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„From Childhood Exposure to Blue Spaces to Adult Environmentalism: The Role of Nature Connectedness and Current Nature Visits in an Austrian Sample“

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Patricia Stehl, BSc

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And to the friends who always got my back,
and who brightened the strange times during which this thesis was created.

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Contents

Introduction

Degradation of the natural world is one of the major challenges humanity is currently facing (IPCC, 2021). This degradation is greatly caused by our own activities, which are rapidly crossing the boundaries from which our planet can recover (Steffen et al., 2015). As climate change and its consequences become more tangible, fundamental changes in people's behaviours are needed to preserve a planet that is habitable for humans (IPCC, 2021). Even though environmental concern is increasing and expressed by citizens globally (Franzen & Vogl, 2013), there is still a gap between the level of concern about environmental problems and the amount of behaviours performed to tackle those problems (Hornsey et al., 2016). This discrepancy shows in the low levels of indicators for pro-environmental behaviour of official statistics. For example, a developed country like Austria experienced an all-time high of CO2-emissions from air travel in 2019 (2.9 million tons vs. less than 1 million tons in 1990; Environment Agency Austria, 2021) and had an increase in meat production of 100% from 1960 to 2018 (FAO, 2021), while the country's population has grown by only 25% during this period (Statistik Austria, 2021).

While population growth is another factor for environmental issues in itself, in accordance with the aforementioned level of counterproductive action, a growing disconnection from the natural world can objectively be observed in western cultures in several ways: First, there is objective evidence that the number of nature-related themes in novels, movies and other forms of popular culture has linearly declined since the 1950's (Kesebir & Kesebir, 2017), and secondly, there are studies detecting a behavioral shift away from nature-based recreation (e.g. Pergams & Zaradic, 2008). This trend was also labelled "extinction of experience" by Robert Pyle (1993) and manifests itself in statistics such as reductions in the visitor frequency of state parks, for example in the USA and Japan between -18% and -25% since the 1980's (Pergams & Zaradic, 2008). The extinction of experience is seen as one of the main behavioural obstacles to reverse environmental degradation (Miller, 2005; Soga & Gaston, 2016).

Research suggests that especially contemporary children tend to spend more time indoors and with digital activities than outside in nature, in comparison to their predecessors (Kellert, 2005; Hofferth, 2009). In accordance with this development, Richard Louv introduced the term "Nature-deficit disorder" and expresses concern about the growing distance from children and nature as follows: "As the care of nature increasingly becomes an intellectual concept severed from the joyful experience of the outdoors, you have to wonder: Where will future environmentalists come from?" (Louv, 2008, pp. 146-147). However, more recent

studies also question the extinction of experience hypothesis and have queried whether contemporary children's experiences with nature really differ in quantity from those of former generations, or if there are rather major differences in the actual activities performed in nature (Oh et al., 2020; Novotny et al., 2021).

The possible shift away from nature of today's children becomes even more concerning when considering the growing body of literature that is suggesting the importance of nature contact in childhood in general as an important predictor for factors such as nature connectedness and pro-environmental attitudes and behaviours later in life (Evans et al., 2018; Cleary et al., 2020; van Heezik et al., 2021). These findings make childhood nature contact an impactful factor to consider for a greater behavioural change towards environmentalism and nature restoration.

Some studies have already provided life course models from experiences with nature in childhood to adult environmentalism with cross-sectional samples (Wells & Lekies, 2006; Rosa et al., 2018; Krepelkova et al., 2020). However, those studies focused exclusively on nature in general, or specifically on green spaces, whereas recent findings suggest possible differential effects of blue natural environments, at least on health and well-being outcomes for adults (Wheeler et al., 2012; White et al., 2021). The question that remains is if blue spaces, such as rivers, lakes, and oceans, can also affect pro-environmental behaviours in a meaningful way, and even more so: Can exposure to blue spaces in childhood predict adult pro-environmental behaviours as well as exposure to green spaces in childhood does?

Theoretical background

Assessing the Impact of Nature Experiences in Childhood

Participation with nature in childhood is found to be associated with a wide range of immediate benefits for children's health and well-being, such as lower levels of psychological distress, enhanced self-regulation and more physical activity (Wells & Evans, 2003; Gill, 2014; Taylor & Butts-Wilmsmeyer, 2020). High levels of nature exposure in childhood and engagement in nature-based environmental education are also directly related to early environmentalist tendencies in children, such as greater nature connectedness, as well as more early ecological behaviours (Otto & Pensini, 2017).

It has also been argued that participation with nature in childhood has positive lasting effects into adulthood on variables similar to those indicating immediate effects for children. For example, the quality of one's mental health in adulthood seems to be associated with the level of nature contact in childhood (Engemann et al., 2019; Preuß et al., 2019), and there are

findings hinting at possible effects of childhood nature contact on personality traits western cultures are fond of, such as higher openness and lower neuroticism in adulthood (Snell et al., 2020).

More relevant for the current study however are the long-term effects of childhood nature experiences on behavioural and cognitive measures that are associated with the natural environment. Wells and Lekies (2006) were the first to propose that participation with nature in childhood can put people on a general "path towards environmentalism", which means that childhood nature exposure facilitates the development of factors such as nature connectedness and pro-environmental attitudes and behaviours. More precisely, according to Wells and Lekies (2006), there are not as many differences in the effects of participating with wild nature (e.g., hiking, camping, or hunting in natural areas) or domesticated nature (e.g., harvesting produce or caring for plants) as one might think. If so, this would further query the extinction of experience hypotheses, because the findings mentioned above indicate that there are many types of nature experiences children can have, and that it doesn't matter which of them children have, as long as contemporary children have at least some experiences with nature.

More recent studies expanded those initial findings by focusing more on nature connectedness, which has been found to predict pro-environmental behaviours in both cross-sectional and experimental studies (Whitburn et al., 2020). For instance, a positive association of childhood nature experiences with nature connectedness has already been found in Canadian (Windhorst & Williams, 2015), US-American (Tam, 2013) and Australian (Cleary et al., 2020) samples. However, there is also a recent study using a sample from New Zealand that could not show a meaningful connection from childhood nature experiences to both, adult nature connectedness and pro-environmental behaviours (van Heezik et al., 2021). Additionally, Cleary and colleagues (2020) suggested that childhood nature exposure is not necessarily needed for heightened levels of nature connectedness and pro-environmental behaviours in adulthood and that nature experiences made later in life can still foster those factors.

Still, given the overlap of findings in several western countries and the assumed importance of long-term environmentalist behaviour for nature restoration, the proposed connection seems to be worth further inquiry and is also supported by the only longitudinal study on this topic so far. Specifically, Evans and colleagues (2018) followed 99 children from rural areas in upstate New York over 12 years, from the ages 6 to 18, and found that the

most meaningful predictors for young adults' pro-environmental behaviours were the levels of their mother's education and their time spent playing outdoors during childhood.

Potential Mechanisms between Childhood Nature Exposure and Adult PEB

Studies have tried to identify the possible underlying mechanisms between childhood nature exposure and adult pro-environmental behaviour. Attempts are being made to propose an order of characteristics emerging over the life course because of a high nature exposure in childhood, where factors are incorporated that also further foster pro-environmental behaviours. Two of the explaining variables proposed, and which are going to be further investigated in the present study, are nature connectedness and current contact with nature.

Nature Connectedness

Nature connectedness refers to a person's subjectively perceived closeness to and relationship with the natural world. It has been operationalized in several ways, including the single-item Inclusion of Nature in Self Scale (Schultz, 2001), the Connectedness to Nature Scale (Mayer & Frantz, 2004) and the Nature Relatedness Scale (Nisbet et al., 2009). Some of them focus on the emotional side of connectedness, while others reflect more cognitive and behavioural processes and appraisals. Nisbet and colleagues (2009) argued that nature connectedness has similar characteristics to those of a personality trait, because it is stable over time and across situations.

Nature Connectedness may be an important factor linking childhood nature exposure and adult pro-environmental behaviour, because as mentioned above, there is evidence that feelings of connectedness to natural environments are facilitated in adults who experienced greater childhood nature exposure (e.g., Cleary et al., 2020). Further, two recent meta-analyses found consistent evidence that self-rated nature connectedness is also a key predictor for pro-environmental behaviours itself (Mackay & Schmitt, 2019; Whitburn et al., 2020).

The combination of these two findings makes nature connectedness a promising possible mediator between childhood nature exposure and adult pro-environmental behaviour. Rosa et al. (2018) already proposed a path model with those exact variables – additionally including current recreational contact with nature – and showed that the relationship between childhood nature exposure and adult pro-environmental behaviour indeed seems to be at least partially mediated by the level of nature connectedness.

Current Contact with Nature

Several types of nature contact can be distinguished. For example, Keniger and colleagues (2013) suggested differentiating between incidental (e.g. everyday neighbourhood

exposure to nature), intentional (e.g. recreational visits to natural spaces), and indirect (e.g. through television or social media) contact. There is established evidence of positive relationships between incidental and intentional nature contact and benefits for several health and wellbeing outcomes (e.g., Gascón et al., 2017; White et al., 2019), but less research has focused on the relationship between different kinds of nature contact and pro-environmental behaviour.

Some studies investigating the relationship between adult nature contact and adult pro-environmental behaviours in isolation have already shown meaningful associations between them (Hartig et al., 2007; Weinstein et al., 2015). This association has even been shown in controlled experimental settings, where participants were only indirectly exposed to nature on a screen (Arendt & Matthes, 2016; Zelenski et al., 2015). Some of the studies mentioned before also considered current contact with nature when assessing the relationship between childhood nature contact and adult pro-environmental behaviour. A consistent finding across cross-sectional studies was an association between early and current nature contact, which is likely to be due to habits and lifestyle preferences established in early childhood (Pensini et al., 2016; Rosa et al., 2018; Kepelkova et al., 2020).

