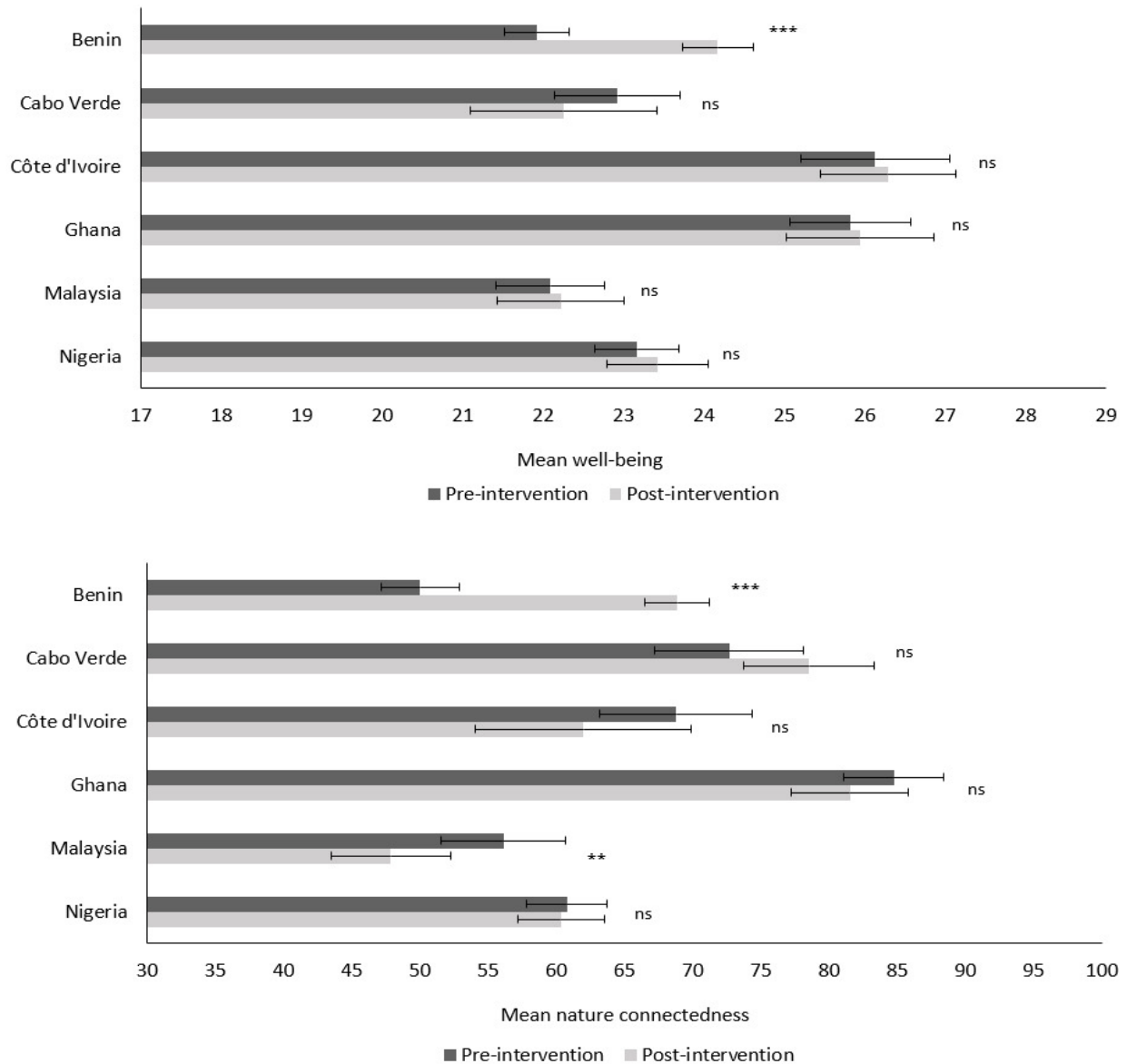
Note. Error bars represent standard error

Discussion

The results of the present study demonstrate that the citizen science intervention in COLLECT positively impacted ocean literacy in Benin, Ghana, Nigeria, Cabo Verde, and Côte d'Ivoire, to differing extents. Students in Benin and Ghana also displayed higher pro-environmental intentions after participating in COLLECT. An increased well-being and nature connectedness were found for students in Benin as well. Ocean literacy was conceptualized by awareness and knowledge towards marine litter, self-reported litter-reducing behaviors, and attitudes towards litter removal. In terms of awareness and knowledge, results indicate a high baseline of problem awareness and concern towards marine litter. This is a finding that has been frequently shown in previous studies investigating citizen science projects related to plastic pollution, namely in the United Kingdom (Hartley et al., 2015), in Italy (Locritani et al., 2019), in Chile (Wichmann et al., 2022), and in Denmark (Oturai et al., 2022). High concern towards marine plastic pollution is also prevalent in the general public in Europe, as displayed in a pan-European citizen survey (H2020 SOPHIE Consortium, 2020). The high baseline problem awareness could be linked with the age group of teenagers recruited in our study, as discussed in Locritani et al. (2019). However, younger children were also found to have high problem awareness prior to any intervention (Oturai et al., 2022; Wichmann et al., 2022). Furthermore, students demonstrated a high perceived salience of plastic on the

Figure 3

Student's Well-Being (top graph; min = 7, max = 35) and Nature Connectedness (bottom graph; min = 0, max = 100) per Country, at Pre- and Post-Intervention



Note. Error bars represent standard error. ** $p < .01$; *** $p < .001$; ns = not significant

coast prior to participating in COLLECT. More specifically, students already considered plastic to be the most common type of marine litter and perceived a high increase of the proportion of plastic bottles over recent years. Although students perceived marine litter as a problem, they somewhat perceived this problem to be a future environmental threat, rather than a present one, and this did not significantly

change after the intervention. This could indicate a form of temporal distancing from the problem (Hartley et al., 2018; Keller et al., 2022), associated with a perceived lack of urgency (Moser and Dilling, 2007). Future interventions should focus on making the urgency of the problem more apparent for the participants.

Students were highly aware of most causes and consequences of marine litter before participating in COLLECT. Similar to Hartley et al. (2015) and Locritani et al. (2019), the negative impact of marine litter on marine wildlife was generally perceived to be greater than the impacts on the appearance of the coast, tourism, and fishing activities. As stipulated by Hartley et al. (2018), this could be due to either the prominent portrayal of marine wildlife being affected by plastic in the media, or the greater value placed on marine wildlife in comparison to other impacts. The latter is consistent with the European public's strong concern towards the loss of marine biodiversity (H2020 SOPHIE Consortium, 2020). Unlike in Hartley et al. (2015) and Locritani et al. (2019), human health was also regarded as an important negative impact of marine litter. This is perhaps due to the increasing media representation of the health risks of plastics, particularly microplastics (Völker et al., 2020; Catarino et al., 2021). Students' perceptions of the causes of marine litter were in line with previous findings, i.e., the perception that people dropping litter is the main cause of marine litter (Campbell et al., 2014; Hartley et al., 2015; Van Dyck et al., 2016). After taking part in COLLECT, students demonstrated a better understanding of other causes of marine litter, i.e., the role of businesses and the fishing industry, product packaging, and rivers discharging wastes into the sea. Enhancing public knowledge of the sources of marine litter is essential as these are often disregarded in the public discourse (Pahl et al., 2017). Importantly, despite the high baseline, participating in COLLECT did lead to increased awareness and knowledge of marine litter, in the majority of the countries.

Consistent with Hartley et al. (2015) and Locritani et al. (2019), students reported greater levels of appropriate litter disposal than all other litter-reducing behaviors at baseline. Picking up litter on the beach was reported with the lowest frequency level, however this could be partially due to the low visit frequency to the beach reported by students (with exception of students from Cabo Verde and Côte d'Ivoire). Participating in COLLECT led to an increase in litter-reducing behaviors in four out of the six evaluated countries. This further supports the notion that citizen science projects have the capacity to impact positive behavior change, as well as awareness. Nonetheless, our study measured behavior through self-report items, and it would be beneficial for future research to assess behavior with experimental measures such as behavioral paradigms (Lange, 2022), to boost empirical evidence of an effect on behavior. Furthermore, in regards to attitudes towards beach litter removal, students already

displayed a high perceived personal responsibility towards removing litter from the beach prior to participating in COLLECT. Similar to Lucrezi and Digun-Aweto (2020), students considered beach litter removal as more of a shared responsibility rather than a government responsibility. This could indicate a high baseline of perceived behavioral control regarding removal of beach litter, and thereby an initial willingness to participate in local actions such as beach clean-ups. After the COLLECT intervention, students' perceived responsibilities did not significantly change, with exception to those in Benin and Malaysia.

Beyond having a positive impact on ocean literacy, participating in COLLECT also led to an increase in intentions to engage in more general pro-environmental behaviors, similar to Wyles et al. (2017). More specifically, students in Benin reported increased intentions to buy products with less packaging, to recycle, and to re-use plastic bags. An increased intention to participate in future beach clean-ups was also found for students in Ghana and Benin. These findings indicate that citizen science projects could lead to spillover effects in which impacting behaviors related to litter reduction encourages intentions to act more sustainably in one's daily life. Moreover, in terms of attitudes, a possible spillover effect could have occurred for students in Benin, in which a positive change in attitudes regarding litter removal (i.e., higher perceived collective responsibility) encouraged a positive increase in pro-environmental attitudes (i.e., higher recognition of the possibility of an eco-crisis).

With exception to students in Benin, participating in COLLECT did not significantly affect pro-environmental attitudes. At baseline, students did report a somewhat high endorsement of rights of nature and a high recognition of a possibility of an eco-crisis. However, this was accompanied with a low rejection of human exemptionalism. To interpret these findings, it is important to consider the cultural context of the participating countries. To a certain extent, the pro-environmental attitudes reflected here resemble those reported by Nigerian students (Ogunbode, 2013), Zimbabwean children (Van Petegem and Blicek, 2006), and Senegalese children (Grůňová et al., 2019). These studies found that participants have both an ecological and utilitarian view of the environment. More specifically, although participants are concerned with the negative effects that humans have on nature, they also show faith in the recovery of nature from human interference and in the possibility of gaining control of nature. Ogunbode (2013) argues that this control of nature is viewed as possible through spiritual empowerment, with the means of religious ritual and negotiation. The low internal consistency of the NEP factors in our sample further demonstrates this dualistic perspective. For example, students show agreement that people should obey the laws of nature but are also supposed to rule over nature, similar to Grůňová et al. (2019). Although the NEP has been rated as the most comprehensive and widely used scale to measure pro-environmental

attitudes (Somerville and Wehn, 2022), our results are consistent with the notion that the perspective utilized by the NEP only partially represents the ecological worldviews within an African context (Ogunbode, 2013). Moreover, possessing anthropocentric values should not be regarded as a barrier towards implementing pro-environmental behaviors. Indeed, recent findings challenge this stereotype by demonstrating a strong expression of pro-environmental behavior in people with anthropocentric values and a high connection with nature (Sockhill et al., 2022). Better understanding of these particular ecological worldviews is thus needed to tailor the interventions and educational modules targeting students from African countries.

Participating in COLLECT did not significantly impact well-being, nor nature connectedness (with exception to students in Benin and Malaysia). The participating countries presented an average baseline in well-being, as their mean scores are comparable to the mean score of the adult population in the United Kingdom (Ng Fat et al., 2017; **Figure 3**). Nevertheless, we cannot exclude the possibility that there was a positive impact on happiness or nature connectedness immediately after the citizen science activities, as post-intervention measurements were taken 1 week after the activities ended. Additionally, results indicate that the COLLECT project was perceived to be highly worthwhile and meaningful, consistent with findings from Wyles et al. (2017). Perhaps the focus on plastic pollution and the exposure to a littered environment curtailed the potential restorative qualities of the coast and induced negative emotions, including a more pessimistic outlook regarding the future of the environment (Severin et al., 2023). As such, the meaningfulness of the citizen science activities was perhaps not sufficient to counteract this (Wyles et al., 2017). Another possibility could be that students did not perceive the coast as a place of leisure and restoration and therefore did not expect to feel happier or more relaxed after visiting the beach. Indeed, the cultural context most likely also plays a role here in shaping the relationship and interactions with the coast (Wheaton et al., 2020). For example, it is possible that a portion of the students consider the coast as a dangerous place or merely view it as a source of food and resources (Wheaton et al., 2020; Phoenix et al., 2021). Despite their close proximity to the coast, the average visit frequency to the beach was less than once a week. Finally, students participated in COLLECT as part of a school activity, which induces the possibility of perceiving the project as more of an obligation and not as a leisure activity (similar to Wyles et al., 2017). With regards to nature connectedness, the baseline mean score of the students is comparable to the mean score found for children aged 7 to 15 years in the United Kingdom (Richardson et al., 2019). Half of the participating countries displayed even higher mean scores (see **Figure 3**), indicating a higher than average baseline of nature connectedness. The non-significant impact of COLLECT on nature connectedness is in contrast to findings from Koss and Kingsley

(2010), although their study is based on volunteers and not schoolchildren, which therefore increased the likelihood of prior motivation and interest to engage with nature.

Influence of country, age, and gender on intervention effects

Each country presented unique results in terms of the effect of the COLLECT project on ocean literacy, pro-environmental intentions and attitudes, and well-being. Two countries in particular demonstrated contrasting findings, namely Benin and Malaysia. A positive change in almost all outcomes was found for students in Benin, indicating that the COLLECT project was effective in enhancing awareness towards marine litter, motivating students to engage in litter-reducing behaviors and to act more sustainably, and boosting students' well-being and nature connectedness. It is important to note however that compared to the other countries, students in Benin reported a lower baseline for the majority of the outcomes, and thus possessed greater room for change. In contrast, students in Malaysia reported a negative change in several outcomes, namely in concern towards marine litter, in perceived impacts and causes of marine litter, in attitudes regarding beach litter removal, and in nature connectedness. Students in Malaysia were also the least satisfied with the COLLECT project and reported the lowest rating in terms of its meaningfulness. Importantly, during the field sampling at the beach, students in Malaysia did not collect any macroplastics and could only sample very few microplastics, as the beach was frequently cleaned by the hotels in the area. This means that students did not directly perceive litter at the beach, thereby potentially reducing the perception of the salience of marine litter on the coastline and creating disinterest towards the aims of the project, similar to findings from Oturai et al. (2022). This is in line with the fact that students in Benin collected the most macroplastics compared to other countries (Catarino et al., 2022), and therefore perceived a strong presence of plastics on the coast, which can partly explain the positive outcomes of the project previously mentioned.

Very few differences in intervention effects were found in terms of age and gender. Indeed, Hartley et al. (2018) demonstrate how age and gender are less important predictors of concern towards marine litter than factors such as values and social norms. Apart from influencing the pre- to post-intervention change in intention to participate in beach clean-ups in Benin (negatively) and Ghana (positively), age did not influence the main intervention effects. This could be due to the low age range with the majority of our sample being between 14 and 18 years old. Previous studies reported differences between those aged 7–12 years and those aged 13–16 years (Hartley et al., 2015; Locritani et al., 2019; Oturai et al., 2022), therefore, age effects are more likely to appear when comparing children with adolescents. The effects of participating in COLLECT did not differ according to gender, except for two

outcomes. First, the perception of the negative impact of marine litter on fishing activities decreased for males and slightly increased for females, in Malaysia. Malaysian women are typically less involved in fishing activities, especially in the capture of seafood (Siason et al., 2001). We would therefore expect that they would feel less concerned with the negative impact of marine litter however this was the case for men, and not women. Second, male students in Benin reported an increased intention to re-use plastic bags whereas female students reported a slightly decreased intention. This contrast could stem from a gender disparity in which women are typically more responsible for household duties and therefore need stronger motivation to change their habits such as re-using plastic bags to buy groceries.

Limitations and future directions

The present study evaluates the impact of a large-scale citizen science project implemented in multiple countries, presenting a unique opportunity for obtaining diverse knowledge from underrepresented regions. This however also led to several methodological limitations that should be considered. First, although the implementation of the project was standardized as much as possible (Catarino et al., 2023), there are notable differences between the countries. One difference is in regards to the time period between the pre- and post-surveys (i.e., 1 month for Nigeria, Benin, Ghana, and Malaysia; 5/6 months for Cabo Verde, Côte d'Ivoire, and Morocco). Additionally, the surveys were conducted in different languages, leading to potential differences in the interpretation of certain words or expressions between the countries. Nonetheless, results of each country were analyzed separately and thus no statistical comparison between countries was made. Furthermore, as is often the case with follow-up measures, results portray only a subset of the total sample (58%) because not all students completed both the pre- and post-surveys. This led to a reduced sample size and a loss of valuable information. Moreover, the data from the surveys had to be manually transferred to a computer due to the surveys being completed in paper format, and was therefore exposed to potential human error. Finally, although efforts were made to use psychometric scales that were validated in various cultural settings (e.g., the SWEMWBS; Stewart-Brown et al., 2009), it is essential to consider the influence of the cultural context upon the validity of the scales and items included in our study.

For future research conducting citizen science in African regions, we recommend further investigation into how African youth shape their environmental attitudes and perspectives regarding current issues such as plastic pollution. For example, it would be beneficial to first conduct a qualitative study exploring the awareness and attitudes of students and teachers and the perceived barriers hindering behavioral change. The resulting knowledge could then be utilized to integrate educational

workshops tailored to these unique perspectives into the global citizen science project. As Wichmann et al. (2022) recommend, these educational modules should inform strategies and competencies for students to adopt to enhance empowerment towards tackling environmental issues. We also recommend to use measurements that have been validated in non-WEIRD populations (Western Educated Industrialized Rich Democratic). Furthermore, to promote empirical evidence of a positive effect of citizen science on attitudes and behavior relating to marine litter, we suggest implementing a longitudinal design to evaluate whether beneficial effects remain in the long-term. Additionally, specifically in terms of beach clean-ups or sampling of beach litter, there should be further research on the influence of the extent of litter present on the beach on subsequent perceptions regarding plastic pollution and motivations for sustainable action (in reference to the negative impacts shown in Malaysia).