In conclusion, the research base suggests that nature connectedness as well as current contact with nature might be important mediators between childhood nature exposure and adult pro-environmental behaviours.

Green spaces vs. blue spaces

The research on the positive effects of nature exposure has mainly focused on assessing nature in general or specifically green natural environments so far. Recent studies reported clear associations between greenspace exposure and benefits for physical as well as mental health outcomes (Twohig-Bennett & Jones, 2018; Tester-Jones et al., 2020) and also more pro-environmental behaviours (e.g. Hartig et al., 2007). However, there is considerable evidence that blue natural environments can have their very own effects, at least on health and well-being outcomes (White et al., 2020). For example, associations between residential coastal proximity and improved health indicators were being found in several European countries (England: Garret et al., 2019; Spain: Ballesteros-Olza et al., 2020; Belgium: Hooyberg et al., 2020).

Blue spaces can be distinguished from green spaces, because they have a range of unique sensory qualities (e.g., light reflections, wave motion, sounds, etc., Völker & Kistemann, 2015), and offer opportunities for other kinds of leisure activities for children and adults that

are not possible around green spaces (e.g., swimming, fishing, watersports; Elliott et al., 2018). However, blue spaces also pose specific hazards and risks, particularly for children (e.g., drowning, infectious diseases, harmful algae blooms; WHO, 2014; Lawes et al., 2021). Those hazards may increase parental concerns and fears about children's contact with these environments (Moran, 2009; Pitt, 2019).

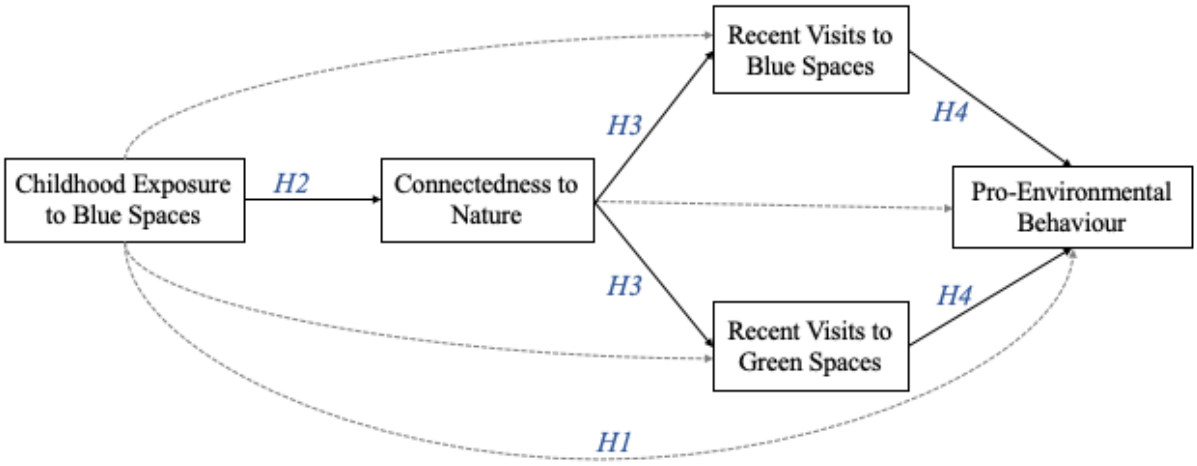
To date, there is relatively little research on the effects of exposure to blue spaces on pro-environmental behaviours, especially not for populations from landlocked countries, and so far, there are no studies investigating the exclusive effects of childhood exposure to blue natural environments.

The Current Study

Based on the literature presented, a path model of the relationship between childhood exposure to blue spaces and adult pro-environmental behaviour was proposed, with nature connectedness and current nature visits as respective serial and parallel mediators included and assumed to explain at least parts of this relationship. The model is similar to those already proposed by Rosa and colleagues (2018) and Krepelkova and colleagues (2020) but adds the dimension of differentiating between recent contact to green and blue spaces and the exclusive focus on blue space exposure in childhood. Doing so enables the possibility for separate results and interpretations for the effects of contact with green and blue spaces on pro-environmental behaviour in adulthood in a landlocked European country.

Figure 1

Proposed mediation model.



Hypotheses

The overarching hypothesis of this study was the proposed positive relationship between childhood exposure to blue spaces and adult pro-environmental behaviour (H1). Parts of this relationship were hypothesized to be explained by the three mediating variables: Individuals with greater childhood exposure to blue spaces were expected to have a closer overall connection to nature in adulthood (H2); individuals with a close connection to nature in adulthood were expected to have a higher frequency of recent visits to green and blue spaces in adulthood (H3), and individuals with greater recent visit frequencies to green and blue spaces were expected to perform a greater amount of pro-environmental behaviours within the last month (H4).

If the proposed mediators would fully explain the relationship between Childhood Exposure to Blue Spaces and Pro-Environmental Behaviours, only the paths depicted by the solid lines in Figure 1 would yield significant effects, whereas in a partial mediation, one or more of the direct associations, depicted by the dotted lines in Figure 1, would also be significant.

Methods

Sample

The data for this study was collected as an extension to a European Union Horizon's 2020 project called BlueHealth (Grellier et al., 2017). As part of that project, data was collected in 18 countries by the international polling company YouGov using online survey panels, stratified to be representative on age, gender and region. The data for Austria was collected three years later in September 2020 by the same polling company, using the same sampling protocol and most of the same questions, with the addition of questions on self-reported pro-environmental behaviours ($N = 2514$). Full methodological information on the broader survey can be found in the BlueHealth International Survey technical report (Elliott & White, 2020).

Omitting participants with missing data in the key variables reduced the sample by 5.7%, leaving an analytic sample of $N = 2370$ participants (50% females), aged between 18 and 89 years. All following statistics and results were calculated using only the analytic sample. Full demographic information of the sample can be found in Appendix A.

Measures

Outcome variable

Pro-Environmental Behaviour was measured with 12 binary yes/no items, adopted from the Special Eurobarometer 501: Attitudes of Europeans towards the Environment (2020). The original Eurobarometer survey consisted of 14 items and asked about engagement in the behaviours in the last six months, whereas the BlueHealth Austria survey left out two items that were directly affected by the pandemic given the time of data collection (e.g. "used your car less by avoiding unnecessary trips, working from home") and asked about having performed the respective behaviour in the last four weeks. See Table 1 for exact wordings of the questions and comparisons of agreement rates between the Eurobarometer survey and the BlueHealth Austria survey. The differences in agreement rates between the Eurobarometer and the BlueHealth Austria survey are striking with responses to the latter consistently higher than the former. This issue is addressed again in the discussion.

To use the scale as a metric outcome, the sum of items answered with "yes" was calculated for each participant (potential scores ranged from 0 to 12; Cronbach's $\alpha = .67$). An exploratory factor analysis revealed no meaningful factor structure and no improvements in internal consistency.

Table 1

Items of the Pro-Environmental Behaviour scale, adopted from the Eurobarometer.

Pro-Environmental Behaviour Scale	**Eurobarometer EU / AT**	**BlueHealth Austria**
Have you done any of the following during the past month for environmental reasons?		
1. Chosen a more environmentally friendly way of travelling (walk, bicycle, public transport, electric car)	27% / 24%	68%
2. Avoided buying over-packaged products	31% / 43 %	76%
3. Avoided single-use plastic goods other than plastic bags (e.g., plastic cutlery, cups, plates, etc.) or bought reusable plastic products	45% / 44%	74%
4. Separated most of your waste for recycling	66% / 46%	89%
5. Cut down your water consumption	29% / 19%	45%
6. Cut down your energy consumption (e.g., turning down air conditioning or heating, not leaving appliances on	37% / 31%	63%

stand-by, buying energy-efficient appliances)		
7. Bought local products	42% / 56%	84%
8. Joined a demonstration, attended a workshop, taken part in an activity (e.g. a collective beach or park clean-up)	7% / 11% 19% / 26%	9% 46%
9. Changed your diet to more sustainable food	32% / 35%	60%
10. Spoken to others about environmental issues	21% / 17%	36%
11. Bought second-hand products (e.g., clothes or electronics) instead of new ones	32% / 30%	66%
12. Repaired a product instead of replacing it		

Note: Items translated from German.

Predictor variable

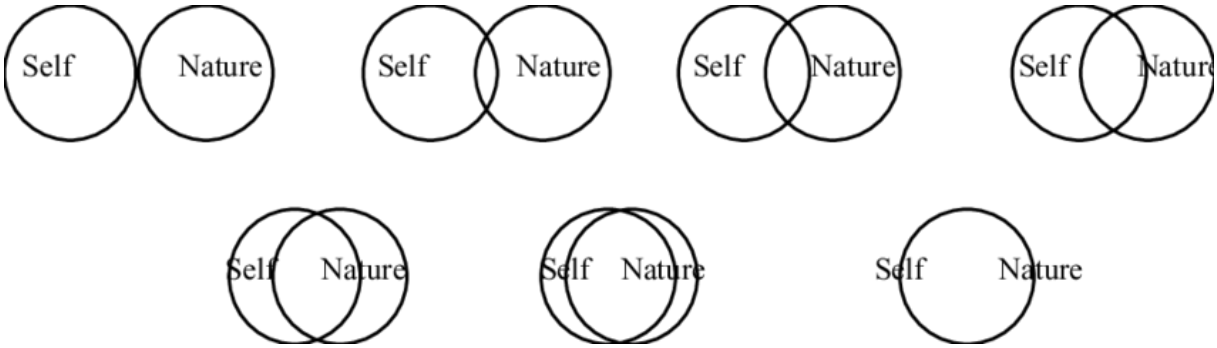
Childhood Exposure to blue spaces – A qualitative study by Lovelock and colleagues (2016) identified two main aspects about children's experiences with nature that predict enduring participation with nature into adulthood: A high amount of early exposure to nature-based recreation and parents or caregivers allowing free interaction with nature without fearing their children's safety. Similarly, childhood exposure to blue spaces was assessed by three questions about experiences made between the ages 0 and 16yrs: (1) *"As a child, there was easily accessible blue space near my home(s)."* (2) *"As a child, my parents/guardians were comfortable with me playing in and around blue spaces."* (3) *"As a child, I often visited blue spaces."* Participants were asked to indicate their agreement to the questions on a 7-point scale, ranging from -3 = "strongly disagree" to 3 = "strongly agree", with a separate "don't know" option which was coded as missing. The internal consistency of the scale was high with Cronbach's $\alpha = .82$. For the analyses, the three variables were collapsed into a single predictor variable.