Conclusion and Implications

In conclusion, the present study highlights the effectiveness of a citizen science intervention to positively impact ocean literacy. Despite a high baseline, students demonstrated greater awareness and a better understanding of the causes and consequences of marine litter, in the majority of the participating countries. Participating in COLLECT also led to an increase in litter-reducing behaviors, such as picking up litter on the beach and avoiding the use of plastic bags. Students reported a high baseline of perceived personal responsibility towards beach litter removal and this did not change at post-intervention. Some shortcomings to the project can be noted. To a certain extent, taking part in COLLECT did not reduce temporal distancing from the issue of marine litter, nor did it positively change pro-environmental attitudes. Moreover, students in Malaysia demonstrated negative shifts in awareness and knowledge, in attitudes towards beach litter removal, and in nature connectedness, possibly due to a lack of perceived salience of marine litter at their local coastline. Nonetheless, participating in COLLECT led to higher pro-environmental behavioral intentions for students in Benin and Ghana, indicating a positive spillover effect. Students from Benin are shown to have benefited the most out of participating in COLLECT as they also demonstrated higher well-being and nature connectedness after the citizen science intervention. The COLLECT project was overall positively perceived by the students and teachers and evaluated as an important learning experience.

In light of these findings, we stress the importance of evaluating the educational and behavioral benefits of citizen science interventions to address plastic pollution on a societal and individual level. Understanding the perceptions regarding marine litter can have important implications for management and policy decision-making. As showcased in Sumeldan et al. (2021), gaining knowledge into how local

communities perceive a particular issue can help inform stakeholders on how to best communicate about this issue or on how to adapt strategies targeting behavior change in accordance with the attitudes and motivations of the public. Moreover, displaying empirical evidence of the positive impacts of citizen science on participants enables to enlarge the range of citizen science benefits and encourage researchers and organizations to implement it wherever possible.

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General Discussion

The overall aim of the present dissertation was to enhance our knowledge of how and why coastal landscapes impact well-being. Three research objectives were set up to understand the emotional mechanisms and moderating factors underlying the effect of coastal landscapes on well-being and pro-environmental attitudes and behaviors. This general discussion first provides an overview of the dissertation's main findings in relation to the three research objectives (Figure 1). Afterwards, the findings are integrated and interpreted in accordance with the current state-of-the-art. I then discuss the theoretical applications and practical considerations, as well as strengths, limitations and future research directions.

Overview of the Main Findings

RO1: To understand the emotional mechanisms underlying the relationship between coastal landscapes and well-being

The primary research objective of this dissertation was to investigate the emotional processes associated with coastal landscapes and to assess to what extent these processes act as underlying mechanisms in the effect of the coast on well-being.

Before looking into the emotional mechanisms, it should first be noted to what extent coastal landscapes had a positive impact on well-being in the research studies. In **Chapter 1**, with the use of a quasi-experimental study, I found that having access to the coast was positively associated with well-being, during the first-wave lockdown of the COVID-19 pandemic. Inland residents were more likely to report an increase in boredom and worry, and a lower happiness, than coastal residents. No difference in terms of stress and well-being, as measured by the Short Warwick Edinburgh Mental Well-Being Scale (SWEMWBS; Stewart-Brown et al., 2009), were found. Visiting the coast more frequently during the lockdown was not found to be associated with a higher well-being.

Other direct evaluations of the effect of the coast on well-being can be found in **Chapter 3**. In two experimental studies, participants who were exposed to a video-clip of either a beach with a sunset, or coastal dunes, demonstrated a stronger reduction in stress compared to participants exposed to a video-clip of an urban street. Exposure to these coastal landscapes did not, however, impact meaning-focused coping in Study 1. Finally, in **Chapter 4**, the effect of real-life exposure to the coast on well-being was investigated via an *in situ* experiment in which participants took part in a guided walk, either along the beach or in an urban street. No significant differences were found in terms of changes in stress, mood, or worry. Chapter 4 therefore did not show support for a positive relationship between the coast and well-being.

Investigation of the emotional mechanisms underlying the relationship between coastal landscapes and well-being began with an initial look into potential mediation of awe and nostalgia in Chapter 1. More specifically, I assessed whether awe and nostalgia mediated the association between coastal visits and well-being. Coastal visits did not lead to a higher experience of awe and nostalgia compared to visits to other natural landscapes. However, experiencing awe at the coast was linked with a lower likelihood of reporting an increase in boredom during the lockdown.

A more comprehensive examination of emotional mechanisms is reported in **Chapter 2**, which presents a qualitative study exploring how coastal residents make sense of the emotions they experience at the coast and of how these emotions affect them. I conducted semi-structured interviews with eight young adults, who grew up near the Belgian coast and/or were currently living there. Through the use of Interpretative Phenomenological Analysis (IPA; Smith et al., 2009), I identified five superordinate themes: emotional restoration, awe, nostalgia, adaptive emotion-regulating strategies, and the coast as a safe haven.

Emotional restoration referred to feelings of calmness and revitalization that participants experienced when visiting the coast. The theme of awe showcased elements of the coast that were perceived as larger than one's self, such as the power and grandeur of the sea. The described experience of awe was accompanied with feelings of small self and humility, as well as unique physical sensations. With regards to nostalgia, participants evoked enduring memories created at the coast, whose recollection could be triggered through symbolic interactions with coastal stimuli. Both awe and nostalgia were demonstrated to be ambivalent, as the expression of awe ranged from fear to fascination, and nostalgic memories were linked with positive affect and sometimes a feeling of loss. In relation to these emotions, participants described several emotion-regulating strategies associated with the coast. These strategies included: being able to reflect, accept or positively reappraise stressors or emotions, to let go or exteriorize emotions, and to seek experiences of peak flow or positive stimulation. These emotional processes emerged partly due to the representation of the coast as a safe haven. The coast offered respite from the stressors and pressures of daily life, as participants were able to feel disconnected from reality and experience a sense of timelessness. The coast also provided feelings of familiarity and freedom, that were emphasized through the opportunities to be alone. Overall, the described emotional experiences elicited by the coast are most likely to be beneficial for well-being, highlighting an initial picture of their role as emotional mechanisms.

The emotions of awe (more specifically small self), nostalgia, and nature connectedness were evaluated as potential mediators in the effect of coastal landscapes on stress reduction in Chapter 3. In

both experimental studies, watching video-clips of a beach with a sunset, or coastal dunes, led to a higher experience of the emotions of small self, nostalgia, and nature connectedness, compared to watching a video-clip of the urban street. In Study 1, the emotions did not significantly affect stress reduction, and thus no mediation effects were found. In Study 2, nostalgia and nature connectedness, but not small self, had positive effects on stress reduction and were shown to be significant mediators. Study 1 additionally addresses the role of these emotions on coping. The more participants experienced small self and nature connectedness while watching the video-clips, the more likely they would engage in meaning-focused coping if confronted with a past stressful moment.

To further test the link between coastal landscapes and adaptive emotion-regulating strategies, I created a scale measuring the emotion-regulating strategies identified in Chapter 2. Participants exposed to the coast were more likely to perceive the type of depicted environment as a place where they could engage in adaptive emotion-regulating strategies, compared to participants exposed to the urban street. This higher likelihood was significant for each strategy included in the scale, as well as for the aggregated mean.

RO2: To determine factors that moderate the relationship between coastal landscapes and well-being

The secondary research objective of this dissertation was to assess to what extent presence of plastic litter, income level, and engagement level act as moderators in the effect of coastal landscapes on well-being.

In Study 1 of Chapter 3, each video-clip depicting a specific environment type (i.e., beach with sunset, coastal dunes, urban street) either contained plastic litter or not. The effects of coastal landscapes on stress reduction, and on the emotions of small self, nostalgia, and nature connectedness, did not differ according to whether plastic was present or not. The presence of plastic did not moderate the relationship between the emotions and stress reduction, nor did it moderate all three mediation pathways simultaneously. Moreover, the presence of plastic had no effect on meaning-focused coping.

The moderating role of income level was tested in Study 2 of Chapter 3. The study's sample represented different levels of individual net income: no income, < €1250, €1250 - €2000, €2000 - €2500, > €2500. In a model that simultaneously assesses moderation of income in all three mediation pathways, income level moderated both the c' -path and b -path. More specifically, for participants earning no income, being exposed to the beach with a sunset led to less stress reduction, in comparison to being exposed to the urban street (i.e., moderation of c' -path). However, for that sample group, experiencing nostalgia had a stronger positive effect on stress reduction (i.e., moderation of b -path). Furthermore,

nostalgia positively mediated the effect of both coastal landscapes on stress reduction, only for participants earning no income. Overall, the study demonstrated a potential buffering role of nostalgia, such that coastal exposure had a less beneficial effect on stress for participants earning no income, but the more these participants experienced nostalgia during coastal exposure, the more their stress levels were reduced.

In Chapter 4, I assessed differential effects between three levels of engagement during coastal exposure. Participants walking along the beach were instructed to either, be mindful of their surroundings (mindful engagement), let their mind wander (mind-wandering), or follow various mental visualization tasks (distraction). No significant group differences were found for changes in stress, mood, or worry. Nonetheless, exploratory analyses of potential differences in emotional experience revealed higher awe in both mind-wandering and mindful engagement groups. Furthermore, being mindfully engaged at the coast led to a higher experience of nature connectedness and higher use of adaptive emotion-regulating strategies, in comparison to being distracted during an urban walk. The emotions of small self and nostalgia did not significantly differ between the groups. Further exploration demonstrated positive mediation of emotion-regulating strategies in the effect of mindful engagement on increase in low-arousal positive mood. This result must be treated with caution as the total effect of environment type and engagement level was not significant.

RO3: To comprehend the relationship between coastal landscapes and pro-environmental attitudes and behaviors, as well as the associated emotional mechanisms and moderating factors

The final research objective of this dissertation was to evaluate the relationship between coastal landscapes and pro-environmental attitudes and behaviors (PEABs), and to assess the emotional mechanisms and moderating factors of this relationship.

In Study 1 of Chapter 3, I included pro-environmental attitudes as an outcome. Being exposed to a coastal landscape, either with or without plastic, did not have a significant impact on pro-environmental attitudes. As expected, experiencing nature connectedness while watching a video-clip of the coast was associated with higher pro-environmental attitudes. Neither small self nor nostalgia significantly correlated with pro-environmental attitudes.

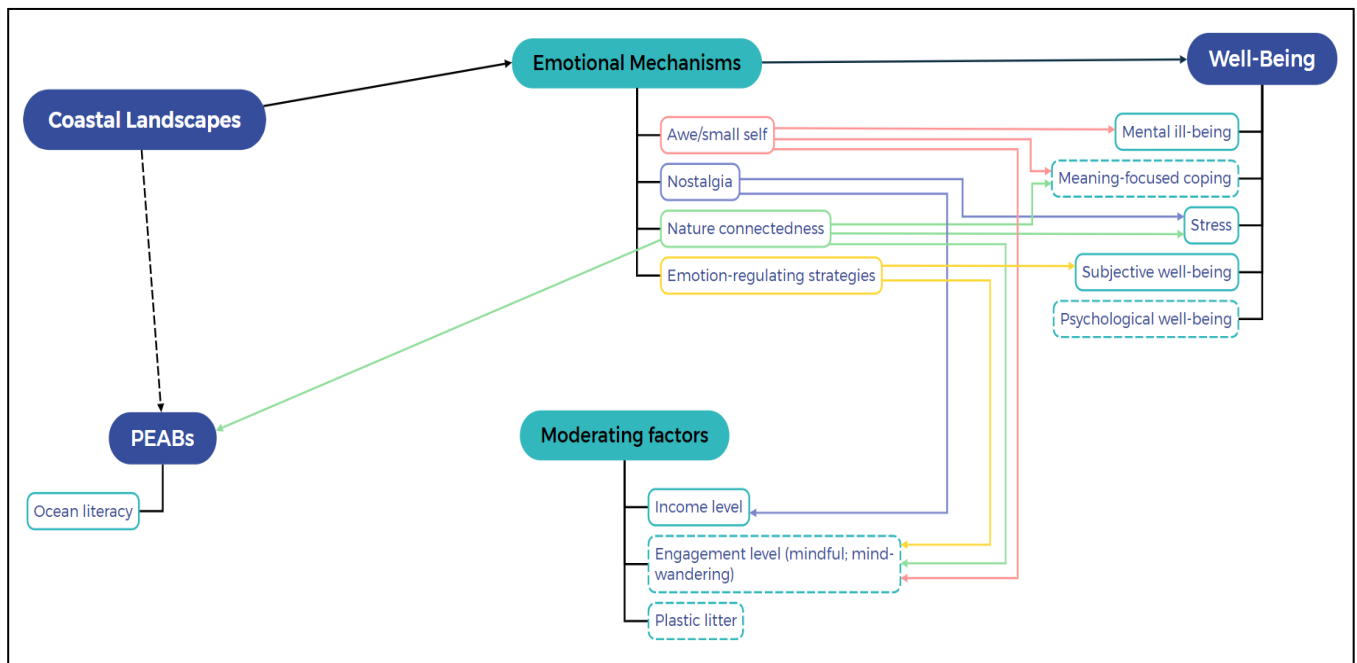
In Study 2 of Chapter 3 and Chapter 4, pro-environmental behavior was measured with the Work for Environmental Protection Task (WEPT; Lange & Dewitte, 2022). Neither virtual nor real-life exposure to a coastal landscape led to differences in performance on the WEPT, compared to exposure to an urban landscape. In addition, there was no difference in performance on the WEPT according to engagement

level in Chapter 4. Moreover, experiencing small self, nostalgia, and nature connectedness during virtual and real-life exposure did not significantly affect WEPT performance.

The relationship between coastal landscapes and PEABs was further tested within the wider context of a citizen science intervention in **Chapter 5**. Secondary school students in several countries in North and West Africa, and one country in South-East Asia, were trained to sample and analyze plastic from sandy beaches. This citizen science project (i.e., ‘COLLECT’) was shown to increase ocean literacy, conceptualized by awareness and knowledge towards marine litter, litter-reducing behaviors, and attitudes towards litter removal, in Benin, Ghana, Nigeria, Cabo Verde, and Côte d’Ivoire. After participating in COLLECT, students in Benin and Ghana also demonstrated higher pro-environmental intentions. Higher well-being and nature connectedness were displayed for students in Benin as well. The students’ pro-environmental attitudes did not significantly change after participating in COLLECT.

Figure 1

Schematic Visualization of Main Findings



Note. PEABs = pro-environmental attitudes and behaviors. Solid lines represent significant associations. Dotted lines and borders represent non-significant associations or outcomes.

Interpretations of Main Findings

Coastal landscapes and well-being

Living near, or being virtually exposed, to coastal landscapes had positive effects on stress reduction, subjective well-being (i.e., happiness), and reduced mental ill-being (i.e., boredom and worry). This is in line with previous research showcasing the coast as a restorative environment (Hooyberg et al., 2023; White et al., 2013), increasing positive affect (MacKerron & Mourato, 2013), and decreasing negative affect (Vert et al., 2020).

Living near the coast was not associated with psychological well-being (PWB; measured by the SWEMWBS). Such an association has not been supported in previous studies (White et al., 2017), with Garrett et al. (2023) even showing a negative link between residential greenness and PWB. Most likely the context of the COVID-19 pandemic interfered with PWB at that time, although in Robinson et al. (2021), residential greenness did predict higher PWB during the pandemic. As mentioned in Chapter 2, proximity to the coast may have a more indirect effect on PWB, that depends on how coastal residents use and attach meaning to the coast. For instance, being able to surf at the coast may fulfill the need for competence, or feeling a sense of connection and familiarity to the coast may fulfill the need for relatedness.

Virtual exposure to the coast did not lead to a higher likelihood of meaning-focused coping. This can be largely attributed to the exposure being insufficient to impact such a trait-like characteristic. In fact, coastal residents do associate the coast with meaning-making processes such as acceptance and positive reappraisal. Similar to PWB, this association may depend on a specific context and accumulate within a larger time period. It is unlikely that exposure to the coast impacts meaning-focused coping within every single timepoint, but perhaps this impact emerges when one is consciously or unconsciously seeking out the coast to cope with stressors or emotions. The coast then potentially facilitates the use of more adaptive coping strategies such as meaning-focused coping, instead of less adaptive strategies such as denial or behavioral disengagement.

In contrast to Chapters 1 and 3, the effect of the coast on stress, subjective well-being (i.e., mood), and mental ill-being (i.e., worry), was not significant in Chapter 4. I had expected to see a larger effect of the coast in this chapter as typically, real-life exposure produces stronger effects than virtual exposure (Browning et al., 2020; Mayer et al., 2009). Nonetheless, this study had a small sample size, which most likely led to insufficient statistical power to detect small effects. Indeed, it is important to note that throughout the research studies, the well-being effects of the coast were either small or small-to-medium. In Chapter 4, the effect size for differences in worry reduction and increase of positive and low-arousal positive mood were small-to-medium, in line with results from the other chapters. The small effect of the coast on well-being is in accordance to previous research (White et al., 2013). The magnitude of these

effects should not be considered as negligible, as it is comparable to more common factors related to well-being, such as physical activity, gender, and socio-economic status (Martin et al., 2020; White et al., 2019).

Emotional mechanisms underlying the effect of coastal landscapes on well-being

The present dissertation provides both qualitative and quantitative support for the important role of awe/small self, nostalgia, and nature connectedness in the emotional experience of the coast. In terms of awe and nostalgia, previous qualitative research had shown a link with coastal landscapes (Jarratt & Gammon, 2016; Jarratt & Sharpley, 2017; Pearce et al., 2017). However, to my knowledge, this link had not yet been investigated with quantitative methodology. The association between the coast and nature connectedness had been previously shown in Wyles et al. (2019), but causal effects remained unknown.

The lack of association between coastal visits and the emotions of awe and nostalgia in Chapter 1 may be explained by the context of the COVID-19 pandemic, that potentially created feelings of anxiety while being outdoors, thereby preventing or reducing a beneficial emotional experience. Another interpretation would be that this association was compared with visits to other natural landscapes and not visits to an urban landscape. Visits to green spaces for example can elicit the emotion of awe as well (Ballew & Omoto, 2018), although a recent study indicated awe to be more frequently elicited by blue spaces, rather than other natural landscapes, including green and mountainous spaces (Chirico et al., 2024).

Looking into each emotional state specifically, different results regarding their associations with well-being emerged. The emotion of awe experienced at the coast during the lockdown was negatively correlated with boredom. This is a novel finding in the literature and suggests that awe felt at the coast enables to captivate one's attention and reinject meaning into our lives, buffering the lack of meaning that typically predicts boredom (Fahlman et al., 2009). As this is a correlation, a reverse relationship may also be the case, such that feeling bored may lead to experiencing awe more strongly when at the coast to mitigate the negative effects of boredom.

Subsequent findings regarding awe in this dissertation distinguishes between a single-item measurement of 'awe' and a ten-item measurement of 'small self'. The specific measurement of small self was introduced in Chapter 3 as it is a central characteristic of awe and partially explains why awe benefits well-being (Monroy & Keltner, 2023). The Pearson correlations between awe and small self in Chapters 3 and 4 ranged from .39 to .64. Although these correlations were significant, varied effects regarding their experience during coastal exposure were found in Chapter 4. Small self did not differ according to

environment type and engagement level, whereas awe was significantly higher for mindful engagement and mind-wandering during a beach walk. The interpretation of experiencing awe could therefore be linked with other facets besides feelings of small self, such as need for accommodation, physical sensations, and feelings of connection (Yaden et al., 2019). Nonetheless, the quantitative results regarding the emotional mechanisms underlying the effect of the coast on well-being are centered upon feelings of small self, and not awe in general.

In both studies of Chapter 3, small self did not mediate the effect of coastal landscapes on stress reduction. This may be due to an overlap with the emotions of nostalgia and nature connectedness that will be discussed further on. Small self was however found to correlate with a higher likelihood of engaging in meaning-focused coping. This is in line with studies demonstrating self-diminishment as enabling a change in perspective and reduced concern towards personal goals, which can be seen as a form of positive reappraisal (Bai et al., 2021; Wallace-Hadrill & Kamboj, 2016).

The emotional states of nostalgia and nature connectedness emerged as significant mediators in the effect of coastal landscapes on stress reduction in Chapter 3, creating a novel finding in the literature. Taking into consideration the nostalgic memories linked with the coast that were expressed in Chapter 2, perhaps even brief exposure to the coast generates a recollection of these memories, whether consciously or unconsciously. The stress-reducing effects of nostalgia generated by the coast can be attributed to a heightened sense of meaning in life, as shown in Routledge et al. (2011). In line with Wyles et al. (2019), exposure to the coast increased a state of nature connectedness. This feeling of connection may arise due to appreciation of the aesthetics of the coast, or due to a sense of familiarity with the coast, as shown in Chapter 2. With regards to nature connectedness reducing stress, this may be due to a facilitation in the use of adaptive emotion-regulating strategies (Bakir-Demir et al., 2021), such as a better ability to reflect (Mayer et al., 2009). This interpretation is supported by the positive link between nature connectedness and meaning-focused coping found in Chapter 3.

Interconnections between the emotional states

Interestingly, across Chapters 1, 3, and 4, an overlap between awe/feelings of small self and nostalgia was found. In Chapter 1, awe correlated with nostalgia ($r = .15$), and in Chapters 3 and 4, small self correlated with nostalgia (r ranging from .38 to .51). To my knowledge, the relationship between awe and nostalgia has not yet been explicitly investigated. The two emotions do share several commonalities, such as being of an ambivalent nature (Arcangeli et al., 2020; Leunissen, 2023), and producing similar benefits to well-being. For example, both awe and nostalgia foster a sense of meaning in life. Experiencing awe increases

positive affect, and helps create a coherent bigger picture in which the self is connected to something greater (Rivera et al., 2020; Danvers et al., 2016). Experiencing nostalgia boosts social connectedness (Wildschut et al., 2010), a sense of self-continuity (i.e., connection between one's past and present self; Sedikides et al., 2015), and authenticity (i.e., alignment with one's true self; Kelley et al., 2022), ultimately enhancing meaning in life (Abeyta & Pillarisetty, 2023).

Besides these commonalities, awe and nostalgia are distinct emotions. A central difference is with regards to the focus on the self, with awe reducing the focus and nostalgia bringing the self forward. Indeed, neurological evidence displays reduced activity in the default mode network (DMN) during the experience of awe (van Elk et al., 2019). The DMN is a network of brain regions that is active during self-referential processing and mind-wandering (Christoff et al., 2009; Qin & Northoff, 2011). In contrast to awe, activity in brain regions involved in self-reflection increase during the experience of nostalgia (Yang et al., 2022). It can be argued that awe and nostalgia address different threats to meaning: awe resolves threats related to one's place within the wider universe, while nostalgia addresses threats concerning one's place within one's own life, particularly one's present position compared to one's past.

Aside from overlapping with each other, awe and nostalgia were also associated with nature connectedness. The correlations of nature connectedness with small self ranged from .58 to .80, and correlations with nostalgia ranged from .28 to .54. The positive link between awe and nature connectedness has been previously supported (Liu et al., 2023; Ng et al., 2023) and has been suggested to arise due to awe's self-transcendent nature leading to a perception of the self as part of a larger entity, such as nature, and increased feelings of connection (Yaden et al., 2017). It can therefore be expected that awe generated at the coast is interlinked with a sense of connection with nature. The association between nostalgia and nature connectedness is less obvious, although perhaps the positive effect of nostalgia on social connectedness can be transformed into connectedness to nature within a specific context. As nostalgia has been found to positively influence place attachment (i.e., an emotional bond to a place; Tsai et al., 2020), nostalgic memories created in a natural space can potentially foster a sense of connection with the associated nature.

This overlap between the emotional states is important to address, as it likely explains why small self was not found to mediate the effect of coastal landscapes on stress reduction in Chapter 3. When evaluated as a single mediator, without the inclusion of nostalgia and nature connectedness, small self was a significant mediator. Ultimately, further research should assess whether the emotional states of awe, nostalgia, and nature connectedness triggered by the coast are experienced through a converged

state of feelings of connection, either with one's self, one's social relationships, or one's natural surroundings, and an ability to change perspective.

Coastal landscapes and emotion-regulating strategies

In relation to a beneficial emotional experience, findings from Chapters 2 and 3 showcase a link between coastal landscapes and adaptive emotion-regulating strategies (ERS). In Chapter 2, coastal residents described strategies such as self-reflection, acceptance, positive reappraisal, mindful awareness, and emotional exteriorization. These strategies were incorporated into a scale in Chapter 3 and were shown to be highly associated with the coast. A recent rapid review displayed such ERS to be linked with nature exposure, and to act as mediators in the benefits of nature on well-being (Vitale & Bonaiuto, 2024). To my knowledge, no research has yet explicitly addressed the role of the coast in emotion regulation, therefore findings reflect an initial investigation of the extent to which the coast facilitates adaptive emotion regulation.

This facilitation is dependent on particular moderating factors. One such factor appeared to be engagement level, as discussed in the following section. Another factor might be the lack of presence of others, as it is suggested in Chapter 2 that the opportunities to be alone at the coast enables the use of ERS. This may be due to an easier attention deployment towards one's natural surroundings and/or one's self, as well as less social pressure to suppress emotions. These processes have also been highlighted by Bratman et al. (2021). Finally, a potentially moderating factor may be an individual's level of familiarity and perception of the coast, as less familiarity and a more negative perception may hinder the possibility to feel safe to engage in ERS.

Interplay between moderating factors and emotional mechanisms

The presence of plastic did not moderate the effect of coastal landscapes on stress, nor on the emotions of small self, nostalgia, and nature connectedness. I had expected the presence of plastic to disrupt the benefits of the coast, as shown in Wyles et al. (2016). A post-study revealed sufficient salience of plastic in the video-clips of coastal dunes and urban street, but not for the video of a beach with a sunset. Despite the plastic being noticeable, perhaps the level was still insufficient and participants were able to focus their attention on other prominent elements in the video-clip. Moreover, it could be that participants were desensitized to the present level of plastic, as demonstrated through the 'shifting baseline syndrome', in which people gradually accept lower thresholds of environmental degradation due to the

lack of knowledge or experience with past environmental conditions (Soga & Gaston, 2018). Greater presence of plastic may have had a larger triggering effect, in line with what was found in Chapter 5.

In contrast to what I had expected, having no income predicted less stress reduction after being exposed to the coast, in comparison to being exposed to an urban landscape. Evidence showcasing a more pronounced beneficial effect of the coast for people with low-income is mostly based on residential proximity (Garrett et al., 2019; Wheeler et al., 2012), or actual time spent in nature (Garrett et al., 2023). In this study, almost all participants were inland residents and were exposed to the coast via a video-clip. Participants with no income therefore could not experience the health-promoting attributes that typically explain the reduction in health disparities such as physical activity (Mitchell & Popham, 2008).

Interestingly, a moderated mediation effect was found, in which nostalgia positively mediated the effect of coastal exposure on stress reduction only for participants with no income. In the context of participants being inland residents, my initial speculation was that being exposed to the coast perhaps brought up feelings of sadness as people with no income typically have less resources or capabilities to frequently visit the coast. These feelings might have been attenuated by recalled nostalgic memories associated with the coast. Although our findings revealed higher feelings of sadness for participants with no income, there was no significant difference in coastal visit frequency between the income groups. This mitigating role of nostalgia for people with low income should therefore be further investigated.

Although brief manipulation of engagement level did not lead to differential effects on well-being, findings revealed differences in terms of emotional experiences. Mindful engagement during a coastal walk led to a stronger experience of awe and nature connectedness, in comparison to being distracted during an urban walk. Similar findings were found in Nisbet et al. (2019), in which being mindfully engaged during a walk along a canal enhanced the emotions of awe and nature connectedness. These results provide further evidence of the associations between mindfulness, awe, and nature connectedness (Schutte & Malou, 2018; Thompson, 2022). Being mindful enables to create distance from one's self, to broaden one's perspective, and to be fully aware of one's surroundings. Moreover, mindful engagement also increased the use of adaptive ERS. Although there is evidence that practicing mindfulness enhances adaptive emotion regulation (Roemer et al., 2015), to my knowledge this had not yet been shown within the context of nature. These findings highlight the importance of being mindfully engaged at the coast to fully experience the associated benefits.

Besides mindful engagement, awe was also surprisingly increased during mind-wandering at the coast. Considering that participants were instructed to deliberately mind-wander, this might have led to more beneficial processes than spontaneous mind-wandering (Seli et al., 2019). As suggested in Williams

et al. (2018), deliberate mind-wandering may shift between moments of fascination towards the environment and moments of self-reflection. Contrary to expectations, mind-wandering did not lead to increased nostalgia. Although mind-wandering triggered by environmental stimuli is more likely past-oriented (Maillet et al., 2017), it remains to be seen whether this retrospection can be accompanied with nostalgic feelings.

Coastal landscapes and pro-environmental attitudes and behaviors

Neither virtual nor real-life exposure to coastal landscapes significantly affected PEABs. This may be due to methodological limitations, such as the reduced variability in the measurement of pro-environmental behavior with the Work for Environmental Protection Task (WEPT). Considering the mixed evidence for the effect of nature exposure on PEABs (Lange & Truylens, 2022), it remains unclear whether brief exposure significantly increases PEABs, or whether this outcome depends on long-term exposure. Taking into account that mindful engagement led to higher awe and nature connectedness, and that these are predictors of PEABs (Barragan-Jason et al., 2023; Yang et al., 2018), cumulative mindful exposure to the coast may have a stronger likelihood to increase PEABs.

An additional interpretation of the non-significant findings may be that PEABs increases via more meaningful activities carried out at the coast, such as the citizen science activities in Chapter 5. In this project, students were informed of the consequences of marine plastic litter, directly contributed to its removal, and analyzed its properties within a scientific framework. These activities produced a positive change in ocean literacy, accompanied with a spillover effect, as students displayed higher pro-environmental intentions, including the intention to participate in future beach clean-ups. These positive effects differed across the participating countries, with students in Benin showing the most positive change. Interestingly, students in Benin were also the ones confronted with the most plastic pollution during their sampling (Catarino et al., 2022), suggesting that the intensity of the plastic litter motivated students to engage in sustainable action to address this issue. In line with previous research (Hartley et al., 2015; Locritani et al., 2019; Oturai et al., 2022; Wichmann et al., 2022), I can therefore state that a meaningful activity such as citizen science acts as an effective means of promoting ocean literacy and PEABs in general.

As expected, nature connectedness positively correlated with pro-environmental attitudes. However, the emotions of awe and nostalgia did not significantly affect PEABs. The lack of association between awe and PEABs may be attributed to the context of the PEAB. For instance, in Chirico et al. (2023), experiencing awe after virtual nature exposure led to increased socially engaging PEABs, but not

personally engaging PEABs. Considering that awe increases pro-social behavior (Piff et al., 2015), perhaps it only affects PEABs that are framed to have a pro-social impact. Awe induced by the coast might have had an impact on PEABs if the social benefits of the environmental organization used for the WEPT would have been made explicit. Similar to the link between nostalgia and nature connectedness, perhaps nostalgia only affect PEABs that specifically target a place that contains meaningful memories. The potential of nostalgia as a motivator for ecological restoration is demonstrated in Willson et al. (2019). Here, the authors present the term ‘ecological nostalgia’, defined as “a desire to return a degraded ecosystem to a past state that complements bittersweet memories of a better ecological period” (Willson et al., 2019, p.949). Consequently, perhaps the nostalgic feelings triggered by the coast would affect PEABs that are framed specifically towards the ocean. This would certainly be dependent on individual experiences however.

Theoretical Applications

Importantly, the knowledge obtained through the present dissertation helps inform two fundamental research gaps set by the Seas, Oceans and Public Health in Europe project (SOPHIE; H2020 SOPHIE Consortium, 2020). First, findings have revealed positive effects of the coast on well-being within a Belgian context, thereby addressing the call for more evidence of blue health impacts across Europe. Second, the gathered evidence contributes to further understanding of the mechanisms underlying the well-being benefits of coastal landscapes. Alongside the physical, social, cognitive, sensory, and symbolic dimensions of the underlying mechanisms, there is now increased comprehension of the emotional dimension, particularly in terms of complex and ambivalent emotions, as well as emotion-regulating processes.

The emotional processes highlighted in this dissertation can be integrated within the conceptual framework of White et al. (2020). In consideration of the present findings, the emotional states of awe, nostalgia, and nature connectedness are potentially part of the instoration and restoration mechanisms. The stress-reducing effects of nostalgia and nature connectedness in Chapter 3 enable to conceptualize these emotional states as a restoration mechanism. As an instoration mechanism, coastal-induced awe and nostalgia can be considered as psychological resources that promote adaptive coping. Moreover, nature connectedness is already integrated within the instoration mechanism in White et al. (2020). Future research should elucidate in which contexts these emotional states are either restorative or instorative, or perhaps both simultaneously. Additionally, their interactions with sensory and symbolic mechanisms should be further examined. For example, can auditory coastal stimuli induce awe to the

same extent as visual coastal stimuli? Do nostalgic feelings related to the coast vary according to one's cultural context?

The results of this dissertation also enable to further inform the three theoretical frameworks that are presented in the general introduction, i.e., the Attention Restoration Theory (ART; Kaplan & Kaplan, 1989), the Stress Recovery Theory (SRT; Ulrich, 1983), and the Nature-based Biopsychosocial Resilience Theory (NBRT; White et al., 2023). With regards to the ART, the experience of awe triggered by the coast may be an underlying mechanism of its cognitive restorative effects. Although such effects were not directly assessed, certain similarities between awe and the environmental components suggested to induce cognitive restoration can be noted. First, the feelings of small self may relate to 'being away', as both processes create a sense of distance from one's thoughts and concerns (Shiota et al., 2007). Second, an experience of awe may accompany the effortless attention constituting 'soft fascination', as both awe and fascination are triggered by captivating and aesthetically pleasing stimuli (Keltner & Haidt, 2003). However, a central tenet of awe is need for accommodation, whereby cognitive effort is necessary to mentally process the awe-evoking stimuli. In Chapter 2, the experience of awe was linked to storms at the coast, which would typically be referred to as 'hard-fascinating' stimuli. As depicted in Joye and Dewitte (2018), it remains unclear whether cognitive restoration depends on soft fascination, or whether hard fascination may also be restorative. Exposure to natural landscapes inducing awe has nevertheless been shown to improve cognitive performance (Collado & Manrique, 2020), and further research should examine to what extent similar effects apply to coastal landscapes.

In relation to the SRT, this dissertation provides further support of the stress-reducing effects of virtual exposure to a natural landscape, now also applied in the context of coastal landscapes. Gaekwad et al. (2023) demonstrate particular uncertainties concerning the SRT, to which the present experimental results may help address. More specifically, it remains unclear to what extent the type of exposure (virtual or immersive) affects stress recovery differently, and whether stress recovery may depend on the previous stress state of participants. In their systematic review, Gaekwad et al. (2023) conclude that immersive exposure is more likely to be effective than virtual exposure in reducing stress. In this dissertation, I found positive effects of virtual, but not immersive, exposure on stress reduction. However, in the *in situ* experiment, participants did not undergo a stress recall procedure to induce stress, such as in the virtual experiments. This suggests that a high stress state is necessary to support the components of the SRT, an assumption which remained unclear in Gaekwad et al. (2023). It is important to note that other elements such as smaller sample size and reduced disparity between the coastal and urban conditions could additionally explain the non-significant effects of immersive exposure.

The gathered evidence helps elucidate several theoretical relationships stated in the NBRT. First, findings revealing positive effects of the coast on better emotional balance (more happiness and less worry and boredom), and on adaptive emotion regulation, enable further understanding of how contact with nature positively affects psychological resilience. Moreover, the NBRT posits that one of the factors supporting recovery resilience in relation to stress is better emotion regulation capacities (White et al., 2023). This dissertation also offers an initial investigation of the intrapersonal aspects of nature contact, that have so far been neglected in the literature. Such aspects relate to intense memories that may be repeatedly recalled and may modulate how future encounters with nature are experienced. The enduring coastal memories described in Chapter 2 are an example of these intrapersonal aspects. Investigating these aspects will enable to understand the top-down processes of the well-being benefits of nature (Smalley et al., 2022). Research has been largely based on a bottom-up perspective, through which the characteristics of the environment are considered to be intrinsically restorative. However, most likely the lived experience of the coast throughout an individual's life strongly affects how that individual interacts with and benefits from the coast (Ratcliffe & Korpela, 2016).

The present dissertation provides preliminary insights into how people with mental health conditions experience coastal landscapes. Several similarities can be found between the experiences of the participant with autism in Chapter 2 and the participants with bipolar or schizophrenia/psychosis conditions in Wright et al. (2024). Both studies showcase the importance of the socially undemanding characteristic of blue space and the opportunity for respite from social stressors. Additionally, blue space was experienced as an 'affective sanctuary' (Butterfield & Martin, 2016), enabled through predictable sensory rhythms (e.g., repetitive moments of waves) and a strong attachment to the space.

Practical Considerations

To understand the practical considerations of this dissertation, it should first be recognized how nature-based interventions are conceptualized. White et al. (2023) characterize nature-based interventions according to three levels. Level 1 refers to primary prevention interventions that target the general population and that focus on bringing nature closer to people, such as through changing infrastructure. Level 2 relates to secondary prevention interventions that target vulnerable groups and that aim to bring people closer to nature, by increasing contact and connection to nature. Level 3 pertains to tertiary prevention interventions that target individuals with physical and/or mental health conditions and that integrate nature with existing medical or psychological treatments.