Mediator variables

Nature Connectedness. To measure Nature Connectedness, the Inclusion of Nature in Self scale by Schultz (2001) was used. It consists of a single visual item: *"Please select the picture that best describes your relationship with the natural environment. How interconnected are you with nature? ('Self' = you; 'Nature' = the environment)."* (See Figure 2). The scale ranges from 1 = "least connected" to 7 = "most connected" with a separate "don't know" option which was coded as missing.

Figure 2

Representation of the Inclusion of Nature in Self (Nature Connectedness) Item.



Current visits to blue and green spaces. To measure current nature visits, participants were presented with a list of 29 natural environments, 12 green spaces and 17 blue spaces (See Table 2 for full list). Participants indicated how often they had visited those environments in the last four weeks (spanning August and September 2020). There were four answer options which were coded as follows: 0 = Not at all in the last four weeks, 1 = Once or twice in the last four weeks, 4 = Once a week, 8 = Several times a week. This coding was chosen to calculate an approximation of the actual amount of participant's nature visits during the last month and is based on the approach of another study using data from the same survey (White et al., 2021). For the analyses, sum variables for green and blue space visits were calculated. To account for a skew due to participants with considerably high visit frequencies, both variables were capped at 56 visits respectively, which indicated a maximum of visiting green and blue spaces twice a day in the last month. Only 1.2% of participants for green space visits and 1.6% of participants for blue space visits were limited by the capping.

Recent visits to both blue and green spaces, were included in this study to assess the potential distinct contributions of both types of nature visits (de Bell et al., 2017; Gascon et al., 2017; Völker & Kistemann, 2015), although the primary interest was in exploring the association between contact to blue spaces (in childhood and adulthood) and adult pro-environmental behaviour. Additionally, the more general measure of nature connectedness has no specific focus on being connected to blue or green spaces. Thus, it is appropriate to explore how a general connection to the natural world is associated with the visiting frequencies of both types of natural environments.

Table 2

Natural environments presented to participants.

Green Spaces	Blue Spaces
▪ Local neighbourhood park	▪ Natural or artificial lake or reservoir
▪ Large urban park	▪ Urban river/canal (surrounded by buildings)
▪ Allotment or community garden	
▪ Playground or playing field	▪ Rural river/canal (with vegetated banks)
▪ Cemetery or churchyard	▪ Waterfall or rapids
▪ Botanical garden or zoo	▪ Small water bodies (e.g., streams or ponds)
▪ Woodland or forest	
▪ Arable farmland	▪ Fen, marsh, or bog
▪ Meadow or grassland	▪ Outdoor public pool, lido, or thermal spa
▪ Mountain, hill, moorland, or heathland	▪ Ornamental water feature or fountain
▪ Country Park	▪ Outdoor skating or ice hockey rink
	▪ Seaside promenade
	▪ Pier, harbour, or marina
	▪ Sandy beach or dunes
	▪ Rocky or stony shore
	▪ Sea cliffs
	▪ Salt marsh, estuary, or lagoon
	▪ Open sea

There is a discussion in the literature about the interplay of nature contact and nature connectedness that needs to be addressed to justify the order of those variables proposed in this study. Because the two constructs are moderately positively correlated (Mayer & Frantz, 2004; Nisbet et al., 2009), Gifford (2014) suggested that they may be interdependent. Theory and research so far usually assume that nature connectedness mediates the relationship between nature contact and positive outcomes. For example, more interaction with nature enhances feelings of connectedness towards nature, which leads to positive outcomes such as pro-environmental behaviours (Mayer et al., 2009; Pensini et al., 2016). According to experimental studies, increased nature exposure enhances some aspects of nature connectedness (e.g., connectedness in the present), which in turn indeed increase pro-environmental behaviours (Whitburn et al., 2018). However, the reverse direction of causality is also possible because it is conceivable that people may choose to surround themselves with

more nature because of their high connectedness to it. To date, this other possible direction of causality has not been studied empirically.

Due to the cross-sectional nature of the data obtained for this study, it was not possible to firmly establish either direction of causality between the mediator variables. However, the operationalization of the variables for nature connectedness and nature contact in the survey that was used for this study, clearly suggest the order that was chosen for the conceptual model (see Figure 1). Nature connectedness does not refer to a specific time frame, while visits to blue and green spaces (as well as the outcome variable) refer only to the last four weeks prior to the survey. Therefore, it can be assumed that nature connectedness refers to a trait measure (in part developing from childhood exposure), while nature visits can be seen as relatively state-like measures in the present study given the limited time frame to which they refer.

Covariates

Individual-level covariates. Following the approach of Martin and colleagues (2020), the analyses were adjusted for the following socio-demographic covariates, that have been shown to be associated with pro-environmental behaviours, nature connectedness and nature contact: Gender (male, female = ref); age groups (18-29 years = ref; 30-39 years, 40-49 years, 50-59 years, ≥ 60 years); self-identified belonging to an ethnic minority in Austria (yes = ref., no); highest level of educational achievement (secondary school or lower = ref; a-levels; degree); employment status (in paid employment, in education, retired, homemakers; other, not working/unemployed = ref); disposable household income quintiles (lowest quintile = ref); relationship status (single/separated/divorced/widowed = ref; married/cohabiting); number of adults in household (1 = ref; 2, ≥ 3); number of children in household (0 = ref, 1, ≥ 2); dog ownership (yes, no = ref); car ownership (yes, no = ref); Austrian region (Vienna = ref; Lower Austria, Upper Austria, Burgenland; Carinthia, Styria; Salzburg, Tyrol, Vorarlberg).

Area-level covariates. Following White and colleagues (2021), nature-related covariates concerning participants' residential or objective exposure to green and blue spaces were considered. The following information were greatly taken from the BlueHealth survey's technical report (Elliott & White, 2020).

For blue spaces, distances to the nearest lake and to the nearest river (More than 1km = ref., less than 1km) were used as dichotomous variables. The survey also provides values for the distance to the nearest coastline, but this measure was not considered, because Austria has

neither its own coastline, nor does it geographically lie near the coastlines of bordering countries, of which participants living close to those neighbouring countries could profit. The distance of participants' residential location to lakes and rivers was assessed with vector representations that are available from the European Catchments and Rivers Network System database (ECRINS, 2012). This data was used to assign Euclidean (crow-flies) distances in kilometres from the home geolocation (measured via home latitude and longitude, which was assessed by participants indicating their home location via a Google Maps application programming interface) to the nearest river and lake separately.

For surrounding greenness, the Normalised Difference Vegetation Index (NDVI) was used, which is a measure of the amount of photosynthesizing green plant canopies within a certain radius around participant's homes. This is done by using multispectral remotely sensed data based on spectral reflectance measurements acquired in the visible (red band) and near-infrared regions. The resulting values range from -1 to 1, with values of < .01 reflecting areas of bare land, rock, sand, water, snow, or tundra; values of 0.2 - 0.3 reflecting shrubs and grassland, and values of 0.6 - 0.8 reflecting temperate and tropical rainforests (Weier & Herring, 2000). The survey was able to establish NDVI values for the amount of vegetation within a radius of 250 meters or 1 kilometre around participants' homes. For both possibilities are again two variables available that indicate the highest and second-highest quality according to a pixel reliability rank. For this study, the NDVI for vegetation within 1 kilometre at second highest quality was used, because it yielded fewer missing values than the highest quality (169 missing values for second-highest quality vs. 246 missing values for highest quality). To include this variable in the analysis, it was grouped into quartiles, with the lowest NDVI quartile indicating the least amount of vegetation around participants' homes (lowest quartile = ref.).

For the analyses, all covariates mentioned were used as categorical variables and were included in the models in dummy coding.

Analytic approach

All analyses were conducted using SPSS Version 27.0 (IBM Corp., 2020) and the PROCESS-Macro by Hayes (2017). PROCESS uses an ordinary least-squares path analytical framework to test for both direct and indirect effects and provides several mediation models to explore. For this analysis, model 81 (serial-parallel mediation) was chosen to test the proposed model shown in Figure 1. All indirect effects were subjected to follow-up bootstrap

analyses with 5000 bootstrap samples to determine if the indirect effects are different from zero by providing 95% confidence intervals around those effects.

Before the main analysis, Pearson correlations were used to estimate the hypothesized directions and possible association strength between predictor, mediator, and outcome variables. After that, preliminary linear regression analyses for pro-environmental behaviour were conducted, starting with a covariates-only model, and adding predictor and mediator variables one at a time. This was done to justify the main mediation analysis, by confirming that by successively adding the mediator variables, the effect of the predictor variable is indeed reduced, while also considering relevant covariates (Martin et al., 2019; Martin et al., 2020). Finally, a mediation analysis was conducted with PROCESS, including predictor and mediator variables and only those covariates, which proved to have a meaningful influence on pro-environmental behaviour in the preliminary regression analyses.