One form of intervention that can act on both Level 2 and Level 3 is ‘nature-based social prescribing’ (NBSP). Social prescribing typically refers to health and social care interventions that aim to connect individuals to nonmedical and community-based practices (Teuton, 2015). A systematic review has found consistent health benefits of NBSP based on green space (Adewuyi et al., 2023), however evidence for NBSP based on blue space is more limited. A recent review did find positive effects of blue prescription for people with various mental health conditions, such as autism, posttraumatic stress disorder, depression, and drug use (Alejandro et al., 2023). By showcasing the positive effects of coastal landscapes on well-being, this dissertation adds further support to the potential effectiveness of blue prescription.

Within Level 3 interventions, therapeutic coastal practices have been largely based on physical activities such as surfing, sailing, swimming, and snorkeling (Maharja et al., 2023; Britton et al., 2020; White et al., 2016). It remains unclear to what extent low-intensity activities such as walking or sitting are effective. However, such activities most likely facilitate the emotions and emotion-regulating strategies showcased in this dissertation, with exception to seeking out peak flow experiences that were linked to kitesurfing in Chapter 2. Moreover, with regards to integrating nature to existing psychological treatments, studies have shown that walking or meditating in nature can improve the outcomes and compliance to talk and mindfulness-based therapies (Lymeus et al., 2018, 2019; van den Berg & Beute, 2021). The findings in Chapter 4 support the beneficial practice of implementing mindfulness at the coast and shed light into the underlying mechanisms of these benefits, namely the emotions of awe and nature connectedness. Furthermore, as nostalgia was found to underlie the stress-reducing effects of the coast, this implicates that coastal landscapes may boost the effectiveness of reminiscence-based interventions (Hallford et al., 2022). In sum, this dissertation highlights the practical use of coastal exposure to optimize pre-existing psychological therapies.

Several practical steps should be considered in order to integrate the coast into existing psychological treatments. One of these steps is to assess the knowledge and perception of clinicians with regards to the well-being benefits of the coast and the use of the coast as an additional therapeutic tool. To ensure sufficient knowledge, awareness of these well-being benefits should be increased within the realms of research, science communication, policy, and the healthcare sector. If clinicians demonstrate positive attitudes towards the implementation of these benefits, then the challenges and potential risks of integrating the coast into their therapeutic practice should be assessed. Finally, to ensure successful therapeutic use of the coast, further research in co-creation with clinicians should evaluate the most effective framework that is tailored to specific population needs and local contexts.

Level 2 interventions that focus on bringing people closer to nature are typically based on long-term and immersive exposures to nature, such as forest bathing (Li, 2010) and community gardens (Litt et al., 2023). This dissertation demonstrates that even brief exposure to the coast, either virtually or in real-life, can increase feelings of connection to nature. Findings from Chapter 5 also highlight citizen science as an additional type of intervention that can enhance nature connectedness and ocean literacy. Although the scientific advantages of citizen science are prominent in the literature, the educational, behavioral, and emotional impacts are much less understood (Severin et al., 2023). This dissertation brings forward the use of citizen science as an innovative tool in reconnecting people to the coast and becoming aware of the imminent issues that are threatening its health.

Level 1 interventions aim to bring nature closer to people, by typically incorporating more green or blue natural elements into infrastructure. Coastal elements such as sand and wave sounds may be integrated into urban infrastructure, however interventions have rather focused on either improving accessibility to the coast, or regenerating coastal areas for more beneficial use. An example of the latter is a small-scale renovation of an urban beach area in Plymouth, UK (van den Bogerd et al., 2021). Improvements to the quality of this area, in co-creation with local stakeholders and residents, led to positive changes in well-being and satisfaction in community belonging.

Although a main implication of this dissertation is to incite people to visit the coast, it is essential to take into consideration the ecological consequences of increasing human presence at the coast. Therefore, I identify several pathways that enable to bring the coast closer to people without requiring their physical presence. Two pathways have been mentioned in the SOPHIE project (H2020 SOPHIE Consortium, 2020). First, people can experience the coast through virtual means, as this dissertation, along with previous research (Hooyberg et al., 2023; Yeo et al., 2020), demonstrates the well-being benefits from virtual exposure. The use of virtual exposure can be a particular asset in psychiatric and medical care (White et al., 2018).

Another pathway to bring the coast closer to people is through art. One of the follow-up outcomes of this dissertation is the involvement in a project entitled 'Waves of Resonance'. This project, led by artist Elise Guillaume, has received a grant by the European Marine Board, in the framework of the 'EMBracing the Ocean Artist-In-Residence Program' (European Marine Board, n.d.). In co-creation between the artist and the scientific collaborators (Clea Parcerisas and myself), the project aims to design an immersive sound piece, built upon recordings of above and below the North Sea. This soundscape, including both ocean and anthropic sounds, will be presented to several population groups (i.e., children, students, gender minorities, and general public) via a constructed workshop. The issue of underwater noise

pollution will be addressed via a group discussion. The impact of this potentially awe-evoking soundscape on participants' well-being, emotions, and ocean literacy will be evaluated with a pre and post-exposure survey. Overall, the project aspires to boost an emotional connection with the ocean, and to inspire sustainable engagement.

An additional pathway to increase contact with the coast without direct physical presence could be through the reminiscence of coastal-based memories. As this dissertation displays enduring and significant memories created at the coast, perhaps the recollection of these memories can act as a means of indirect exposure, that potentially triggers nostalgic feelings and benefits well-being. This type of contact with the coast may be particularly beneficial for people with low-income, who are more prone to experience nostalgia (Hepper et al., 2020), and for whom coastal-induced nostalgia positively mediated stress reduction in Chapter 3.

Finally, a key factor in reducing the environmental impacts of actual visits to the coast is through enhancing ocean literacy. As stated in Beeharry et al. (2021), visitors should be more aware of how their activities negatively affect the coast and of the actions they can take to minimize these ecological impacts (e.g., by leaving only footprints behind; by using reef-safe sunscreens). Change in individual perception and behavior should naturally be accompanied with regulatory and policy measures, such as limiting overcrowding (Basterretxea-Iribar et al., 2019), and reducing the distance to bins (Schultz et al., 2013).

Strengths, Limitations, and Future Directions

One of the strengths of this dissertation pertains to the varied set of methodologies (i.e., quasi-experimental, qualitative, experimental, and interventional designs) that support the main findings. In addition to this variety, findings are based on diverse forms of contact with the coast (i.e., residential proximity; intentional, virtual, and real-life exposure), as well as diverse sample groups (i.e., secondary school students, university students, coastal and inland residents, people with low-income). This diversity thereby enhances the generality of this dissertation. Moreover, with exception to Chapter 1, each chapter's study design, hypotheses, and analyses have been pre-registered and the collected data is findable on the Integrated Marine Information System (IMIS¹). The adherence to these open science practices boost this dissertation's scientific integrity.

As each chapter discusses the limitations linked to the specific studies, the present section will provide the general theoretical and methodological limitations of this dissertation. A first limitation pertains to the lack of comparison of the investigated associations with other natural landscapes. The

¹ <https://www.vliz.be/en/imis?persid=38302>

quantitative findings in this dissertation reflect the well-being and emotional effects of coastal landscapes in comparison to an urban landscape. Therefore, I cannot infer whether the coast is better or worse for well-being than other blue or green landscapes. Considering the demonstration of the positive effects of the coast, and that most research on nature and health is based on green space (Grellier et al., 2017), promoting the potential of the coast as a suitable contender is nonetheless a valuable outcome.

Despite the absent direct comparison with other natural landscapes, certain findings appear to be unique to coastal landscapes. In Chapter 2, participants expressed fascination towards the vastness and beauty of the sea. Such a vast body of water cannot be found in most inland blue spaces, such as rivers and canals. Moreover, participants were appreciative of the opportunities to be alone at the coast, which enabled them to feel disconnected from the rest of the world. While such opportunities may occur in other natural landscapes, they may be less common. Perhaps it is the combination of a vast body of water and an openness that forms the unique effects of the coast, as these elements are rarely found in forests for example. Only mountainous regions with lakes offer similar elements, potentially producing comparable effects to those of the coast, albeit this is still open for investigation.

In a similar vein, findings do not indicate the extent to which the emotional mechanisms of awe, nostalgia, and nature connectedness are unique to the coast. Awe and nature connectedness have been shown to underlie the benefits of natural landscapes (Anderson et al., 2018; Mayer et al., 2009), although studies show these emotions are more frequently triggered by coastal or blue spaces (Chirico et al., 2024; Wyles et al., 2019). Unique elements of the coast, such as its grandeur and hedonic symbolism, may enhance awe and nature connectedness, more so than other natural landscapes. Additionally, nostalgia may have a particular link with the coast, due to its aspect of timelessness and creation of enduring social memories. Further research should nonetheless assess whether nostalgia can be triggered in other natural landscapes, and whether these feelings act as an underlying mechanism of their well-being effects.

A second limitation relates to the measurement of the emotions of awe and nostalgia. As awe was characterized by a ten-item measurement of feelings of small self in Chapters 3 and 4, this excluded the evaluation of other facets of awe. Future research should utilize more comprehensive measurements, such as the Awe Experience Scale (AWE-S; Yaden et al., 2019). Nostalgia was assessed by a single-item, which is typically considered as less reliable. However, to my knowledge, there is no extensive scale of state nostalgia, and studies measuring nostalgia have only used two or three items (van Tilburg et al., 2013; Wildschut et al., 2006). Single-items were employed to evaluate awe and nostalgia in order to be consistent with previous research centered upon emotions (Piff et al., 2015; Rudd et al., 2012).

To enhance the reliability of measuring emotions, there exist alternative techniques that objectively assess emotions. These techniques are based on coding the participant's facial expression during the experience of an emotion. Specifically for positive emotions, Cross et al. (2023) present the advantages and applications of four techniques, i.e., facial electromyography (EMG), the Facial Action Coding System (FACS), computerized approaches, and modified/simplified hand coding techniques. The emotion of awe has already been linked with unique facial expression that can be reliably coded (Cordaro et al., 2018). Facial coding for nostalgia may be more challenging as its ambivalence is more pronounced and it is not included in the taxonomy of positive emotions, as delineated by Keltner and Cowen (2021). Although Franěk et al. (2022) did not find differences in emotional facial expressions after viewing nature or urban images, further research should utilize this objective technique to assess the emotional responses to coastal landscapes.

A third limitation is with regards to accounting for individual and situational factors that may moderate the effect of coastal landscapes on well-being and the underlying emotional mechanisms. Although in this dissertation I investigated presence of litter, income level, and engagement level as moderating factors, other prominent factors may have played a role. For instance, the effect of weather was not directly examined, but was indirectly evoked in Chapter 2. While some participants spoke fondly of the coast during summertime, associating it with a holiday atmosphere, other participants preferred the coast during wintertime, due to unique natural phenomena such as snow on the beach and reduced presence of other people. Furthermore, coastal storms were associated with feelings of overwhelming excitement or fear, reflecting the emotion of awe, as well as enduring memories. Further research should assess to what extent weather conditions affect coastal benefits, as cloudiness appears to negatively impact restoration (Hipp & Ogunseitan, 2011).

Another situational factor that was not directly taken into account pertains to the heterogenous landscape structure of the Belgian coast. As demonstrated in Hooyberg et al. (2022), the Belgian coastline contains high variation in terms of urban, blue, and green elements, that affects the restorative quality of the coast. In this dissertation, only the components of open water, beach, and dunes were evaluated during virtual exposure. In the *in situ* experiment, participants had a more diverse exposure, including views of urban buildings in the distance and other urban elements such as benches and bins. Further research in how landscape structure affects the emotional experience of the coast should be implemented. For example, do windmill farms potentially reduce the nostalgic potential of the coast?

Although findings are based upon diverse samples in terms of age, gender, education level, and income level, other individual factors should be further considered. For example, with exception to

Chapter 5, the research studies have been conducted with Flemish-speaking adults, thereby excluding other Belgian residents that speak English or French. Residents living in Brussels or Wallonia may have a different emotional experience of the coast. Furthermore, as shown in Phoenix et al. (2021) and Wheaton et al. (2020), ethnicity and cultural context do play an important role in shaping one's relationship and experience of the coast. This is briefly discussed in Chapter 5, whereby students in north/west African countries reported visiting the beach on average less than once a week despite living nearby. Given the increasingly multicultural context in Flanders (Jeram & Adam, 2015; Statbel, 2024), the role of ethnicity on coastal benefits should be further evaluated. Considering that 95% of participants in Chapter 3 were of Belgian ethnicity, the recruitment of ethnically diverse groups remains a challenge and may necessitate alternative methods (McLean & Campbell, 2003).

Future research should also consider how the duration of the coastal exposure affects the resulting outcomes. In this dissertation, I discuss how brief exposure led to stress reduction and heightened emotions, but did not impact meaning-focused coping, nor PEABs. The question of how much dosage is required to obtain positive effects is a research gap identified by the SOPHIE project (H2020 SOPHIE Consortium, 2020). Although health benefits do appear to depend on dosage for green spaces (Shanahan et al., 2016), this remains unclear for blue spaces. Nevertheless, according to Bell et al. (2019), evaluating dose-response functions is reductionist as it potentially excludes individuals or groups whose interactions with nature may deviate from the norm. The authors argue the need to draw upon theories of social practice that take into account the meanings, materialities, and competences that support or hinder individual nature experiences. Assessing dose-response relationships should therefore go hand-in-hand with addressing moderating situational and individual factors.

A final limitation is the limited understanding of potential negative effects of the coast on well-being. While this dissertation did not find any negative effects, it is possible that a negative relationship exists in different situational or individual contexts. Experiencing a coastal-related traumatic event could for example disrupt one's relationship with the coast. Examples of such events may be: drowning, experiencing a natural disaster such as flooding or a tsunami, or migrating across the sea under high-risk conditions. In relation to the emotional mechanisms, further research should also assess whether the negative facets of awe and nostalgia play a role on coastal benefits, or whether the ambivalence of these emotions actually explains their well-being effects (Braniecka et al., 2014; Moss & Wilson, 2015).

Conclusion

Restoring and promoting healthy interactions between people and coastal landscapes is essential to address the imminent challenges related to climate change and mental health deterioration. To obtain a comprehensive understanding of how the coast affects well-being and pro-environmental attitudes and behaviors, the present dissertation aimed to investigate underlying emotional mechanisms, as well as potential moderating factors.

Chapter 1 demonstrates a replication of the positive effect of the coast on well-being, in the context of a global health crisis in Belgium. Chapters 2, 3, and 4 highlight the emotions of awe/small self, nostalgia, and nature connectedness as important contributors to the emotional experience of the coast. Nostalgia and nature connectedness are found to underlie the stress-reducing effects of coastal exposure. These emotional mechanisms appear to vary according to one's income level and one's level of engagement during coastal exposure. Moreover, the coast is shown to represent a safe haven, a place where one can typically experience adaptive emotion-regulating strategies to cope with challenging stressors and emotions. Although no significant effects of coastal exposure on pro-environmental attitudes and behaviors were found, Chapter 5 showcases the effectiveness of a citizen science intervention on ocean literacy, pro-environmental intentions, and well-being.

Overall, the results highlight an emotional experience of the coast that is characterized by feelings of connection and changes in perspective, and that potentially fosters a sense of meaning in life. This emotional experience should be harnessed when integrating the coast into therapeutic settings. Future research should evaluate additional situational and individual factors that interact with this emotional experience, in the aim of further optimizing a (re)connection with coastal landscapes.

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Epilogue

“For whatever we lose (like a you or a me)

it's always ourselves we find in the sea”

– E. E. Cummings (*The Complete Poems*, 1904-1962)

What does this work mean in the larger scheme of things? Can we now just say, “go to the coast and everything will be ok?”. In my opinion, that is certainly not the case. However, I believe that integrating more contact in your daily life, or just becoming more aware of the effects the coast has on you, can benefit your well-being.

I see the coast as a place that soothes you when you are facing troubles. It allows you to think, or to not think, to feel, to rest, to play, to put a pause in everything. In a society where everything, everywhere, is tainted with urgency, productivity, expectation, and pressure, feeling safe may be rare. Feeling the right and the encouragement to stop, to pause, to slow down, may be experienced at the coast. And we should definitely prioritize this more into our daily lives.

So no, the coast is not a miracle drug, a one-size-fits-all solution, or a panacea for our mental health. However, that does not mean it's not important, and that we should forget about it. Nor does it mean it shouldn't be integrated into our health system and clinical practice. If a doctor or therapist were to tell you “go take a walk at the beach”, you might be surprised, but ultimately we have been intuitively doing that exact thing for centuries. I think the benefits of the coast can be the same as listening to music, spending time with friends and family, or engaging in your favorite hobby. I even think the positive effects of these activities increase when they are conducted at the coast, although that is left to be seen.

Ultimately it all comes back to that vicious cycle presented in the introduction of this dissertation. If we lose the value of the coast, we may very well be losing ourselves in the process.

Publication List

Articles – published (peer reviewed)

- Severin, M.I.**, Akpetou, L.K., Annasawmy, P., Asuquo, F.E., Beckman, F., Benomar, M., Jaya-Ram, A., Malouli, M., Mees, J., Monteiro, I., Ndwiga, J., Neves Silva, P., Nubi, O.A., Sim, Y.K., Sohoul, Z., Shau-Hwai, A.T., Woo, S.P., Zizah, S., Buysse, A., Raes, F., Krug, L.A., Seeyave, S., Everaert, G., Mahu, E., & Catarino, A.I. (2023). Impact of the citizen science project COLLECT on ocean literacy and well-being within a north/west African and south-east Asian context. *Frontiers in Psychology, 14*, 1130596. <https://doi.org/10.3389/fpsyg.2023.1130596>
- Catarino, A.I.*, Mahu, E.*, **Severin, M.I.***, Akpetou, L.K., Annasawmy, P., Asuquo, F.E., Beckman, F., Benomar, M., Jaya-Ram, A., Malouli, M., Mees, J., Monteiro, I., Ndwiga, J., Neves Silva, P., Nubi, O.A., Martin-Cabrera, P., Sim, Y.K., Sohoul, Z., Woo, S.P., Zizah, S., Everaert, G., Shau-Hwai, A.T., Krug, L.A., & Seeyave, S. (2023). Addressing data gaps in marine litter distribution: Citizen science observation of plastics in coastal ecosystems by high-school students. *Frontiers in Marine Science, 10*, 1126895. <https://doi.org/10.3389/fmars.2023.1126895>
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Articles - unpublished

- Severin, M.I.**, Pauwels, L., Verheye, J., Loeys, T., Everaert, G., Buysse, A., & Raes, F. (2024). Effects of the coast on emotions, well-being, and pro-environmental attitudes and behaviors. *Manuscript under review*
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Book Chapter

Severin, M.I.*, Hooyberg, A.*, Everaert, G., & Catarino, A.I. (2023). Using Citizen Science to understand plastic pollution: Implications for science and participants. In: J. Kramm, C. Völker (Eds.), *Living in the plastic age: Perspectives from humanities, social sciences and environmental sciences*, (pp. 133–168). Campus Verlag. <https://doi.org/10.12907/978-3-593-44902-9>

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Presentations

Severin, M. I., Buysse, A., Everaert, G., & Raes, F. (2024, May 30). *Effect of coastal walks and engagement interventions on pro-environmental behavior* [conference presentation]. Annual Meeting of the Belgian Association for Psychological Science (BAPS), Brussels, Belgium.