Results

Descriptive Statistics

Means, standard deviations and correlations of the key variables can be seen in Table 3. In first support of all hypotheses, all variables correlated positively and significantly with each other. As might be expected, the correlation between recent visits to blue and green spaces was particularly strong. Table 3 also shows that Austrians visited green spaces on average considerably more frequently than blue spaces within the last month, which can be explained by a lack of coastline and few large water bodies in the country. The table also shows that the means for nature connectedness as well as for pro-environmental behaviours lie both above their scale medians (*Mdn* = 3.5 for nature connectedness, *Mdn* = 6.5 for pro-environmental behaviours).

Table 3

Means, standard deviations and correlations of key variables.

			Correlations			
	M	*SD*	1	2	3	4
1. Childhood Exposure to Blue Spaces	0.87	1.56	-			
2. Nature Connectedness	4.56	1.66	.15**	-		
3. Recent visits to blue spaces	10.10	11.75	.12**	.15**	-	
4. Recent visits to green spaces	16.86	13.49	.17**	.25**	.57**	-
5. Pro-Environmental Behaviour	7.23	2.45	.18**	.26**	.17**	.24**

** $p \leq .01$

Preliminary Regression Analyses

An initial linear regression, producing five models and using the enter-method for each model, was fit to justify the main analysis and to identify the covariates that have a significant influence on pro-environmental behaviour.

In the first model, only the relevant covariates were included as predictors for pro-environmental behaviour (PEB). In the second model, the main predictor variable "Childhood Exposure to Blue Spaces" was included and proved to be a significant predictor for PEB. After that, the three mediator variables "Nature Connectedness", "Recent Visits to Blue Spaces" and "Recent Visits to Green Spaces" were added successively and they all proved to be significant predictors for PEB, and the effect of childhood exposure was reduced with every variable that was added. This indicates that all proposed mediators are promising candidates for mediating variables. However, the effect of childhood exposure on PEB was still significant, even when all three mediators were included, which gives a first hint that only partial mediation was present (see Appendix B for full model with all covariates).

The following covariates proved to be significant predictors for PEB in the last model, when all key variables were included, and were therefore kept for the main analysis with PROCESS: Gender (ref. group: females, b = -0.65, $p \leq .001$), work status (ref. group: unemployed, in paid work: b = -0.42, p = .008, in education: b = 0.08, p = .730, retired: b = -0.51, p = .023, other: b = -0.52, p = .026), income (ref. group: lowest quintile, second quintile: b = 0.12, p = .496, third quintile: b = -0.03, p = .850, fourth quintile: b = -0.05, p = .775, highest quintile: b = -0.57, p = .003, no answer: b = -0.52, p = .003), number of adults in household (ref. group: 1 adult, 2 adults: b = 0.65, p = .009, 3 or more adults: b = 0.70, p = .001).

As a last preliminary step, a linear regression analysis with the key variables and only the relevant covariates was run (see Table 4 for full model). Again, the first model included only the covariates, but this time only those that were identified as relevant for PEB in the prior step. In the second model, the predictor variable was included and proved to be significantly associated with PEB (b = .19, $p \leq .001$). For the third model, mediator variable 1 "Nature Connectedness" was included. It proved to be a significant predictor for PEB (b = .23, $p \leq$ .001) and the effect of childhood exposure was reduced (b = .15, $p \leq .001$), which indicates a possible mediating effect of Nature Connectedness between predictor and outcome. In model 4, mediator variable 2 "Recent visits to blue spaces" was included, which significantly predicts PEB (b = .12, $p \leq .001$) and further reduces the effect of childhood exposure on PEB (b = .14, $p \leq .001$) and the effect of nature connectedness on PEB (b = 0.22, p ≤ .001). Lastly,

mediator 3 “Recent visits to green spaces” was included. It proved to be a significant predictor for PEB (b = .14, $p \leq .001$) and further reduced the effect of childhood exposure on PEB (b = .13, $p \leq .001$) and the effect of nature connectedness on PEB (b = 0.19, p ≤ .001). Including recent green space visits also resulted in a reduced effect of blue space visits on PEB (b = .05, p = .040), indicating a large amount of shared variance between green and blue space visits. With a strong positive association between green space and blue space visits (see Table 3), the residual terms for these two visit frequency variables were allowed to covary. The final model, including relevant covariates and all key variables turned out to be overall significant with R^2 = .15, F(16, 2353) = 26.68, $p \leq .001$.

Mediation Analysis

Table 5 shows the direct and indirect path coefficients for the key variables (see Appendix C for full mediation model). The total effect model of childhood exposure to blue spaces on adult PEB (model without mediators) was significant with R^2 = .07, F(13, 2356) = 14.49, $p \leq .001$ and an effect of childhood exposure to blue spaces of b = 0.29 [0.23; 0.36], $p \leq .001$. The direct effect model, where all mediators were considered, turned out to be still significant (R^2 = 0.15, F(16, 2353) = 26.68, $p \leq .001$), with an effect of childhood exposure to blue spaces of b = 0.20 [0.14; 0.26], $p \leq 0.001$). These results support Hypothesis 1, which predicted a general association between childhood exposure to blue spaces and PEB. However, the inclusion of the mediator variables reduced the effect of childhood exposure to blue spaces on adult PEB by 0.09 and did not eliminate the direct effect, which indicates partial mediation. This was already suspected based on the results from the preliminary regression analysis.

In line with Hypothesis 2, childhood exposure to blue spaces was significantly associated with nature connectedness (b = 0.16 [0.12; 0.21], $p \leq .001$). Hypothesis 3 was also supported, because the model showed positive associations between nature connectedness and recent visits to blue spaces (b = 1.02 [0.74; 1.31], $p \leq .001$) and green spaces (b = 1.89 [1.58; 2.21], $p \leq .001$). Finally, consistent with Hypothesis 4, recent visits to blue spaces (b = 0.01 [≤ 0.01; 0.02], p = .040) and green spaces (b = 0.03 [0.02; 0.03], $p \leq .001$) were significantly associated with PEB. To sum up, the model supports all proposed hypotheses and yields findings that are in line with those from the literature reviewed.

Indirect Effects

Supporting the overarching mediation assumption, the model provided small but significant indirect pathways from childhood exposure to blue spaces through both, nature connectedness and recent visits to blue spaces (Estimate < 0.01, SE < 0.01, 95% CI [< 0.01; <

0.01]), and through nature connectedness and recent visits to green spaces (Effect = 0.01, SE < 0.01, 95% CI [< 0.01; 0.01]). The biggest indirect effects were provided by the path through the nature connectedness mediator only (Estimate = 0.05, SE = 0.01, 95% CI [0.03; 0.06]) and by the path through the green space visits mediator only (Estimate = 0.03, SE < .01, 95% CI [0.02; 0.04]). The indirect effect through blue space visits only turned out to be the only non-significant indirect effect (Estimate = 0.01, SE = 0.01, 95% CI [< -0.01; 0.02]). Visualizations of all indirect effects can be seen in Appendix D.

While there were meaningful direct associations between childhood and adult blue space exposure, and adult blue space exposure and PEB, the results of the indirect effects suggest that the adult blue space exposure mediator alone is not sufficient to explain a significant part of the relationship between childhood blue space exposure and adult PEB. For adult blue space exposure to become a significant mediator of this relationship, nature connectedness needs to be incorporated into the assumed causal chain. The fact that all indirect effects including nature connectedness were significant and that the direct effect of nature connectedness on PEB was the strongest out of all key variables, emphasizes the findings from recent meta-analytic literature that the level of a person's connectedness to nature is strongly associated with their amount of PEB performed.

Secondary results

The results of the covariates included were broadly in line with known trends in determinants of pro-environmental behaviours (see Appendix C for exact values from the main mediation analysis).

Women reported on average more PEBs than men. Male participants did, however, report significantly more greenspace visits than their female counterparts.

Employed Austrians and those who did not want to state their occupation performed significantly less pro-environmental behaviours than unemployed Austrians. This can be compared to the result that higher income groups also tend to perform less PEBs than participants from the lowest income group. For the other key variables, the results of this covariate were rather inconsistent, because compared to unemployed participants, employed and retired participants had higher nature connectedness on the one hand, but indicated a lot less nature visits, especially to blue spaces, on the other.

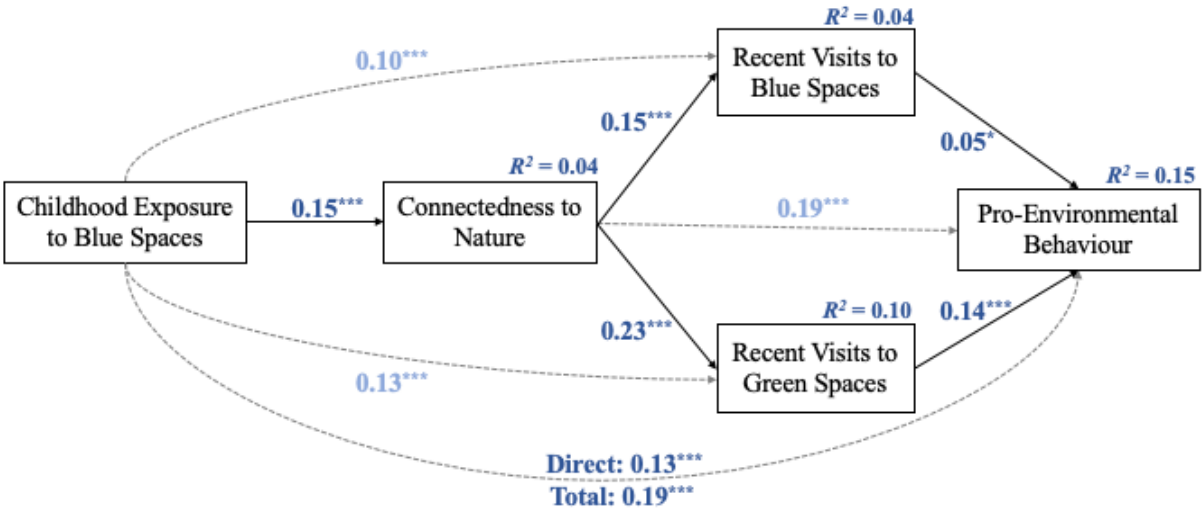
Participants in the highest income quintile and those who did not want to make a statement about their income performed significantly less pro-environmental behaviours in comparison to participants in the lowest quintile. Additionally, participants from higher income groups indicated spending more time in nature than participants from the lowest

income group. However, this finding was not linear across income quintiles in this study and only participants from the income quintiles 3 and 5 stated significant more visits to blue and green spaces than the reference group.