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Catarino, A.I., Mahu, E., **Severin, M.I.**, Akpetou, K.L., Annasawmy, P.A., Asuquo, F.E., Beckman, F., Benomar, M., Jaya-Ram, A., Malouli, M., Mees, J., Monteiro, I., Ndwiga, J., Neves Silva, P., Nubi, O.A., Martin-Cabrera, P., Sim, Y.K., Sohau, Z., Pinn, W.S., Zizah, S., Everaert, G., Tan Shau Hwai, A., Krug, L., & Seeyave, S. (2023, March 1). *Citizen observation of plastic pollution in coastal*

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Supplementary Materials

Supplementary Materials for Chapter 3

Study 1

Table 1

Measurement of covariates

Covariate	Scale	Item/example items	Categories/scale points
Age	-	What is your birth year?	
Gender	-	Which gender do you identify with?	Man – Woman - Other
Educational attainment	-	What is the highest level of education you have obtained?	Primary school – Professional secondary school – Technical secondary school – General secondary school – Non-university higher education – University school
Subjective health	-	How would you currently rate your own health?	1 (<i>very bad</i>) to 5 (<i>very good</i>)
Dispositional awe	Awe subscale of the Dispositional Positive Emotion Scales (Shiota et al., 2006)	“I feel wonder almost every day”	1 (<i>strongly disagree</i>) to 7 (<i>strongly agree</i>)
Dispositional nostalgia	Southampton Nostalgia Scale (Barrett et al., 2010)	“How important is it for you to bring to mind nostalgic experiences?” “How often do you experience nostalgia?”	1 (<i>not at all</i>) to 7 (<i>very much</i>) 1 (<i>very rarely</i>) to 7 (<i>very frequently</i>)
Trait nature connectedness	Nature Relatedness Scale (NR-6; Nisbet & Zelenski, 2013)	“My relationship to nature is an important part of who I am”	1 (<i>strongly disagree</i>) to 5 (<i>strongly agree</i>)
Meaning in life	Meaning in Life Questionnaire (Steger et al., 2006; Dutch translation of the scale provided by M. van den Heuvel, Utrecht University)	“I have a good sense of what makes my life meaningful”	1 (<i>strongly disagree</i>) to 7 (<i>strongly agree</i>)
Engagement with natural beauty	Nature subscale of the Engagement with Beauty Scale (Diessner et al., 2008)	“I notice beauty in one or more aspects of nature”	1 (<i>very unlike me</i>) to 7 (<i>very much like me</i>)

Table 2

Three-way mixed ANCOVA testing interaction effects of within-subject factor “time” and between-subject factors “environment type” and “plastic” on stress

Source ^a	Sum of Squares	df	Mean Square	F	η_p^2
Time	3.44	1	3,44	1.77	.007
Time x Environment Type	19.91	2	9.96	5.12**	.041
Time x Plastic	0.64	1	0.64	.33	.001
Time x Environment Type x Plastic	1.29	2	0.64	.33	.003

^a Adjusted for subjective health

** $p < .01$

Table 3

Estimated marginal means and simple main effects of Time x Environment Type on stress

Variable	Urban		Dunes		Sunset		F (2, 241)	η_p^2
	M	SE	M	SE	M	SE		
Pre-stress	5.98 ^a	0.23	6.16 ^a	0.22	5.69 ^a	0.23	1.11	.009
Post-stress	4.44^a	0.22	3.8 ^a	0.21	3.26^a	0.21	7.45***	.058

^a Adjusted for subjective health

*** $p < .001$

Note. Bonferroni-corrected pairwise comparisons indicated lower post-stress for sunset condition, compared to urban condition ($p < .001$)

Table 4

Two-way ANCOVAs testing main and interaction effects of between-subject factors “environment type” and “plastic” on small self, nostalgia, and nature connectedness

Variable	Source	Sum of Squares	df	Mean Square	F	η_p^2
Small self ^a	Environment Type	37.06	2	18.53	14.28***	.108
	Plastic	0.13	1	0.13	0.10	.000
	Environment Type x Plastic	2.24	2	1.12	0.86	.007
Nostalgia ^b	Environment Type	261.76	2	130.88	53.06***	.307
	Plastic	0.29	1	0.29	0.12	.001
	Environment Type x Plastic	4.78	2	2.39	0.97	.008
Nature connectedness ^c	Environment Type	10.22	2	5.11	8.58***	.068
	Plastic	0.08	1	0.08	0.13	.001
	Environment Type x Plastic	2.62	2	1.31	2.20	.018

^a Adjusted for dispositional awe, dispositional nostalgia, meaning in life, engagement with natural beauty, and trait nature connectedness

^b Adjusted for dispositional nostalgia, meaning in life, and trait nature connectedness

^c Adjusted for dispositional awe, dispositional nostalgia, meaning in life, engagement with natural beauty, and trait nature connectedness

*** $p < .001$

Table 5

Estimated marginal means of small self, nostalgia, and nature connectedness according to environment type

Variable	Urban		Dunes		Sunset	
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>
Small self	2.51^a	0.13	3.31^a	0.12	3.39^a	0.13
Nostalgia	2.33^b	0.18	4.57^b	0.17	4.51^b	0.17
Nature connectedness	3.65^c	0.09	4.10^c	0.08	4.08^c	0.09

^a Adjusted for dispositional awe, dispositional nostalgia, meaning in life, engagement with natural beauty, and trait nature connectedness

^b Adjusted for dispositional nostalgia, meaning in life, and trait nature connectedness

^c Adjusted for dispositional awe, dispositional nostalgia, meaning in life, engagement with natural beauty, and trait nature connectedness

Note. Small self and nostalgia were higher for both dunes and sunset conditions, compared to urban condition ($p < .001$ for all)

Nature connectedness was higher for both dunes and sunset conditions, compared to urban condition ($p < .001$ for dunes, $p = .002$ for sunset)

Table 6

Pearson correlations between small self, nostalgia, nature connectedness, and stress reduction

Variable	Small Self	Nostalgia	Nature Connectedness	Stress Reduction
Small Self	-			
Nostalgia	.385***	-		
Nature Connectedness	.581***	.277***	-	
Stress Reduction	.208***	.215***	.101	-

*** $p < .001$ (one-tailed)

Table 7

PROCESS model 4 of direct and indirect effects of environment type, emotions, and stress reduction, with urban landscape as reference category

Outcome	Predictor	Estimate	SE	95% CI
Direct Effects^a				
Stress Reduction	Dunes	0.531	0.36	[-0.183, 1.246]
	Sunset	0.642	0.37	[-0.080, 1.365]
	Small Self	0.194	0.13	[-0.058, 0.447]
	Nostalgia	0.093	0.08	[-0.069, 0.255]
	Nature Connectedness	-0.057	0.19	[-0.426, 0.312]
Small Self	Dunes	0.813***	0.18	[0.462, 1.164]
	Sunset	0.874***	0.18	[0.515, 1.233]
Nostalgia	Dunes	2.283***	0.25	[1.799, 2.768]
	Sunset	2.235***	0.25	[1.739, 2.731]
Nature Connectedness	Dunes	0.474***	0.12	[0.237, 0.710]
	Sunset	0.425***	0.12	[0.183, 0.667]
Indirect Effects^a		Estimate	Boot SE	Boot 95%CI
Small Self	Dunes	0.158	0.12	-0.078, 0.399
	Sunset	0.170	0.13	-0.078, 0.436
Nostalgia	Dunes	0.212	0.19	-0.155, 0.581
	Sunset	0.207	0.18	-0.150, 0.581
Nature	Dunes	-0.027	0.109	-0.250, 0.186
Connectedness	Sunset	-0.024	0.098	-0.229, 0.168

^a Adjusted for dispositional awe, dispositional nostalgia, trait nature connectedness, meaning in life, engagement with natural beauty, and subjective health

*** $p < .001$

Table 8

Moderated mediation models of plastic in the effect of coastal landscapes on stress reduction using structural equation modeling

Outcome	Predictor	Estimate ^a	SE	95% CI
Model 1: Moderation of <i>a</i>-path^b				
Small self	Dunes x Plastic	-0.443	0.35	[-1.098, 0.244]
	Sunset x Plastic	-0.206	0.36	[-0.888, 0.539]
Nostalgia	Dunes x Plastic	0.059	0.46	[-0.853, 0.970]
	Sunset x Plastic	0.550	0.50	[-0.468, 1.517]
Nature connectedness	Dunes x Plastic	-0.356	0.25	[-0.837, 0.134]
	Sunset x Plastic	0.066	0.26	[-0.427, 0.566]
Model 2 : Moderation of <i>b</i>-path^b				
Stress reduction	Small self x Plastic	0.343	0.27	[-0.234, 0.863]
	Nostalgia x Plastic	0.005	0.14	[-0.273, 0.289]
	Nature connectedness x Plastic	-0.738	0.39	[-1.494, 0.094]
Model 3 : Moderation of <i>c'</i>-path^b				
Stress reduction	Dunes x Plastic	-0.195	0.64	[-1.465, 1.055]
	Sunset x Plastic	0.192	0.66	[-1.089, 1.445]
Model 4 : Moderation of all pathways^b				
Stress reduction	Dunes x Plastic	-0.252	0.71	[-1.679, 0.987]
	Sunset x Plastic	0.070	0.76	[-1.386, 1.405]
	Small self x Plastic	0.340	0.27	[-0.207, 0.857]
	Nostalgia x Plastic	0.018	0.17	[-0.289, 0.354]
	Nature connectedness x Plastic	-0.733	0.40	[-1.477, 0.087]
Small self	Dunes x Plastic	-0.443	0.35	[-1.132, 0.226]
	Sunset x Plastic	-0.206	0.36	[-0.905, 0.521]
Nostalgia	Dunes x Plastic	0.059	0.46	[-0.839, 1.019]
	Sunset x Plastic	0.550	0.50	[-0.462, 1.564]
Nature connectedness	Dunes x Plastic	-0.356	0.25	[-0.832, 0.157]
	Sunset x Plastic	0.066	0.26	[-0.426, 0.572]

^a Unstandardized coefficients

^b Adjusted for subjective health, dispositional nostalgia, trait nature connectedness, meaning in life, and engagement with natural beauty

Study 2

Table 9

Measurement of additional covariates

Covariate	Scale	Item/example items	Categories/scale points
Ethnicity	-	How would you describe your ethnicity?	Belgian - Dutch – French - Italian - Turkish - Moroccan - Spanish - Polish - Other, namely: ____
Residential coastal proximity	-	What is your current residence?	Postcode: ____
Familiarity with the landscape	Two items	How familiar are you with environments similar to the one you saw in the video? How often do you visit environments similar to the one you saw in the video?	1 (<i>not at all familiar</i>) to 5 (<i>very familiar</i>) Never - One or twice a year - Once every 2 to 3 months - Once or twice a month - Once a week - More than once a week – Everyday - More than once a day
Dispositional nostalgia	Two items from Southampton Nostalgia Scale (Barrett et al., 2010) One constructed item	How often do you experience nostalgia? How pleasant is it for you to experience nostalgia?	1 (<i>very rarely</i>) to 7 (<i>very frequently</i>) 1 (<i>very unpleasant</i>) to 7 (<i>very pleasant</i>)

Adaptive emotion-regulating strategies scale [ENG version]

Please indicate to what extent you agree with each of the statements below.

1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7 = strongly agree

The kind of environment I saw in the video is a place where...

1. I reflect on the big questions of life
2. I can reflect on my feelings and emotions
3. I simply think of nothing
4. I can let my feelings and emotions be as they are
5. I realize that some stressful things are not so important in the end
6. I can let everything go for a while
7. I can clear my head
8. I am more aware of the present moment
9. I can let out my anger or my sadness
10. I can take a break from the hustle and bustle of my daily life
11. I can feel safe
12. I am more open to my feelings and emotions

+ filler items:

1. I spend time with friends and/or family
2. I don't pay much attention to my surroundings
3. I like to exercise
4. I like to spend my free time
5. I can feel tense
6. I worry more about my future

Table 10*Factor loadings of the individual items in the adaptive emotion-regulating strategies scale*

Item	Factor loading	
	1	2
1. I reflect on the big questions of life	.82	-.41
2. I can reflect on my feelings and emotions	.89	-.06
3. I simply think of nothing	.10	.79
4. I can let my feelings and emotions be as they are	.71	.09
5. I realize that some stressful things are not so important in the end	.62	.24
6. I can let everything go for a while	.65	.46
7. I can clear my head	.62	.45
8. I am more aware of the present moment	.81	-.02
9. I can let out my anger or my sadness	.76	-.02
10. I can take a break from the hustle and bustle of my daily life	.72	.30
11. I can feel safe	.75	.12
12. I am more open to my feelings and emotions	.90	-.10

Note. The extraction method was principal component analysis with an oblique (Oblimin with Kaiser Normalization) rotation. *KMO* measure = .944

Table 11

Means, standard deviations, and one-way ANOVA in time perception and emotion-regulating strategies (ERS) according to environment type

Variable	Urban		Dunes		Sunset		F
	M	SD	M	SD	M	SD	
Time perception							
Item 1	3.79	1.38	4.08	1.42	3.91	1.40	1.79
Item 2	14.94	24.78	13.59	8.04	12.51	6.58	0.98
Item 3	4.02	1.00	4.22	1.12	4.20	1.21	1.61
Emotion-regulating strategies							
Item 1	2.60	1.60	4.21	1.66	4.40	1.57	63.36***
Item 2	2.71	1.52	4.73	1.64	5.06	1.47	113.86***
Item 3	3.36	1.71	4.67	1.51	4.41	1.74	29.10***
Item 4	3.10	1.54	4.82	1.44	5.04	1.45	86.82***
Item 5	3.09	1.53	4.45	1.49	4.57	1.54	48.77***
Item 6	2.51	1.46	5.15	1.47	5.29	1.58	181.04***
Item 7	2.37	1.42	5.13	1.56	5.31	1.55	199.37***
Item 8	3.29	1.62	4.82	1.58	5.00	1.55	59.26***
Item 9	2.61	1.42	4.37	1.62	4.49	1.60	77.33***
Item 10	2.44	1.52	5.29	1.49	5.53	1.45	223.56***
Item 11	3.01	1.59	4.90	1.47	4.79	1.51	81.04***
Item 12	2.51	1.35	4.54	1.50	4.72	1.48	122.28***
ERS mean	2.80	1.09	4.76	1.21	4.88	1.11	176.22***

*** $p < .001$

Supplementary Materials for Chapter 4

Table 1

Measurement of covariates

Covariate	Scale	Item/example items	Categories/scale points
Age	-	What is your birth year?	
Gender	-	Which gender do you identify with?	Man – Woman - Other
Educational attainment	-	What is the highest level of education you have obtained?	Primary school – Professional secondary school – Technical secondary school – General secondary school – Non-university higher education – University school
Subjective health	-	How would you currently rate your own health?	1 (<i>very bad</i>) to 5 (<i>very good</i>)
Mindfulness skills	Dutch Comprehensive Inventory of Mindfulness Experiences (CHIME-SF; Bergomi et al., 2014; Cladder-Micus et al., 2019)	“In everyday life, I am aware that my perspective on things is subjective and does not necessarily have to align with the facts”	1 (<i>almost never</i>) to 6 (<i>almost always</i>)
Trait mind-wandering	Mind-Wandering Questionnaire (Mrazek et al., 2013)	“I find myself listening with one ear, thinking about something else at the same time”	1 (<i>almost never</i>) to 6 (<i>almost always</i>)
Trait repetitive negative thinking	Core characteristics subscale of the Perseverative Thinking Questionnaire (PTQ-NL; Ehring et al., 2011; Ehring et al., 2012)	“The same thoughts keep going through my mind again and again”	1 (<i>never</i>) to 5 (<i>almost always</i>)
Dispositional awe	Awe subscale of the Dispositional Positive Emotion Scales (Shiota et al., 2006)	“I feel wonder almost every day”	1 (<i>strongly disagree</i>) to 7 (<i>strongly agree</i>)
Dispositional nostalgia	Two items from Southampton Nostalgia Scale (Barrett et al., 2010) One constructed item	“How often do you experience nostalgia?” “How pleasant is it for you to experience nostalgia?”	1 (<i>very rarely</i>) to 7 (<i>very frequently</i>) 1 (<i>very unpleasant</i>) to 7 (<i>very pleasant</i>)
Trait nature connectedness	Nature Relatedness Scale (NR-6; Nisbet & Zelenski, 2013)	“My relationship to nature is an important part of who I am”	1 (<i>strongly disagree</i>) to 5 (<i>strongly agree</i>)
Meaning in life	Meaning in Life Questionnaire (Steger et al., 2006; Dutch	“I have a good sense of what makes my life meaningful”	1 (<i>strongly disagree</i>) to 7 (<i>strongly agree</i>)

Engagement with natural beauty	<p>translation of the scale provided by M. van den Heuvel, Utrecht University)</p> <p>Nature subscale of the Engagement with Beauty Scale (Diessner et al., 2008)</p>	“I notice beauty in one or more aspects of nature”	1 (<i>very unlike me</i>) to 7 (<i>very much like me</i>)
--------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------	---------------------------------------------------------------

Figure 1

Maps illustrating the walking route along the beach (top image) and in the urban street (bottom image)