Finally, participants from households with more than one adult performed significantly more pro-environmental behaviours and participants from households with three or more people seemed to spend substantially more time around green spaces than one-person households.

Figure 3

Tested path model with hypothesised and additional path coefficients (standardized).



* p ≤ .05, ** p ≤ .01, *** p ≤ .001

Note: Covariate paths omitted for clarity. Hypothesized paths coefficients are depicted in dark blue, additional path coefficients in light blue.

Table 4

Ordinary Least Squares regression results predicting pro-environmental behaviours as a function of childhood blue space exposure, nature connectedness, visits to green and blue spaces, and relevant covariates.

	Model 1			Model 2			Model 3			Model 4			Model 5		
Predictor	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Childhood Exposure				0.29***	0.03	.19	0.24***	0.03	.15	0.22***	0.03	.14	0.20***	0.03	.13
Nature Connectedness							0.34***	0.03	.23	0.32***	0.03	.22	0.29***	0.03	.19
Recent Visits to Blue Spaces										0.03***	≤0.01	.12	0.01*	0.01	.05
Recent Visits to Green Spaces													0.03***	≤0.01	.14
Gender (female = ref.)	-0.65***	0.10	-0.13	-0.66***	0.10	-.13	-0.61***	0.10	-.12	-0.65***	0.10	-.13	-0.65***	0.10	-.13
Work status (unemployed = ref.)															
In paid work	-0.31*	0.16	-.06	-0.39*	0.16	-.08	-0.47**	0.15	-.10	-0.43**	0.15	-.09	-0.43**	0.15	-.09
In education	0.08	0.25	.01	0.08	0.25	.01	0.07	0.24	.01	0.10	0.24	.01	0.10	0.24	.01
Retired	-0.23	0.19	-.04	-0.20	0.19	-.03	-0.38*	0.18	-.06	-0.32	0.18	-.05	-0.32	0.18	-.05
Other	-0.45	0.24	-.05	-0.53*	0.24	-.05	-0.55*	0.23	-.06	-0.56*	0.23	-.06	-0.56*	0.23	-.06
Household income (Lowest Quintile = ref.)															
Quintile 2	0.23	0.19	.03	0.23	0.19	.03	0.16	0.18	.02	0.15	0.18	.02	0.15	0.18	.02
Quintile 3	0.09	0.18	.01	0.12	0.18	.02	0.08	0.18	.01	0.01	0.17	≤.01	0.01	0.17	≤.01
Quintile 4	0.09	0.19	.01	0.06	0.19	.01	0.07	0.18	.01	0.01	0.18	≤.01	0.01	0.18	≤.01

Quintile 5	-0.32	0.19	-0.5	-0.37	0.19	-.06	-0.39*	0.17	-.06	-0.49**	0.18	-.08	-0.49**	0.18	-.08
No response	-0.48**	0.18	-0.8	-0.46*	0.18	-0.7	-0.47**	0.17	-.07	-0.50**	0.17	-.08	-0.50**	0.17	-.08
Adults in household (1 = ref.)															
2 adults	0.44***	0.14	.09	0.48***	0.13	.10	0.41***	0.13	.08	0.41***	0.13	.08	0.41***	0.13	.08
3 or more adults	0.66***	0.14	.13	0.67***	0.14	.13	0.60***	0.14	.12	0.51***	0.14	.10	0.51***	0.14	.10
Constant	7.47***			7.25***			5.85***			5.67***			5.69***		
R^2_{adj}	.04			.07			.12			.14			.15		

* p ≤ .05, ** p ≤ .01, *** p ≤ .001

Note: B = unstandardized, SE = Standard Error, β = standardized coefficients.

Table 5

Results of mediation analysis examining direct and indirect pathways linking childhood exposure to blue spaces and pro-environmental behaviours.

Outcome	Predictor	Effects pathway	B	95% CI	β
Nature Connectedness $R^2 = 0.04$	Childhood Exposure to Blue Spaces	Direct	0.16***	0.12, 0.21	0.15
Recent visits to blue spaces $R^2 = 0.04$	Childhood Exposure to Blue Spaces	Direct	0.72***	0.42, 1.02	0.10
	Nature Connectedness	Direct	1.02***	0.74, 1.31	0.15
Recent visits to green spaces $R^2 = 0.10$	Childhood Exposure to Blue Spaces	Direct	1.11***	0.77, 1.45	0.13
	Nature Connectedness	Direct	1.89***	1.58, 2.21	0.23
Pro-Environmental Behaviour $R^2 = 0.15$	Childhood Exposure to Blue Spaces	Direct	0.20***	0.14, 0.26	0.13
		Indirect via Nature Connectedness (1)	0.05	0.03, 0.06	0.03
		Indirect via recent visits to blue spaces (2)	0.01	< -0.01, 0.02	< 0.01
		Indirect via recent visits to green spaces (3)	0.03	0.02, 0.04	0.02

		Indirect via Nature Connectedness and recent visits to blue spaces (4)	< 0.01	< 0.01, < 0.01	< 0.01
		Indirect via Nature Connectedness and recent visits to green spaces (5)	0.01	< 0.01, 0.01	0.01
	Nature Connectedness	Direct	0.29***	0.23, 0.34	0.19
	Recent Visits to Blue Spaces	Direct	0.01*	< 0.01, 0.02	0.05
	Recent Visits to Green Spaces	Direct	0.03***	0.02, 0.03	0.14

* p ≤ .05, ** p ≤ .01, *** p ≤ .001

Note: Reported were only the pathways available in the PROCESS output. Indirect pathways yield no assessment of significance, thus they are evaluated as significant, when their confidence intervals do not entail zero.

Discussion

Research suggests that extensive experiences with the natural world in childhood can predispose environmentalist behaviours later in life (Wells & Lekies, 2006; Evans et al., 2018). As possible underlying mechanisms for this relationship, nature connectedness (Rosa et al., 2018; Cleary et al., 2020) and nature visits in adulthood (Pensini et al., 2016; Rosa et al., 2018; Krepelkova et al., 2020) are suggested. Most research in this area has focused on the effects of green natural spaces or nature in general, but there is recent evidence suggesting that blue natural spaces can have effects on several health and behavioural outcomes, separate from those of green natural spaces (White et al., 2020).

The current study investigated the associations between childhood exposure to blue spaces, overall nature connectedness in adulthood, recent visits to green and blue spaces and recent adult pro-environmental behaviours, using a representative cross-sectional sample from Austria.

Summary of Aims and main Findings

The main aim of this study was to investigate whether there was a meaningful association between childhood exposure to blue spaces and adult pro-environmental behaviours, while incorporating mechanisms into the model that are suggested to explain at least parts of this relationship, based on the current state of research. The very novelty of this study is its exclusive focus on exposure to blue spaces in childhood, which has, to date, not been studied before in isolation, and has therefore not been considered as a predictor for adult pro-environmental behaviours.

Another novel aspect of the present study was to include current nature visits to green and blue spaces separately from each other, to assess the effect of different types of nature contact on pro-environmental behaviours. This has been done before (e.g., van Heezik et al., 2021), but was special in this study, because a representative sample from a landlocked country was used. This means that the positive effects of coastlines on well-being and other psychological outcomes, which have mainly been the focus of prior studies of blue spaces (e.g., White et al., 2020), could not be considered and therefore more confident statements about the standalone effects of other types of inland blue natural spaces became possible.

Finally, this study proposed a novel order of the mediating variables of nature connectedness and current nature visits, by putting nature connectedness before current nature visits in a hypothesised causal chain of the path model.

Prior research mostly investigated nature contact more broadly or focused on green spaces only (Wells & Lekies, 2006; Evans et al., 2018). In line with this, the present study showed that greater exposure to blue spaces in childhood was associated with heightened levels of pro-environmental behaviours in adulthood. This relationship held after controlling for known individual-level and area-level covariates that are likely to influence the amount of pro-environmental behaviours performed (Model 1).

Overall, the study supported the proposed path model and therefore all the hypotheses were supported, at least to some extent. This means that the positive and significant association that could be found between childhood exposure to blue spaces and adult pro-environmental behaviours is partially mediated by nature connectedness and current visits to green and blue spaces (see Figure 3 for summary and visualization of results of the main path coefficients). The final regression (and mediation model) explained 15% of the variance in PEB. This indicates that variables apart from childhood exposure to blue spaces, the included mediators and covariates had an influence on the adult pro-environmental behaviours.

In addition to the hypothesised paths, three unexpected direct associations were also significant: childhood blue space visits and both adult blue and green space visits unmediated through connectedness, and between connectedness and PEBs unmediated through visits. Frequently visiting blue spaces and nature in general as a child and experiencing decreases in stress and negative affect around those spaces, might for example create positive habits that sustain into adulthood. This in turn may increase feelings of safety and familiarity towards certain natural environments, which then lead to more frequent visits of those environments (Bratman et al., 2021). Other studies suggest that self-determination and intrinsic motivation could be a meaningful explaining variable for this association. A recent study by Vitale and colleagues (2022) addressed this and explicitly identified self-determination and therefore intrinsic motivation to visit natural environments as a meaningful mediating variable between childhood exposure to blue spaces and recent visits to blue and green spaces, while using a path model similar to this of the present study. The direct relationship between nature connectedness and PEB is perfectly understandable in that being connected to nature may be related to PEB through other mechanisms rather than just visiting more often, including for instance, environmental attitudes (Whitburn et al., 2019), environmental values (Pereira & Forster, 2015) or biospheric concern (Gosling & Williams, 2010).