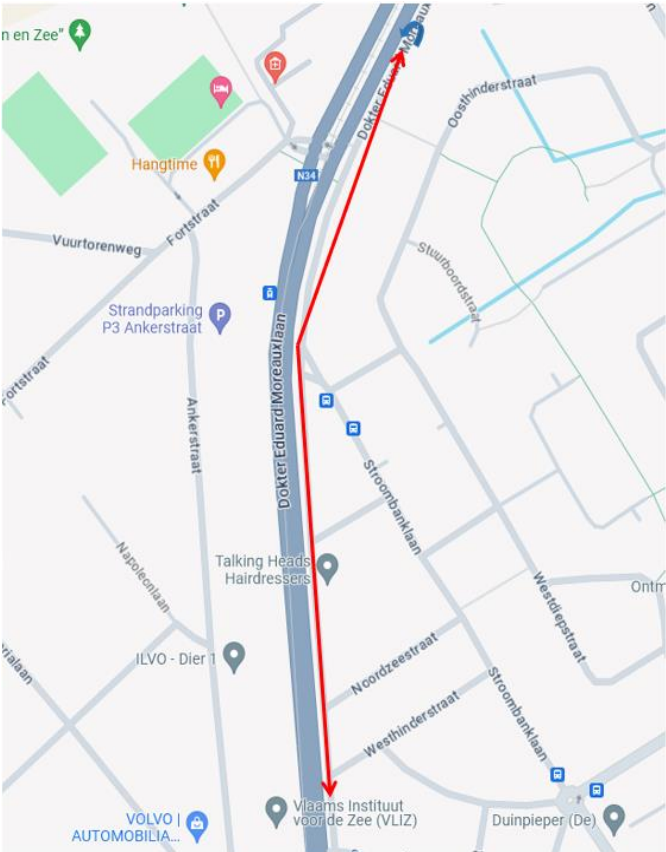
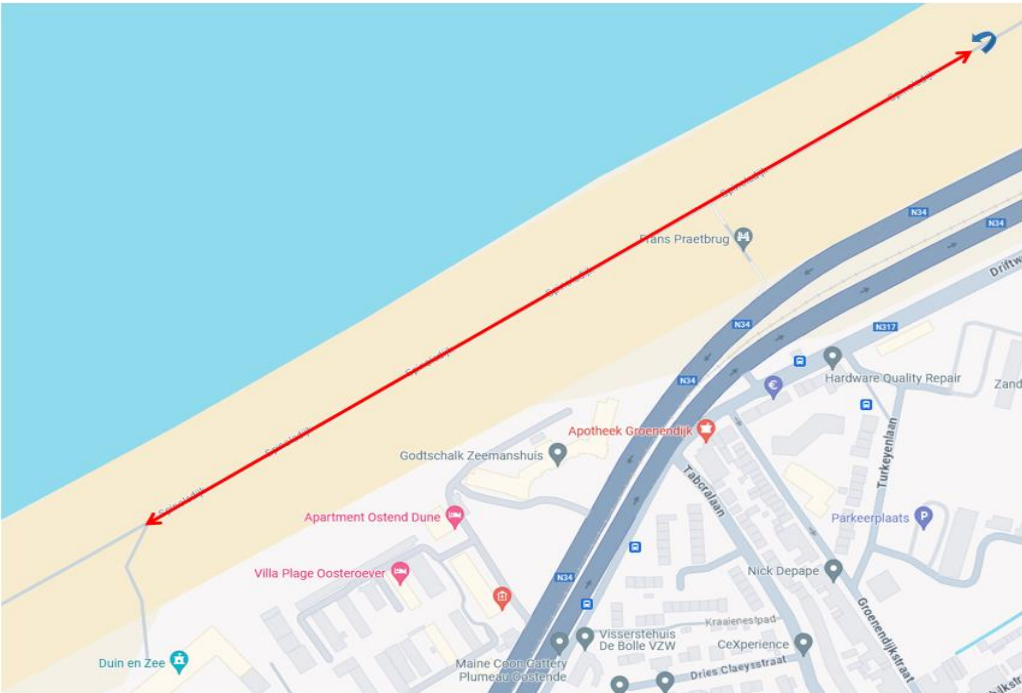


Table 2*Weather conditions during each day of the experiment in May and June 2023*

Date (morning/afternoon)	Low/High Temperature in °C	Weather descriptor	Wind km/h	Humidity %
May 22 nd	11/12	Partly sunny	18	90
	12/13	Partly sunny	20	87
May 23 rd	10/13	Partly sunny	24	79
	12/13	Scattered clouds	27	68
May 24 th	4/14	Passing clouds	6	83
	13/15	Passing clouds	11	60
June 3 rd	12/18	Passing clouds	17	75
	16/17	Passing clouds	30	62
June 4 th	12/17	Sunny	19	68
	15/17	Sunny	31	69
June 6 th	12/14	Partly sunny	23	80
	14/15	Passing clouds	31	73
June 9 th	15/21	Sunny	16	66
	21/22	Passing clouds	25	62

Note. Data retrieved from www.timeanddate.com. May 22nd to June 4th correspond to days with coastal walks and June 6th to June 9th correspond to days with urban walks

Table 3*Estimated marginal means and one-way ANCOVAs in well-being and pro-environmental behavior*

Variable	Distraction urban		Distraction coast		Mind-wandering		Mindful engagement		F	η_p^2
	M	SE	M	SE	M	SE	M	SE		
Stress reduction ^a	0.55	0.64	1.19	0.69	1.07	0.69	1.47	0.73	0.37	.017
Worry reduction ^b	0.81	0.44	0.12	0.48	1.30	0.47	-0.27	0.48	2.18	.09
PA increase ^c	-1.41	1.32	-0.28	1.37	1.62	1.33	0.56	1.37	0.98	.045
NA decrease ^d	2.12	0.86	1.65	0.93	2.86	0.90	1.95	0.93	0.32	.014
PA_LA increase ^e	1.09	0.68	0.78	0.76	1.73	0.73	2.57	0.74	1.15	.051
WEPT ^f	4.70	0.73	5.13	0.81	5.75	0.77	4.71	0.81	0.42	.019

Note. PA = Positive Affect; NA = Negative Affect; PA_LA = Positive Affect Low Arousal ; WEPT = Work for Environmental Protection Task

^a Adjusted for coastal residency, mindfulness skills, and trait repetitive negative thinking

^b Adjusted for subjective health and trait repetitive negative thinking

^c Adjusted for age, gender, dispositional awe, dispositional nostalgia, trait mind-wandering

^d Adjusted for subjective health and dispositional awe

^e Adjusted for age and meaning in life

^f Adjusted for age and dispositional awe

Supplementary Materials for Chapter 5

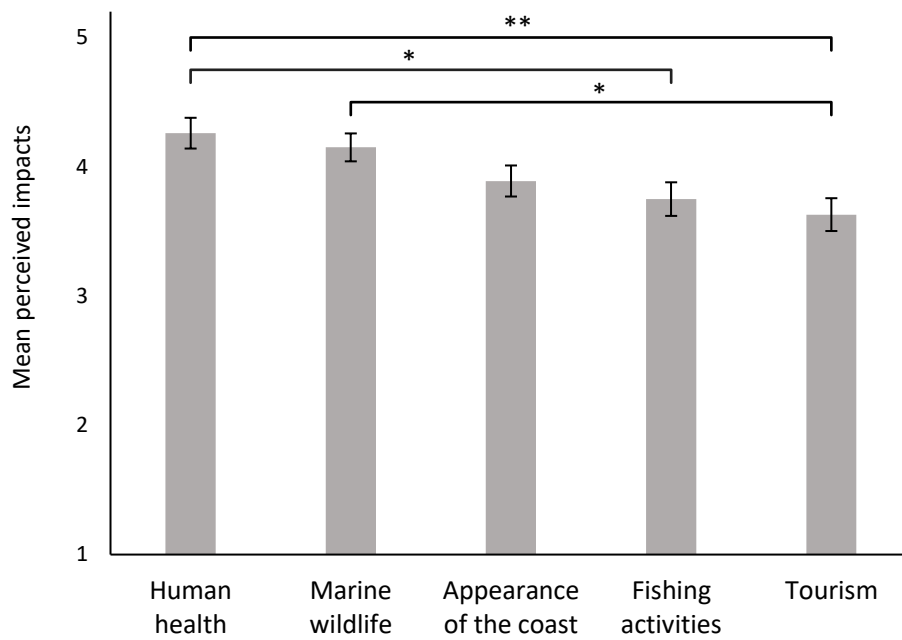


Figure 1. Perceived impacts of marine litter in Benin at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. * $p < .05$; ** $p < .01$.

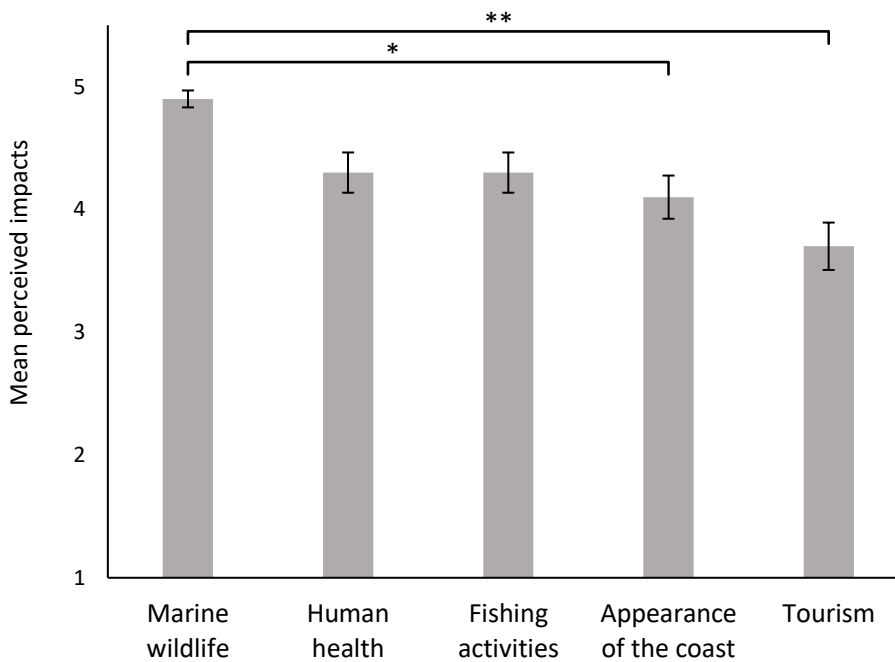


Figure 2. Perceived impacts of marine litter in Cabo Verde at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. * $p < .05$; ** $p < .01$.

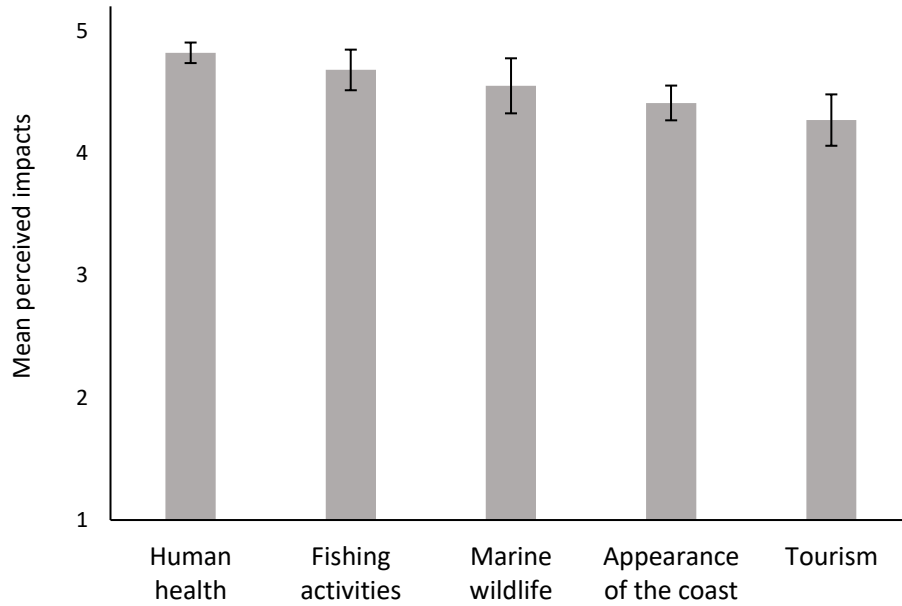


Figure 3. Perceived impacts of marine litter in Côte d'Ivoire at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error.

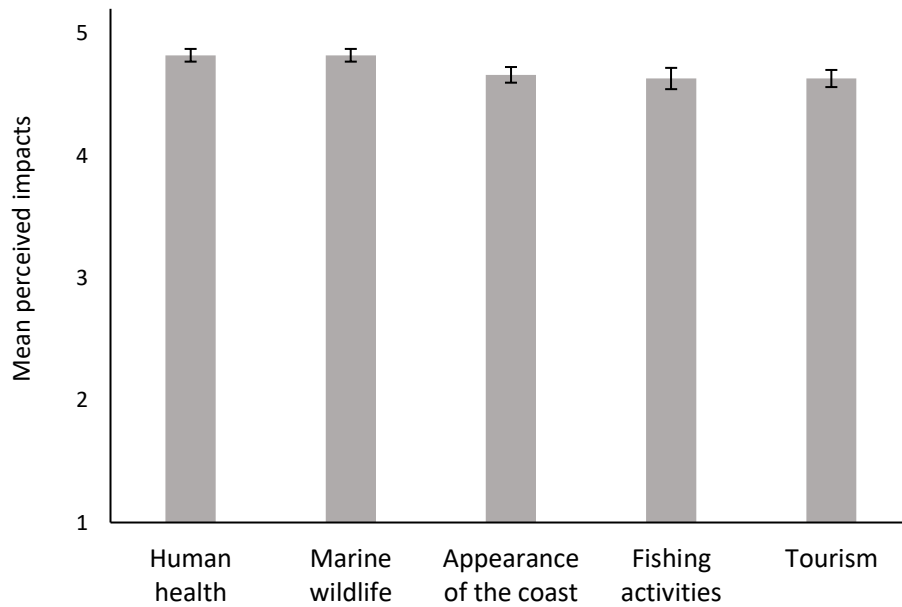


Figure 4. Perceived impacts of marine litter in Ghana at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error.

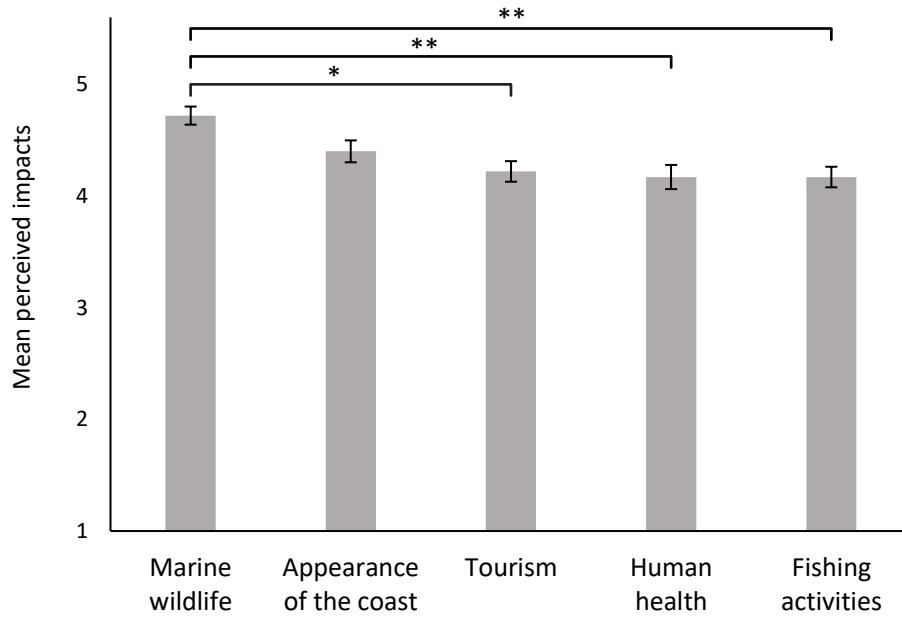


Figure 5. Perceived impacts of marine litter in Malaysia at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. * $p < .05$; ** $p < .01$.

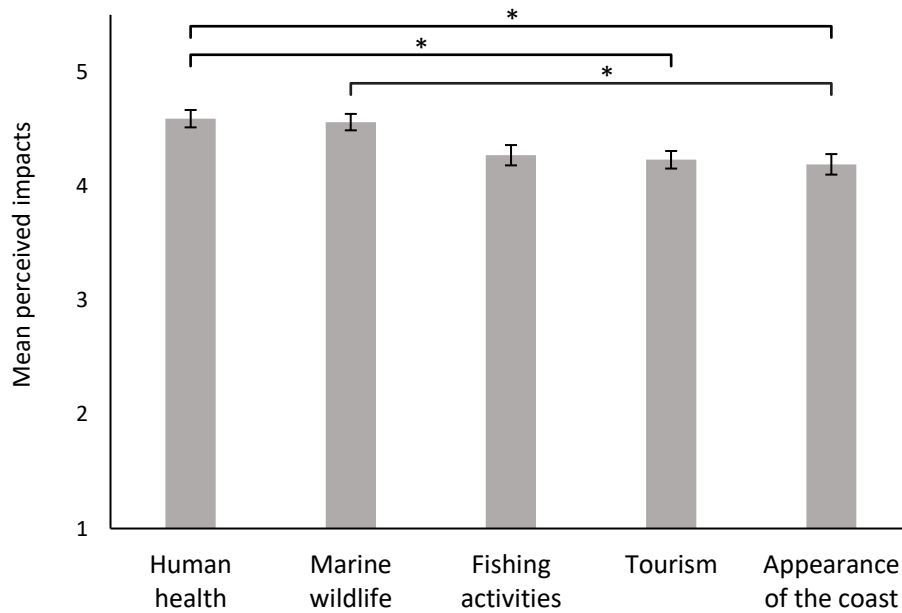


Figure 6. Perceived impacts of marine litter in Nigeria at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. * $p < .05$.

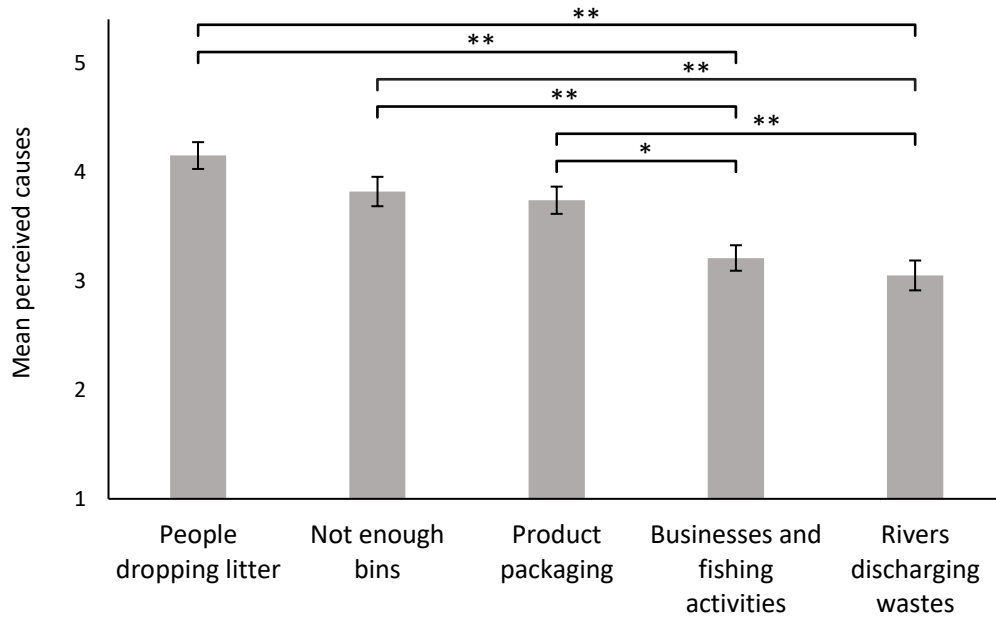


Figure 7. Perceived causes of marine litter in Benin at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. * $p < .05$; ** $p < .01$.