While the overall mediation model provided significant pathways only, the variance it explains with covariates included is still comparably low (15%), which suggests that there is yet a lot to discover about factors predicting and influencing pro-environmental behaviours.

Discussion of Secondary Results

The findings between the included covariates and the key variables were described in the results section and are mostly in line with prior findings from the literature:

In the present study, women reported on average more PEBs than men and it is argued that this is the case because women tend to have a stronger ethic of care and are more socially responsible, which can be translated to the care about nature (Zelezny et al., 2000). Male participants did, however, report significantly more greenspace visits than their female counterparts, which could also be found in studies with samples from other countries (e.g. Boyd et al., 2018;). One argumentation for this pattern is that women worry more about their safety in terms of physical and/or verbal abuse when spending time in nature alone (Skår, 2010).

The results regarding the employment status were rather inconsistent. Interpretable is the finding that employed and retired participants had higher nature connectedness on the one hand, but indicated a lot less nature visits, especially to blue spaces, on the other, in comparison to unemployed participants. This pattern might be due to employed participants not having as much free time to spend in nature as the unemployed, and retired participants facing physical immobility.

Participants in the highest income quintile and those who did not want to make a statement about their income performed significantly less pro-environmental behaviours in comparison to participants in the lowest quintile, which is consistent with previous findings (e.g. Gatersleben et al., 2014). Additionally, and also in line with the literature, participants from higher income groups spend more time in nature than participants from the lowest income group (e.g. Boyd et al., 2018) and it is argued that low-income groups might have limited awareness for or knowledge about their local nature (Miller et al., 2011).

Finally, participants from households with more than one adult performed significantly more pro-environmental behaviours. It has been argued that the larger a household, the lower the per capita impact of its members (e.g. Minx et al., 2013), but to date there are no studies demonstrating an effect of number of adults in household on individual-level PEB (Huddart Kennedy et al., 2015).

Limitations and future directions

Even though the results of this study proved to be promising, there are some methodological and conceptual issues that need to be addressed and may provide directions for future research.

Measuring childhood nature contact

First, the three questions that make up the predictor variable of childhood exposure to blue spaces were not taken from an existing scale, but were formulated freely, without the intention of possibly collapsing them. The questions contained blue space accessibility in childhood, visit frequency as a child and social support for playing around blue spaces by caregivers. Collapsing those questions into a single mean variable of "exposure" to blue spaces may have undermined or not sufficiently measured the differential effects those variables eventually have.

Even though some other studies on the topic have assessed childhood nature contact with even less items (e.g. only one in Rosa et al., 2018), others (e.g. Cleary et al., 2020) made use of scales like the Early Environmental Experiences Scale (Hinds, 2018). This scale consists of four questions that greatly resemble the three aspects covered in the questions of the present study, but the questions were adapted by the researchers to fit the natural areas that exist in the country where the study was conducted.

Apart from that, an overall issue with questions about experiences that lay far back in time is the recall bias, which is a systematic error that occurs when participants do not remember previous events or experiences accurately or omit details about those events (Brassey & Mahtani, 2017). Even though childhood experiences in nature will tend to be more mundane than traumatic childhood events (in which context the recall bias is often considered, e.g., Hardt & Rutter, 2004), it can still not be ruled out that some participants did not remember the details about their nature contact back then correctly, especially those whose childhood happened several decades ago. In this context it could also be found that individuals who perceived themselves to be more actively engaged with, or invested in, the natural world during adulthood might overestimate the frequency of their childhood nature exposure (Wells & Lekies, 2006; Chawla & Derr, 2012). Additionally, there are no details known about the actual kind of blue spaces participants experienced in their childhood, for example if they even grew up in Austria or if they maybe grew up in a different country that has a coastline. Therefore, no statements could be made about the type of blue spaces participants experienced in their childhood and how those specific areas possibly influenced adult pro-environmental behaviours. To gain more information on the qualities of participants' childhood experiences, qualitative interviews could be of great use, but would still not be able to rule out a recall bias.

One of the few possibilities to work against the recall bias in a case like this, would be through a longitudinal study design, which would be much more cost- and time-intensive than

cross-sectional surveys, but they enable a better assessment of previous cross-sectional findings. Another possibility would be to include a module on nature contact for children in large-scale longitudinal household studies, like they exist in several countries (e.g., the UK Household Longitudinal Study or the German Socio-Economic Panel), where the same participants are questioned over many years. Still, it would take a long time until such measures provide results. Evans et al. (2018) could find significant associations between childhood nature exposure and adult environmentalism in the only longitudinal study on this association to date, but even in cases like this, the data is still correlational and does therefore not allow for causal explanations, because in longitudinal studies it is even more difficult to control for any possible confounding factors. From an ethical perspective, longitudinal studies with pro-environmental behaviour as an outcome variable, that would take up more than a decade to make first statements about possible predictors and mechanisms, would also not live up to the urgency of the environmental and climate action that is needed right now.

Measuring current nature contact

Second, even though a representative sample from Austria was used, there can be made no clear statements about the country-specific location of the natural environments people visited during the last month. In general, people tend to spend more time outside during the summer months, to which the questions of nature contact referred, than they do during the winter months (e.g., Matz et al., 2014). More specific, the questions about nature contact refer to experiences made in August and September, which lie in the summer holiday season. Therefore, it cannot be ruled out that participants visited countries other than Austria and that they thought of green and blue natural spaces that are different from those existing in Austria when filling in the questionnaire. Coastal spaces could be excluded from the analyses, but the bias cannot be eliminated completely by that, because technically all nature visits participants indicated could have taken place in countries other than Austria. Therefore, the results allow to make statements about the Austrian population, but not about the possibly exclusive effects of Austrian nature.

To make sure participants only make statements about nature visits in their respective country, the questions about that need to ask specifically for that. For example, Pensini and colleagues (2016) included only common natural environments in Australia for their study with an Australian sample and used these environments to assess both childhood as well as adult nature contact. Experimental studies have taken other and more controllable forms of nature contact, such as watching or listening to nature programmes on TV, into account and could also establish meaningful relationships between this kind of nature contact and

increased pro-environmental behaviours (Martin et al., 2020). By showing participants only the nature of the country or region of interest, this bias could also be ruled out experimentally.

Distinguishing inland water bodies from green spaces

Third, it is questionable if blue spaces can clearly be viewed as separate from green spaces, especially when only considering inland water bodies. In comparison to coastlines, inland water bodies are often surrounded by greenery, but coastlines were mainly studied in the context of blue spaces before. It has been elaborated earlier how blue spaces differ in their characteristics from green spaces, but the studies cited there mostly refer to oceanic environments as well. To date not much research has exclusively focused on inland water bodies before, but recent studies that do were for example not able to find clear salutogenic effects of inland blue spaces on mental health outcomes (Pearson et al., 2019), while studies on coastlines do find those positive effects on health and well-being (White et al., 2020). Even though the present study provides promising results, the unique characteristics and benefits of inland water bodies, and if they can in fact be clearly separated from those of green spaces, are still up for debate.

Again, this issue connects to the recall bias of childhood nature experiences, because no clear statements can be made about the memories people recalled from experiences around blue spaces in Austria (or another country), and if those memories refer to the actual inland water body that might have been present, or if the effect can be attributed to the green natural environment around that water body. A solution for this could also be found within qualitative approaches or more detailed quantitative items about location and characteristics of blue spaces, as well as activities that were performed there, the feelings those spaces elicited back then and how participants feel about those experiences now.

Correlation vs. causation in mediation models

Fourth, and as already touched upon before, the nature of the data used does not allow to test any direction of causality about the relationship between childhood exposure to blue spaces and adult pro-environmental behaviour. Even though mediation models aspire to come close to causal chains, it is seldom possible to make such assumptions with cross-sectional human samples.

The possibility of reverse causation can probably be ruled out between childhood exposure to blue spaces and other variables that focus on the present, provided that no strong recall bias occurred. For the other pathways this is less straightforward. For example, people who behave in environmental-friendly ways or may have only recently educated themselves on environmental and sustainability topics, might choose to spend more time in nature and

develop greater nature connectedness because of their environmentally friendly behaviour. However, in line with this study's findings, recent meta-analyses suggest nature connectedness to be a strong predictor for pro-environmental behaviours (Mackay & Schmitt, 2019; Whitburn et al., 2020). The interplay between nature connectedness and nature contact has mostly been studied in reverse order than proposed in the present study, but both directions provide meaningful results. Because those variables are also highly intercorrelated, it is difficult to make clear statements about the most appropriate order without making use of randomized controlled experiments. However, the use of the variables in this study made sense when considering their coding. The question on nature connectedness referred to an overall trait, while the nature visits focused on the last four weeks only. The order was therefore chosen to match the assumed timeline of the mediation model and provided a significant result this way.

Effects of Covid-19

Lastly, some of the issues mentioned above arise because the survey that was used already existed, and data collection was completed when the proposed model was conceptualized. Therefore, modification of the questionnaire was not possible for the current piece of work. Another factor that could not been altered, but which could have influenced participants' answers, is the fact that data collection took place during the Covid-19 pandemic. Even though in August and September 2020 Austria experienced a more relaxed phase, the experiences from the beginning of the pandemic in spring 2020 might have still influenced participants' levels of nature connectedness, nature contact, and pro-environmental behaviours compared to pre-pandemic times.

Recent studies on that topic show that recreational contact with nature increased drastically during the initial phase of the pandemic in spring 2020 and it is suggested that this heightened level of nature contact was sustained for at least six months after the end of a lockdown (Venter et al., 2021). Apart from that, the pandemic already led to some hopeful findings concerning pro-environmental behaviours. For example, it was found that people engaged in more household and leisure-related pro-environmental behaviours in order to deal with the confinements of lockdown (Ramkissoon, 2020) and there seems to be an increase in the belief of the existence and severity of the issues that arise from humans interfering with nature (Daryanto et al., 2022). Since the questions on pro-environmental behaviours in this study focused only on the last four weeks and there is no pre-pandemic measurement of pro-environmental behaviours for this sample, it is possible that participants executed more of those behaviours that they would have only half a year earlier, especially when also

considering the huge differences in the agreement rates between the original Eurobarometer survey and the BlueHealth Austria survey. However, those difference can possibly be due to other survey circumstances. For instance, the Eurobarometer survey was conducted via phone interviews, while the participants of the BlueHealth Austria survey completed the questionnaire online and unsupervised. Other than that, the surveys took place during different seasons (Eurobarometer in winter 2019 vs. BlueHealth Austria in autumn 2020). Lastly, in the BlueHealth Austria survey the questions about pro-environmental behaviours were asked in the end, after participants had thought about nature visits a lot, which could have primed the concept of nature and environmentally friendly behaviours.

Circling back to the possible influences of the pandemic, it is yet unclear if this possible increase in pro-environmental behaviours during the initial phase of the pandemic sustains, as the pandemic is still ongoing and likely to change everyday life in the long run.

Implications

Even though no direct causal inferences can be drawn from the present study, its findings still yield some practical implications.

First, the findings indicate that children should be encouraged and supported to spend time in nature and especially around blue spaces. Because of the potential risks associated with blue spaces, some parents might be afraid of their children playing around them (Pitt, 2019) and therefore keeping them from doing so. To tackle this, appropriate supervision of childhood recreational activities and enhanced safety measures around public blue spaces is suggested.

Second, the findings might be relevant for Austrian practitioners and policy makers due to the nationally representative sample. The study highlights again that frequent nature contact and especially exposure to blue spaces in childhood might lead to increased levels of nature connectedness and pro-environmental behaviours in the population, which is a current key policy goal. In other words, the results of this study strongly suggest the need for protection and maintenance of natural areas, especially Austria's few large water bodies. It also suggests that investing in and promoting recreational programs for children as well as for adults that involve activities in and around those natural environments might pay off in the long run. Such programs might help in returning to levels of nature connectedness from prior centuries, which in turn might be one factor to promote the reaching of the desired levels of environmentally friendly behaviour in the population.

Conclusion

The present study investigated the relationship between childhood exposure to blue spaces and adult pro-environmental behaviours and how this association is affected by nature connectedness and recent nature visits. A serial-parallel mediation model including those factors was fitted, using a representative sample from Austria. The model supported all proposed hypotheses, suggesting a partial mediation with significant positive direct effects between all key variables. This provides the novel insight that contact with blue spaces in childhood as well as in adulthood predicts adult environmentalist behaviours, even when considering a sample from a country with no coastline. Austria does have many rivers, but relatively few large water bodies in general.

Future research could address this study's limitations by using a survey that is more tailored to the research question, for example with qualitative approaches, more exhaustive scales for childhood experiences around blue spaces, or a greater focus on nature experiences made in the country of interest. Since the specific relationship between childhood exposure to blue spaces and adult pro-environmental behaviours has not been the subject of other research so far, the results are also in need of more generalization to samples from other cultures and countries with green and especially blue spaces different from those available in Austria. Those could possibly detect even stronger associations between blue space exposure and pro-environmental behaviours.

Overall, this study provides a new perspective on the importance of childhood experiences with nature in fostering environmentalist behaviours later in life. It highlights the need to provide safe and diverse opportunities for raising children around nature and emphasizes that exposure to blue natural spaces might be as important for the development of environmentalist behaviours as the exposure to green spaces. On the big scale, this could play a crucial role in the long-term improvement of our planetary health, because spending time in nature no matter at what age could improve human's connection to nature again, which in turn supports the societal change towards more sustainable behaviour.

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Appendix

Appendix A

Frequencies of individual-level and area-level variables used in the study.

Variable	Category	Frequency	Percent
Gender	Female	1190	50.2%
	Male	1180	49.8%
Age Groups	18 to 29 years	515	21.7%
	30 to 39 years	437	18.4%
	40 to 40 years	452	19.1%
	50 to 59 years	513	21.6%
	60+ years	453	19.1%
Belonging to an ethnic minority	Yes	144	6.1%
	No	2150	90.7%
	Do not know	76	3.2%
Education	Secondary school or lower	928	39.2%
	A-Levels	870	36.7%
	Higher Degree	572	24.1%
Work status	Unemployed	314	13.2%
	In paid work	1321	55.7%
	In education	133	5.6%
	Retired	449	18.9%
	Other	153	6.5%
Household income	Lowest quintile	347	14.6%
	Second quintile	320	13.5%
	Third quintile	421	17.8%
	Fourth quintile	419	17.7%
	Highest quintile	437	18.4%
	Prefer not to answer	426	18.0%
Marital status	Single	890	37.6%
	Married/cohabiting	1305	55.1%
	Other	175	7.4%
Adults in household	1 adult	599	25.3%
	2 adults	892	37.6%
	3 or more adults	879	37.1%

Children in household	0 children	1180	49.8%
	1 child	320	13.5%
	2 or more children	870	36.7%
Dog ownership	No	1820	76.8%
	Yes	550	23.2%
Car ownership	No	374	15.8%
	Yes	1996	84.2%
Austrian region	Burgenland	81	3.4%
	Carinthia	152	6.4%
	Lower Austria	507	21.4%
	Upper Austria	418	17.6%
	Salzburg	123	5.2%
	Styria	374	15.8%
	Tyrol	160	6.8%
	Vorarlberg	82	3.5%
	Vienna	473	20.0%
River within 1km of residence	No	545	23.0%
	Yes	1825	77.0%
Lake within 1km of residence	No	2199	92.8%
	Yes	171	7.2%
NDVI quartiles	Lowest quartile	558	23.5%
	Second quartile	554	23.4%
	Third quartile	551	23.2%
	Highest quartile	548	23.1%
	Missing	159	6.7%

Appendix B

Full preliminary linear regression model. B = unstandardized, SE = Standard Error, β = standardized coefficients.

	Model 1			Model 2			Model 3			Model 4			Model 5		
Predictor	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Childhood Exposure				0.29***	0.03	.19	0.24***	0.03	.15	0.22***	0.03	.14	0.20***	0.03	.13
Nature Connectedness							0.34***	0.03	.23	0.32***	0.03	.22	0.29***	0.03	.19
Visits to Blue Spaces										0.03***	≤0.01	.12	0.01*	0.01	.05
Visits to Green Spaces													0.03***	≤0.01	.14
Gender (female = ref.)	-0.65***	0.10	-.13	-0.66***	0.10	-.13	-0.61***	0.10	-.12	-0.65***	0.10	-.13	-0.65***	0.10	-.13
Work status															
(unemployed = ref.)															
In paid work	-0.31*	0.16	-.06	-0.39*	0.16	-.08	-0.47**	0.15	-.10	-0.43**	0.15	-.09	-0.43**	0.15	-.09
In education	0.08	0.25	.01	0.08	0.25	.01	0.07	0.24	.01	0.10	0.24	.01	0.10	0.24	.01
Retired	-0.23	0.19	-.04	-0.20	0.19	-.03	-0.38*	0.18	-.06	-0.32	0.18	-.05	-0.32	0.18	-.05
Other	-0.45	0.24	-.05	-0.53*	0.24	-.05	-0.55*	0.23	-.06	-0.56*	0.23	-.06	-0.56*	0.23	-.06
Household income															
(Lowest Quintile = ref.)															
Quintile 2	0.23	0.19	.03	0.23	0.19	.03	0.16	0.18	.02	0.15	0.18	.02	0.15	0.18	.02
Quintile 3	0.09	0.18	.01	0.12	0.18	.02	0.08	0.18	.01	0.01	0.17	≤.01	0.01	0.17	≤.01
Quintile 4	0.09	0.19	.01	0.06	0.19	.01	0.07	0.18	.01	0.01	0.18	≤.01	0.01	0.18	≤.01
Quintile 5	-0.32	0.19	-.50	-0.37	0.19	-.06	-0.39*	0.17	-.06	-0.49**	0.18	-.08	-0.49**	0.18	-.08

No response	-0.48**	0.18	-.08	-0.46*	0.18	-.07	-0.47**	0.17	-.07	-0.50**	0.17	-.08	-0.50**	0.17	-.08
Adults in household															
(1 = ref.)															
2 adults	0.44***	0.14	.09	0.48***	0.13	.10	0.41***	0.13	.08	0.41***	0.13	.08	0.41***	0.13	.08
3 or more adults	0.66***	0.14	.13	0.67***	0.14	.13	0.60***	0.14	.12	0.51***	0.14	.10	0.51***	0.14	.10
Age Groups (18-29 = ref.)															
30 to 39 years	-0.12	0.17	-.02	-0.10	0.17	-.02	-0.15	0.16	-.02	-0.08	0.16	-.01	-0.06	0.16	-.01
40 to 49 years	-0.26	0.17	-.04	-0.21	0.17	-.03	-0.31	0.17	-.05	-0.24	0.16	-.04	-0.21	0.16	-.03
50 to 59 years	0.11	0.17	.02	0.15	0.17	.03	-0.07	0.16	-.01	0.02	0.16	<.01	0.08	0.16	.01
60+ years	0.30	0.22	.05	0.34	0.22	.06	0.17	0.22	.03	0.21	0.21	.03	0.27	0.21	.04
Education (secondary school or lower = ref.)															
A-Levels	0.27*	0.12	.12	0.21	0.12	.04	0.22*	0.11	.04	0.20	0.11	.04	0.18	0.11	.04
Higher Degree	0.24	0.14	.04	0.19	0.13	.03	0.24	0.13	.04	0.19	0.13	.03	0.18	0.13	.03
Ethnic minority (yes = ref.)	-0.47*	0.21	-.06	-0.53*	0.21	-.06	-0.42*	0.20	-.05	-0.27	0.20	-.03	-0.27	0.20	-.03
No	-0.36	0.35	-.03	-0.39	0.34	-.03	-0.31	0.33	-.02	-0.24	0.33	-.02	-0.21	0.33	-.02
Do not know															
Marital status (single = ref.)															
Married/cohabiting	0.06	0.14	.01	0.06	0.14	.01	0.02	0.13	<.01	0.03	0.13	.01	0.04	0.13	.01
Other	-0.32	0.21	-.03	-0.33	0.20	-.04	-0.3	0.20	-.04	-0.33	0.20	-.04	-0.31	0.20	-.03
Children in household															