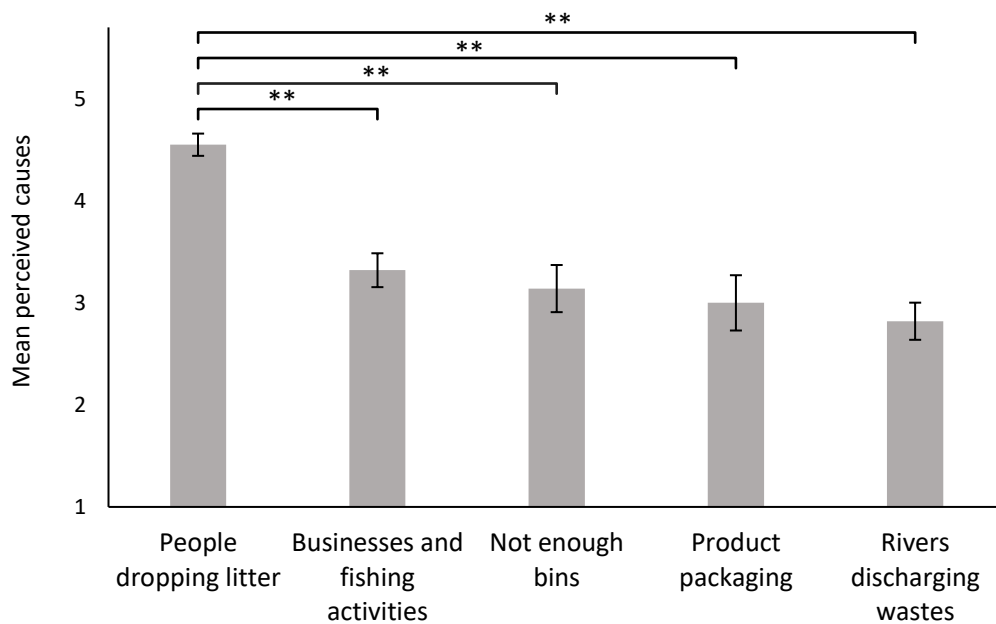


Figure 8. Perceived causes of marine litter in Cabo Verde at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. ** $p < .01$.

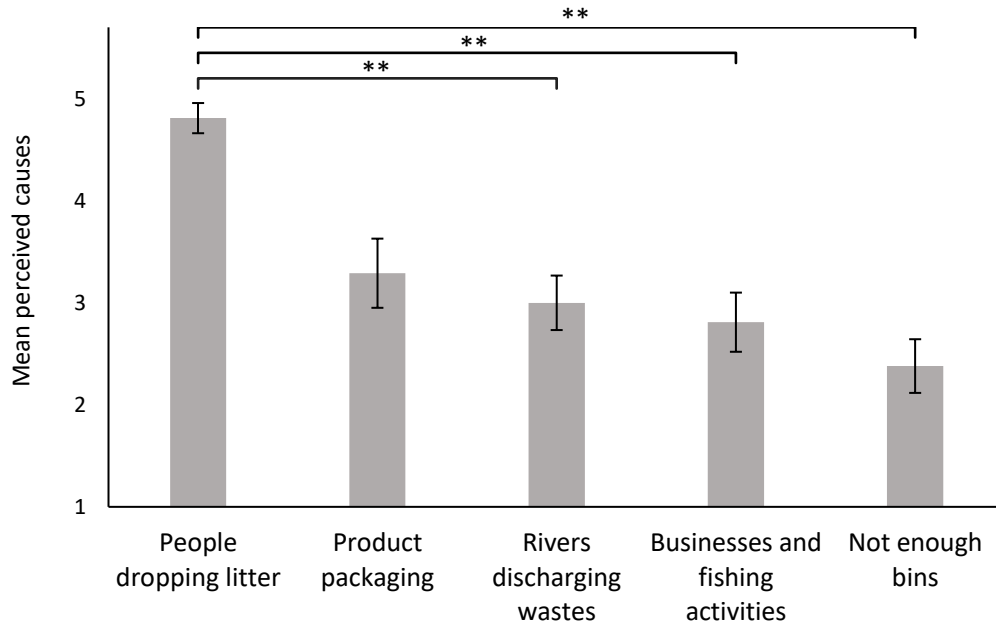


Figure 9. Perceived causes of marine litter in Côte d'Ivoire at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. ****** $p < .01$.

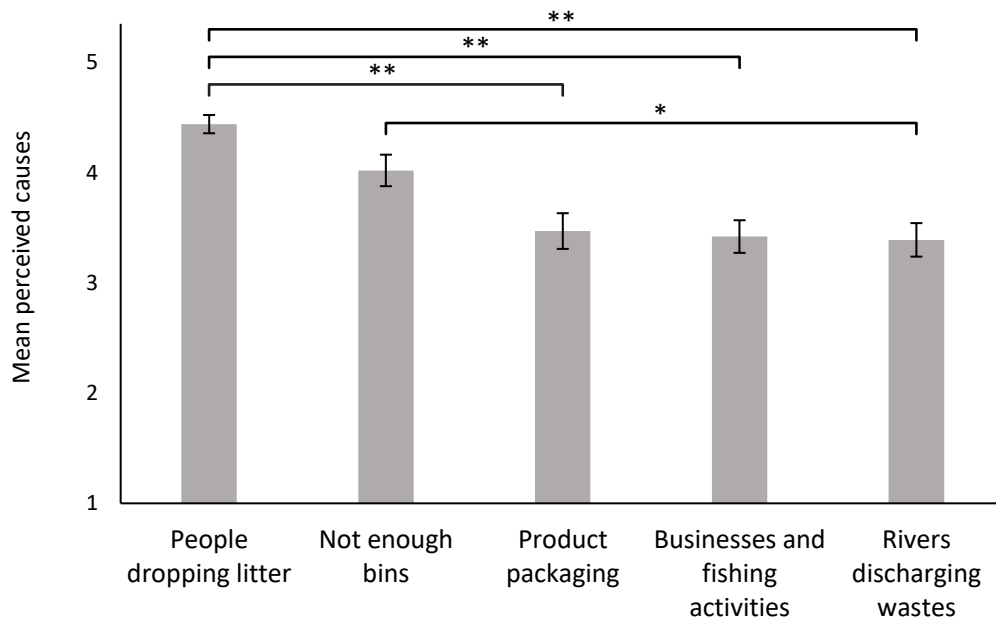


Figure 10. Perceived causes of marine litter in Ghana at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. ***** $p < .05$; ****** $p < .01$.

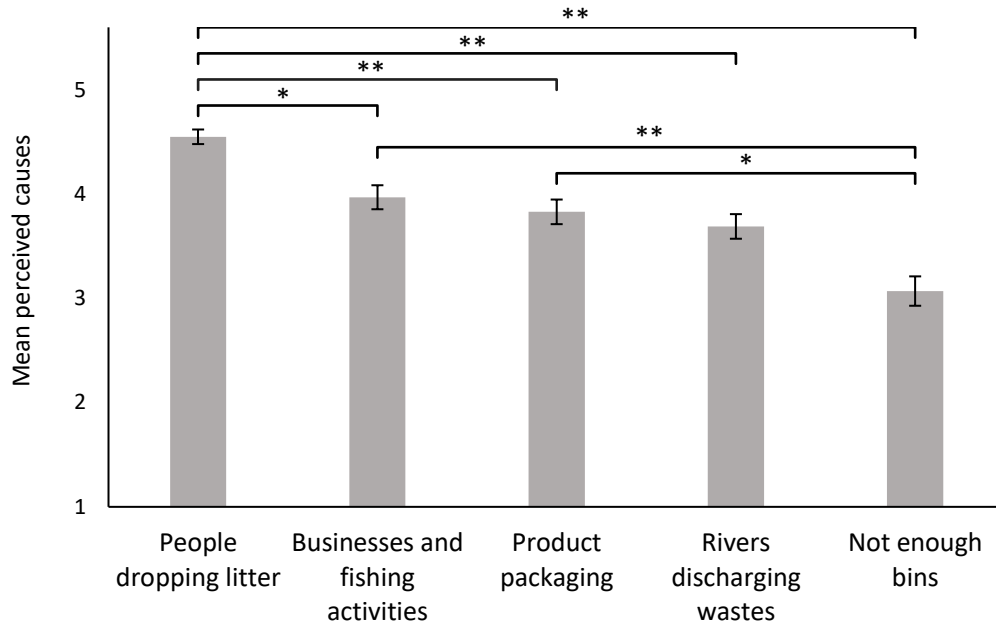


Figure 11. Perceived causes of marine litter in Malaysia at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. * $p < .05$; ** $p < .01$.

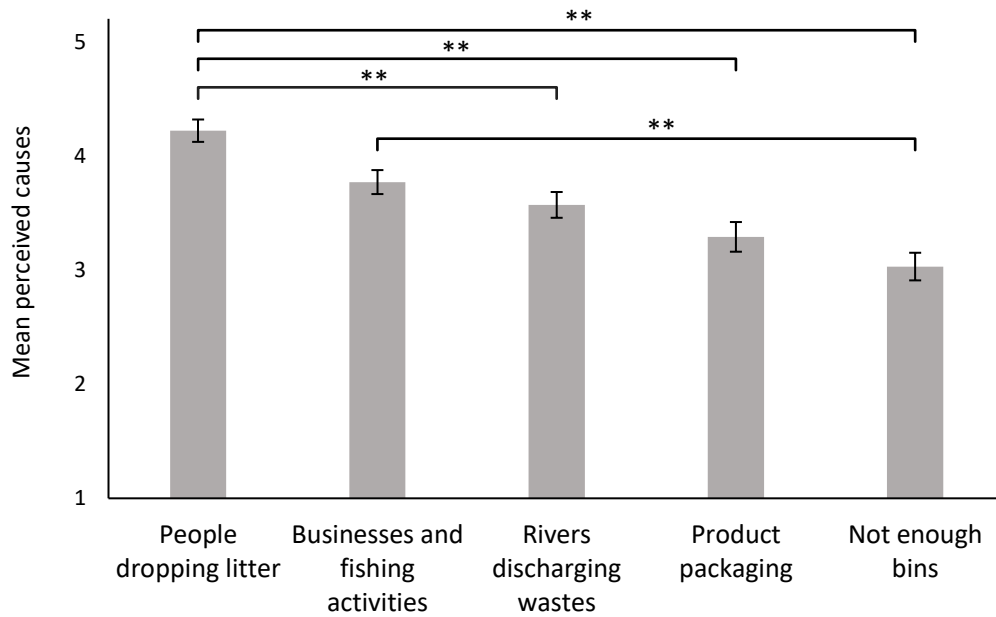


Figure 12. Perceived causes of marine litter in Nigeria at pre-intervention (1 – 5 scale: *strongly disagree–strongly agree*). Note. Error bars represent standard error. ** $p < .01$.

Table 1. Attitudes towards beach litter removal at pre-intervention, per country (1 – 5 scale: *strongly disagree–strongly agree*). Note. * $p < .05$; ** $p < .01$.

Attitudes towards beach litter removal at baseline, per country		M (SD)	Significant differences	
Benin				
1	Local government is responsible	3.80 (0.99)	1 > 5**	
2	Local community is responsible	3.62 (0.96)	2 > 5*	
3	Everyone is responsible, including me	3.95 (1.22)	3 > 5**	
4	Collective activities are important to keep the beach litter-free	4.05 (0.82)	4 > 5**	
5	Only the original polluters are responsible	2.55 (1.27)		
Cabo Verde				
1	Local government is responsible	2.89 (0.96)	3 > 1**	
2	Local community is responsible	3.89 (0.76)	4 > 1*	
3	Everyone is responsible, including me	4.89 (0.32)	2 > 5*	
4	Collective activities are important to keep the beach litter-free	4.39 (0.78)	3 > 5**	
5	Only the original polluters are responsible	2.28 (0.96)	4 > 5**	
Côte d'Ivoire				
1	Local government is responsible	2.86 (1.12)	3 > 1**	
2	Local community is responsible	3.73 (1.32)	4 > 1**	
3	Everyone is responsible, including me	4.86 (0.35)	3 > 5**	
4	Collective activities are important to keep the beach litter-free	4.77 (0.53)	4 > 5**	
5	Only the original polluters are responsible	2.18 (1.40)		
Ghana				
1	Local government is responsible	2.70 (1.11)	2 > 1**	2 > 5**
2	Local community is responsible	3.81 (1.18)	3 > 1**	3 > 5**
3	Everyone is responsible, including me	4.72 (0.76)	4 > 1**	4 > 5**
4	Collective activities are important to keep the beach litter-free	4.39 (0.90)	3 > 2*	
5	Only the original polluters are responsible	1.87 (1.06)		
Malaysia				
1	Local government is responsible	3.64 (0.95)	3 > 1*	
2	Local community is responsible	3.88 (0.86)	2 > 5**	
3	Everyone is responsible, including me	4.24 (0.68)	3 > 5**	
4	Collective activities are important to keep the beach litter-free	4.14 (0.74)	4 > 5**	
5	Only the original polluters are responsible	3.05 (1.11)		
Nigeria				
1	Local government is responsible	3.17 (1.10)	3 > 1**	1 > 5**
2	Local community is responsible	3.53 (1.14)	4 > 1**	2 > 5**
3	Everyone is responsible, including me	4.47 (0.71)	3 > 2**	3 > 5**
4	Collective activities are important to keep the beach litter-free	4.35 (0.69)	4 > 2**	4 > 5**
5	Only the original polluters are responsible	2.19 (1.01)		

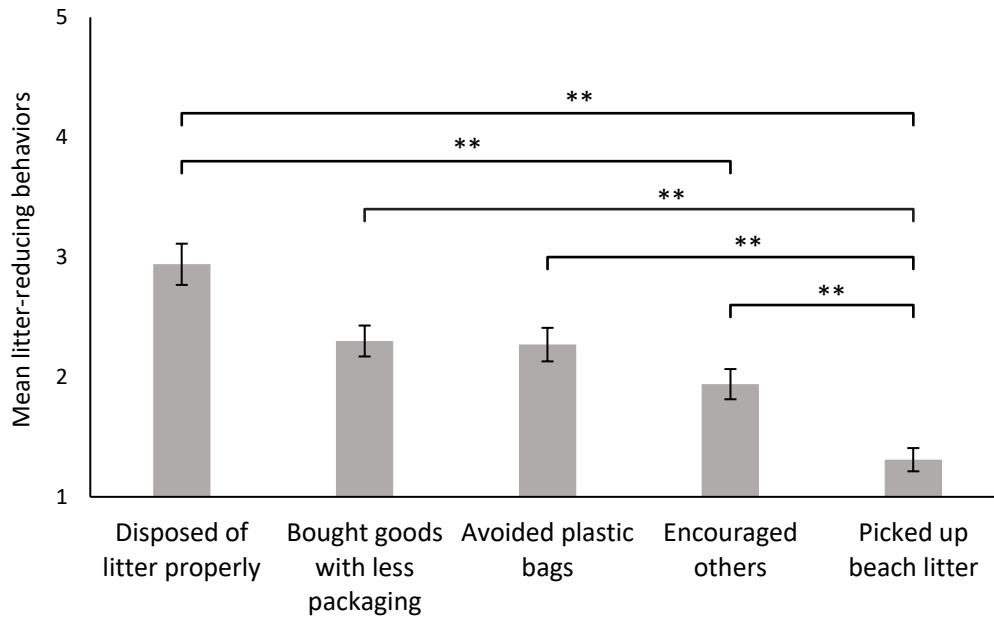


Figure 13. Self-reported litter-reducing behaviors in Benin at pre-intervention (1 – 5 scale: *never–a great deal*). Note. Error bars represent standard error. ** $p < .01$.

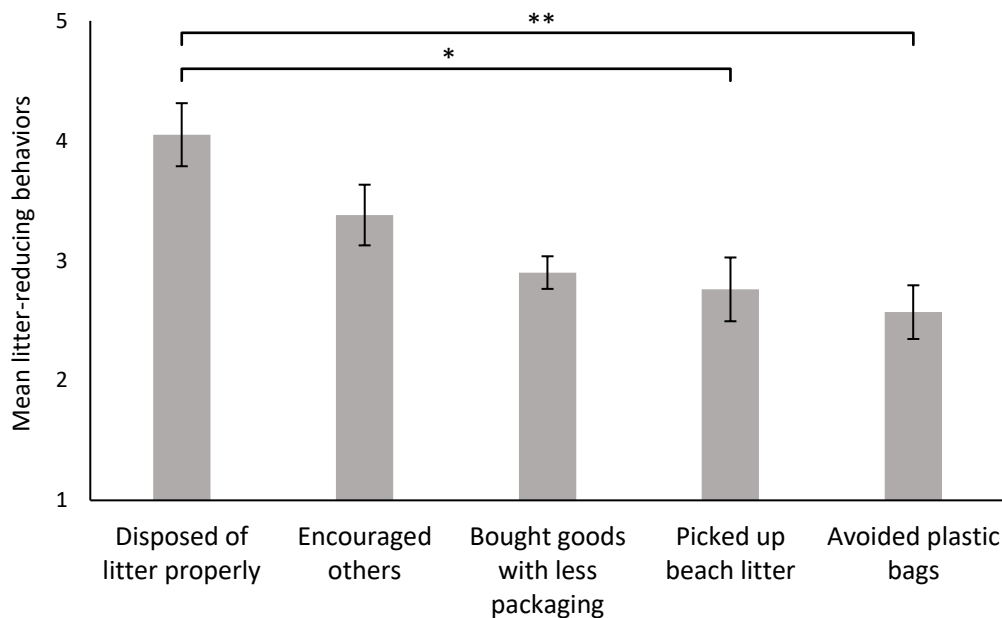


Figure 14. Self-reported litter-reducing behaviors in Cabo Verde at pre-intervention (1 – 5 scale: *never–a great deal*). Note. Error bars represent standard error. * $p < .05$; ** $p < .01$.