(0 = ref.)															
1 child	0.07	0.18	.01	0.12	0.18	.02	0.12	0.17	.02	0.07	0.17	.01	0.04	0.17	.01
2 or more children	0.38	0.20	.08	0.45*	0.20	.09	0.38	0.20	.07	0.31	0.19	.06	0.29	0.19	.06
Dog ownership (no = ref.)	0.26	0.12	.04	0.20	0.12	.04	0.12	0.12	.02	0.05	0.12	.01	-0.04	0.12	-.01
Car ownership (no = ref.)	0.13	0.15	.02	0.09	0.15	.01	0.08	0.14	.01	0.05	0.14	.01	-0.03	0.14	<.01
AT Region (Vienna = ref.)															
Lower & Upper Austria	0.27	0.15	.05	0.27	0.15	.05	0.25	0.15	.05	0.26	0.14	.05	0.21	0.14	.04
Carinthia & Styria	0.04	0.17	.01	0.04	0.16	.01	-0.01	0.16	<.01	0.01	0.16	<.01	-0.04	0.16	-.01
Salzburg, Tyrol & Vorarlberg	0.28	0.18	.04	0.23	0.18	.03	0.21	0.18	.03	0.15	0.17	.02	0.10	0.17	.02
Dist. to river ≤ 1km (no = ref.)	0.08	0.12	.01	0.06	0.12	.01	0.08	0.12	.01	0.06	0.11	.01	0.06	0.11	.01
Dist. to lake ≤ 1km (no = ref.)	0.20	0.19	.02	0.18	0.19	.02	0.09	0.18	.01	0.05	0.18	.01	0.06	0.18	.01
NDVI															
(Lowest quartile = ref.)															
Second quartile	0.04	0.14	.01	0.02	0.14	<.01	-0.05	0.14	-.01	-0.03	0.14	-.01	-0.01	0.14	<.01
Third quartile	0.22	0.15	.04	0.21	0.15	.04	0.10	0.14	.02	0.10	0.14	.02	0.08	0.14	.01
Highest quartile	0.09	0.15	.02	0.07	0.15	.01	-0.06	0.14	-.01	-0.08	0.14	-.01	-0.08	0.14	-.01
Constant	7.47***			7.25***			5.85***			5.67***			5.69***		
R^2	.04			.07			.13			.14			.15		

*** p ≤ .001, ** p ≤ .01, * p ≤ .05

Appendix C

Full mediation model. B = unstandardized, SE = Standard Error, β = standardized coefficients.

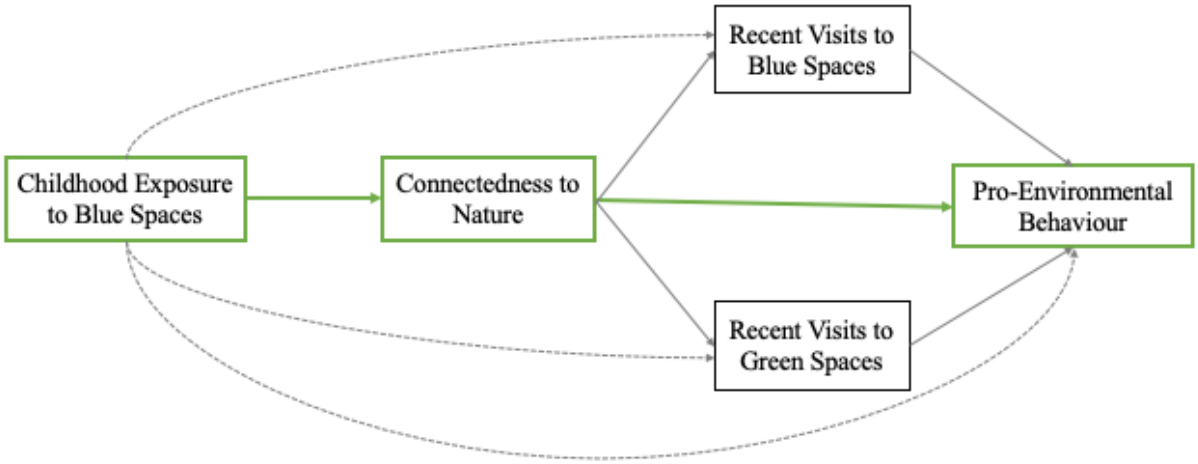
	Outcome: INS			Outcome: Blue Space Visits			Outcome: Green Space Visits			Outcome: PEB			Total Effect Model		
Predictor	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**	**B**	**SE**	**β**
Childhood Exposure	0.16***	0.02	.15	0.72***	0.15	.10	1.11***	0.17	.13	0.20***	0.03	.13	0.29***	0.03	.19
Nature Connectedness				1.02***	0.14	.15	1.89***	0.16	.23	0.29***	0.03	.19			
Visits to Blue Spaces										0.01*	0.03	.05			
Visits to Green Spaces										0.03***	<0.01	.14			
Gender (female = ref.)	-0.15	0.07	-.04	0.93	0.49	.04	1.35*	0.54	.05	-0.65***	0.10	-.13	-0.66***	0.10	-.13
Work status (unemployed = ref.)															
In paid work	0.25*	0.11	.07	-2.51**	0.76	-.11	-0.72	0.85	-.03	-0.43**	0.15	-.09	-0.34*	0.16	-.08
In education	0.03	0.17	<.01	-1.86	1.20	-.04	-0.48	1.34	-.01	0.10	0.24	.01	0.08	0.25	.01
Retired	0.52***	0.13	.12	-3.76***	0.92	-.13	-0.81	1.02	-.02	-0.32	0.18	-.05	-0.20	0.19	-.03
Other	0.08	0.17	.01	0.07	1.15	<.01	0.17	1.29	<.01	-0.56*	0.23	-.06	-0.52*	0.24	-.05
Household income (Lowest Quintile = ref.)															
Quintile 2	0.21	0.13	.04	0.23	0.91	.01	0.46	1.01	.01	0.15	0.18	.02	0.23	0.19	.03
Quintile 3	0.10	0.13	.02	2.31**	0.87	.08	1.92	0.97	.05	0.01	0.17	<.01	0.12	0.18	.02
Quintile 4	-0.03	0.13	-.01	1.60	0.91	.05	1.85	1.01	.05	0.01	0.18	<.01	0.06	0.19	.01

Quintile 5	0.06	0.13	.01	3.10***	0.93	.10	2.79**	1.03	.08	-0.49**	0.18	-.08	-0.37	0.19	-.06
No response	0.04	0.12	.01	0.32	0.87	.01	1.19	0.97	.03	-0.51**	0.17	-.08	-0.46*	0.18	-.07
Adults in household (1 = ref.)															
2 adults	0.20*	0.09.	.06	-0.87	0.64	-.04	0.41	0.72	.01	0.41**	0.13	.08	0.45***	0.13	.10
3 or more adults	0.18	0.10	.05	-0.06	0.68	<.01	3.61***	0.76	.13	0.51***	0.14	.10	0.66***	0.14	.13
Constant	4.05***			5.55***			4.21***			5.69***			7.25***		
R^2	.04			.05			.11			.15			.07		

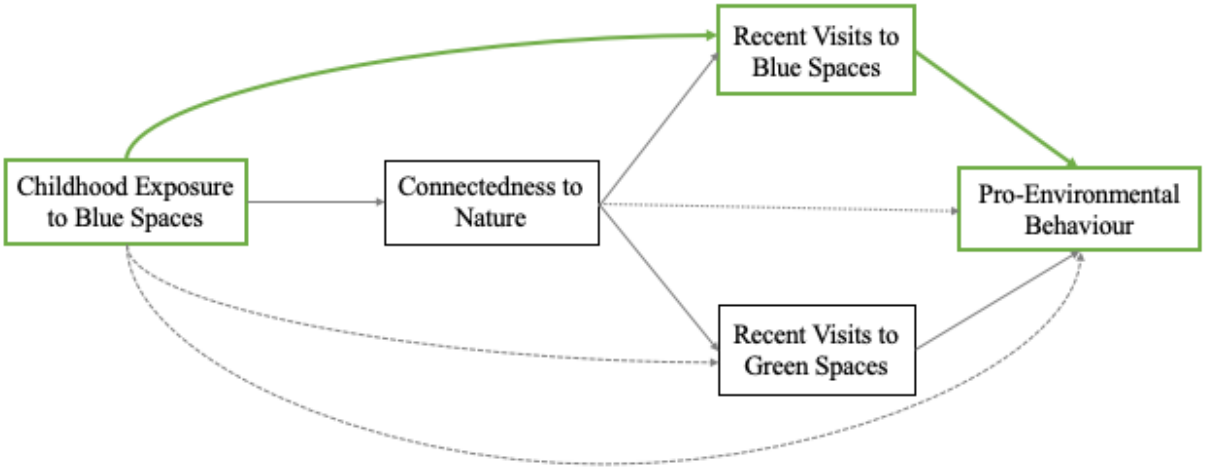
*** p ≤ .001, ** p ≤ .01, * p ≤ .05

Appendix D