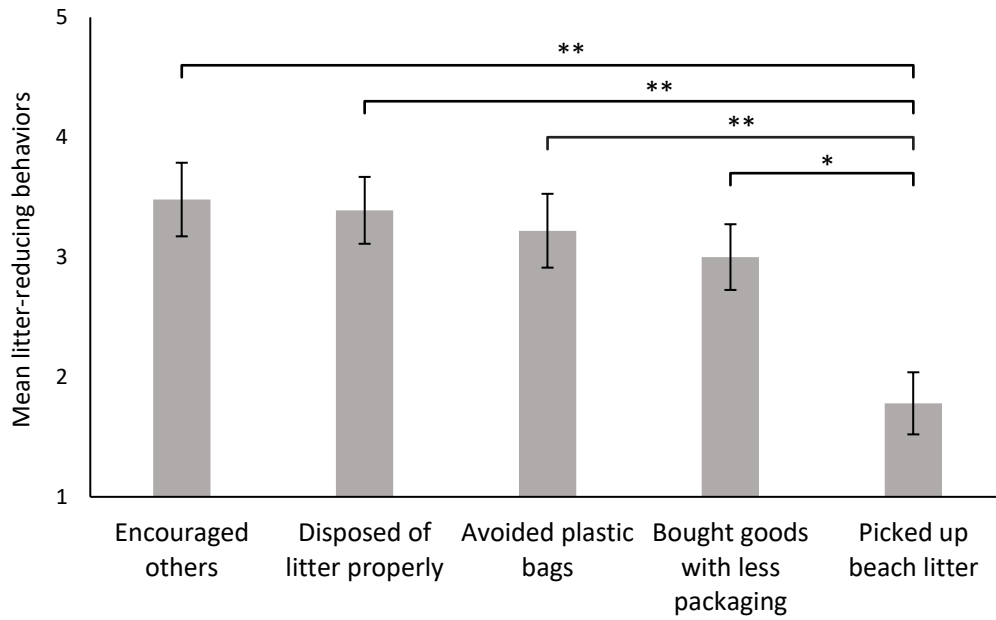


Figure 15. Self-reported litter-reducing behaviors in Côte d'Ivoire at pre-intervention (1 – 5 scale: *never–a great deal*). Note. Error bars represent standard error. * $p < .05$; ** $p < .01$.

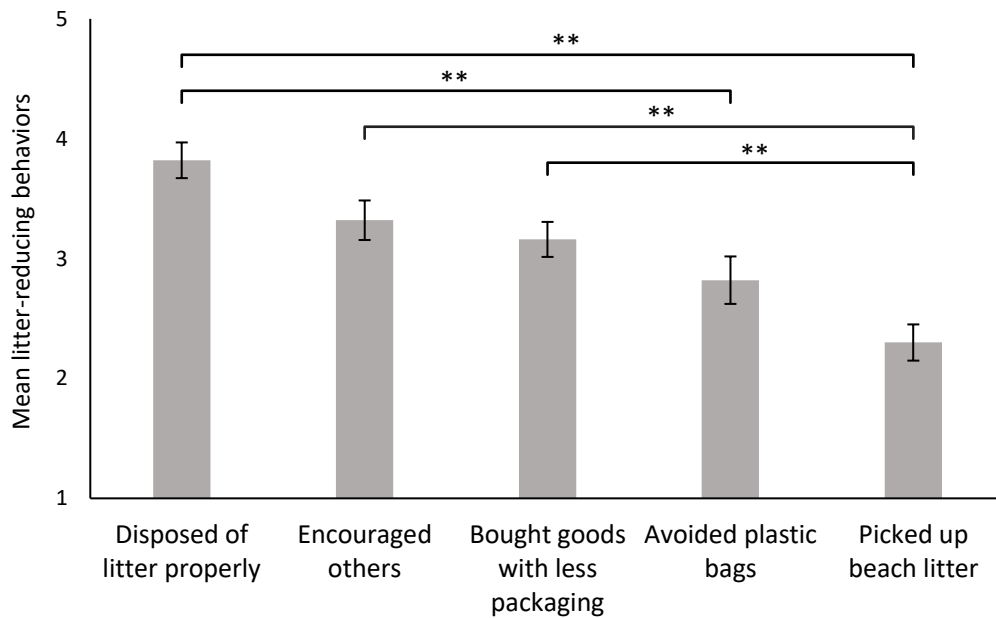


Figure 16. Self-reported litter-reducing behaviors in Ghana at pre-intervention (1 – 5 scale: *never–a great deal*). Note. Error bars represent standard error. ** $p < .01$.

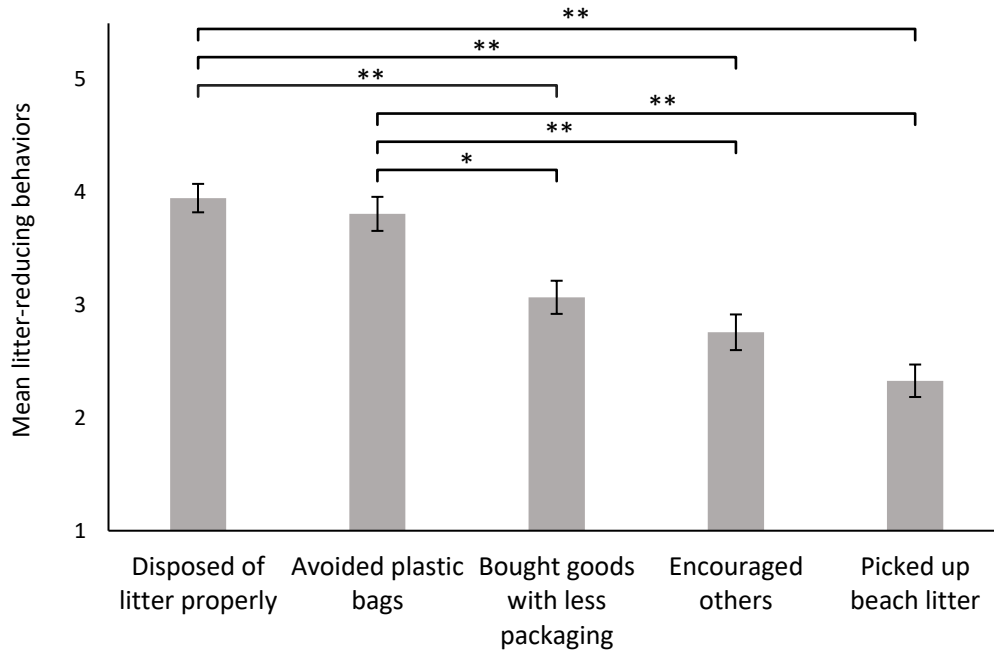


Figure 17. Self-reported litter-reducing behaviors in Malaysia at pre-intervention (1 – 5 scale: *never–a great deal*). Note. Error bars represent standard error. * $p < .05$; ** $p < .01$.

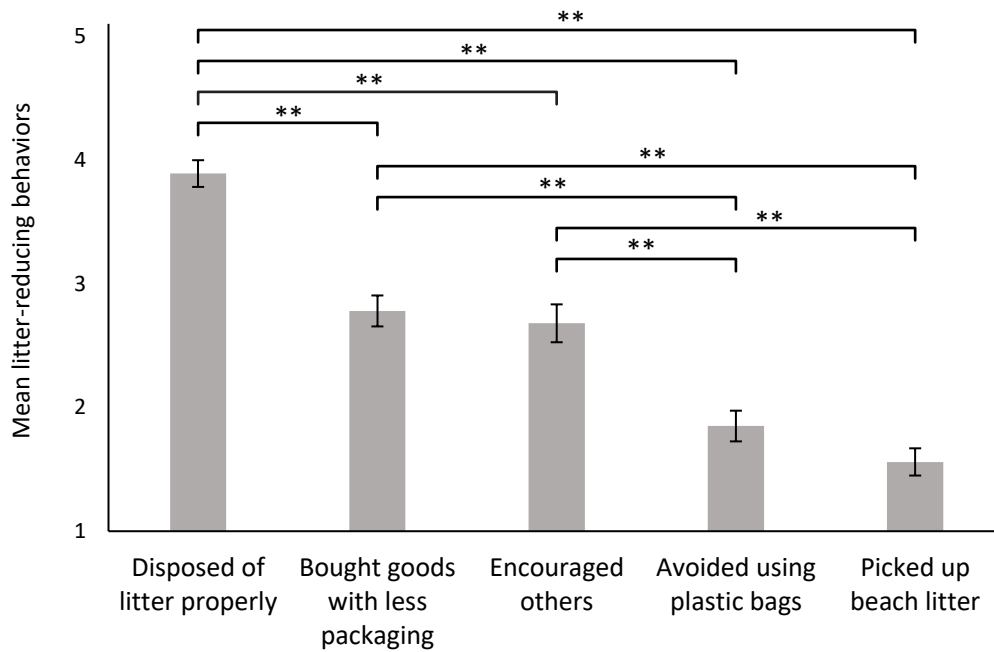


Figure 18. Self-reported litter-reducing behaviors in Nigeria at pre-intervention (1 – 5 scale: *never–a great deal*). Note. Error bars represent standard error. ** $p < .01$.

Data Storage Fact Sheets

Data Storage Fact Sheet 1

Name/identifier study: Influence of the Belgian coast on well-being during the COVID-19 pandemic

Author: Severin, M.I., Vandegehuchte, M.B., Hooyberg, A., Buysse, A., Raes, F., Everaert, G.

Date: December 2020

1. Contact details

=====

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If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

=====

* Reference of the publication in which the datasets are reported:

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>

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- all members of the research group
- all members of UGent
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- file(s) containing processed data. Specify: ...
- file(s) containing analyses. Specify: SPSS output
- files(s) containing information about informed consent: blank copy saved on researcher PC
- a file specifying legal and ethical provisions: documents for application for ethical committee, including application form, data management plan, GDPR record
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Data Storage Fact Sheet 2

Name/identifier study: A qualitative study on emotions experienced at the coast and their influence on well-being

Author: Severin, M.I., Raes, F., Notebaert, E., Lambrecht, L., Everaert, G., Buysse, A.

Date: November 2021

1. Contact details

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1a. Main researcher

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If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

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* Reference of the publication in which the datasets are reported:

Severin, M.I., Raes, F., Notebaert, E., Lambrecht, L., Everaert, G., Buysse, A. (2022). A qualitative study on emotions experienced at the coast and their influence on well-being. *Frontiers in Psychology*, 13, 902122. <https://doi.org/10.3389/fpsyg.2022.902122>

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- main researcher
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- all members of the research group
- all members of UGent
- other (specify): master students Evie Notebaert and Luka Lambrecht

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- file(s) containing processed data. Specify: transcripts from audio files
- file(s) containing analyses. Specify: analyses saved in Word files
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- all members of UGent
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Data Storage Fact Sheet 3

Name/identifier study: Effects of the coast on emotions, well-being, and pro-environmental attitudes and behaviors

Author: Severin, M.I., Pauwels, L., Verheye, J., Loeys, T., Everaert, G., Buysse, A., & Raes, F.

Date: March 2023

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=====

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If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

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* Reference of the publication in which the datasets are reported:
Severin, M.I., Pauwels, L., Verheye, J., Loeys, T., Everaert, G., Buysse, A., & Raes, F. (2024). Effects of the coast on emotions, well-being, and pro-environmental attitudes and behaviors. *Manuscript under review*

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- research group file server
- other (specify): Marine Data Archive: online repository of the Flanders Marine Institute; master students PC; statistician PC

* Who has direct access to the raw data (i.e., without intervention of another person)?

- main researcher
- responsible ZAP
- all members of the research group
- all members of UGent
- other (specify): master students Louis Pauwels and Justine Verheye; statistician Anna Snoeck

3b. Other files

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- file(s) describing the transition from raw data to reported results. Specify: SPSS and R syntax
- file(s) containing processed data. Specify:
- file(s) containing analyses. Specify: SPSS and R outputs
- files(s) containing information about informed consent: blank copy saved on researcher PC
- a file specifying legal and ethical provisions: documents for application for ethical committee, including application form, data management plan, GDPR record, Data Protection Impact Assessment
- file(s) that describe the content of the stored files and how this content should be interpreted. Specify:
- other files. Specify: metadata describing the survey data in the Integrated Marine Information System (IMIS)

* On which platform are these other files stored?

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- research group file server
- other: Marine Data Archive: online repository of the Flanders Marine Institute; master students PC; statistician PC

* Who has direct access to these other files (i.e., without intervention of another person)?

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- all members of the research group
- all members of UGent
- other (specify): master students Louis Pauwels and Justine Verheye; statistician Anna Snoeck

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Data Storage Fact Sheet 4

Name/identifier study: Effect of coastal walks and engagement interventions on well-being and pro-environmental behavior

Author: Severin, M.I., Mertens, L., Gündüz, O., Van der Gucht, K., Everaert, G., Buysse, A., & Raes, F.

Date: September 2023

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If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

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- * Reference of the publication in which the datasets are reported:
Severin, M.I., Mertens, L., Gündüz, O., Van der Gucht, K., Everaert, G., Buysse, A., & Raes, F. (2024).
Effect of coastal walks and engagement interventions on well-being and pro-environmental behavior.
Manuscript under review

- * Which datasets in that publication does this sheet apply to?:
This sheet applies to all the data used in the publication stated above.

3. Information about the files that have been stored

=====

3a. Raw data

- * Have the raw data been stored by the main researcher? [x] YES / [] NO
If NO, please justify:

* On which platform are the raw data stored?

- researcher PC
- research group file server
- other (specify): Marine Data Archive: online repository of the Flanders Marine Institute; master students PC

* Who has direct access to the raw data (i.e., without intervention of another person)?

- main researcher
- responsible ZAP
- all members of the research group
- all members of UGent
- other (specify): master students Onur Gündüz and Lore Mertens

3b. Other files

* Which other files have been stored?

- file(s) describing the transition from raw data to reported results. Specify: SPSS and R syntax
- file(s) containing processed data. Specify:
- file(s) containing analyses. Specify: SPSS and R outputs
- files(s) containing information about informed consent: blank copy saved on researcher PC
- a file specifying legal and ethical provisions: documents for application for ethical committee, including application form, data management plan, GDPR record, Data Protection Impact Assessment
- file(s) that describe the content of the stored files and how this content should be interpreted.

Specify:

- other files. Specify:

* On which platform are these other files stored?

- individual PC
- research group file server
- other: Marine Data Archive: online repository of the Flanders Marine Institute; master students PC

* Who has direct access to these other files (i.e., without intervention of another person)?

- main researcher
- responsible ZAP
- all members of the research group
- all members of UGent
- other (specify): master students Onur Gündüz and Lore Mertens

4. Reproduction

=====

* Have the results been reproduced independently?: YES / NO

* If yes, by whom (add if multiple):

- name: Dries Debeer (statistical consultant)
- address: Henri Dunantlaan 2, 9000 Ghent, Belgium
- affiliation: Ghent University
- e-mail: stat.pp@ugent.be

Data Storage Fact Sheet 5

Name/identifier study: Impact of the citizen science project COLLECT on ocean literacy and well-being within a north/west African and south-east Asian context

Author: Severin, M.I., Buysse, A., Raes, F., Krug, L.A., Seeyave, S., Everaert, G., Mahu, E., Catarino, A.I.

Date: December 2022

1. Contact details

=====

1a. Main researcher

- name: Marine Severin
- address: Jacobsenstraat 1, 8400 Ostend, Belgium
- e-mail: marine.severin@vliz.be

1b. Responsible Staff Member (ZAP)

- name: Ann Buysse
- address: Henri Dunantlaan 2, 9000 Ghent, Belgium
- e-mail: ann.buysse@ugent.be

If a response is not received when using the above contact details, please send an email to data.pp@ugent.be or contact Data Management, Faculty of Psychology and Educational Sciences, Henri Dunantlaan 2, 9000 Ghent, Belgium.

2. Information about the datasets to which this sheet applies

=====

* Reference of the publication in which the datasets are reported:

Severin, M.I., Akpetou, L.K., Annasawmy, P., Asuquo, F.E., Beckman, F., Benomar, M., Jaya-Ram, A., Malouli, M., Mees, J., Monteiro, I., Ndwiga, J., Neves Silva, P., Nubi, O.A., Sim, Y.K., Sohau, Z., Shau-Hwai, A.T., Woo, S.P., Zizah, S., Buysse, A., Raes, F., Krug, L.A., Seeyave, S., Everaert, G., Mahu, E., Catarino, A.I. (2023). Impact of the citizen science project COLLECT on ocean literacy and well-being within a north/west African and south-east Asian context. *Frontiers in Psychology*, 14, 1130596.

<https://doi.org/10.3389/fpsyg.2023.1130596>

* Which datasets in that publication does this sheet apply to?:

This sheet applies to all the data used in the publication stated above.

3. Information about the files that have been stored

=====

3a. Raw data

 * Have the raw data been stored by the main researcher? YES / NO

If NO, please justify:

* On which platform are the raw data stored?

- researcher PC
- research group file server
- other (specify): Marine Data Archive: online repository of the Flanders Marine Institute; private Microsoft Teams channel

* Who has direct access to the raw data (i.e., without intervention of another person)?

- main researcher
- responsible ZAP
- all members of the research group
- all members of UGent
- other (specify): co-researcher Ana Catarino

3b. Other files

* Which other files have been stored?

- file(s) describing the transition from raw data to reported results. Specify: SPSS syntax
- file(s) containing processed data. Specify: Excel file with anonymized data
- file(s) containing analyses. Specify: SPSS outputs
- files(s) containing information about informed consent: blank copy saved on researcher PC
- a file specifying legal and ethical provisions: documents for application for ethical committee, including application form, data management plan, GDPR record, Data Protection Impact Assessment
- file(s) that describe the content of the stored files and how this content should be interpreted. Specify: codebook saved as a Word file
- other files. Specify: metadata describing the survey data in the Integrated Marine Information System (IMIS)

* On which platform are these other files stored?

- individual PC
- research group file server
- other: Marine Data Archive: online repository of the Flanders Marine Institute; excel file with anonymized data and codebook are openly available in IMIS

* Who has direct access to these other files (i.e., without intervention of another person)?

- main researcher
- responsible ZAP
- all members of the research group
- all members of UGent

- [x] other (specify): co-researcher Ana Catarino; open access to excel file with anonymized data and codebook

4. Reproduction

=====

* Have the results been reproduced independently?: YES / NO

* If yes, by whom (add if multiple):

- name:

- address:

- affiliation:

- e-mail: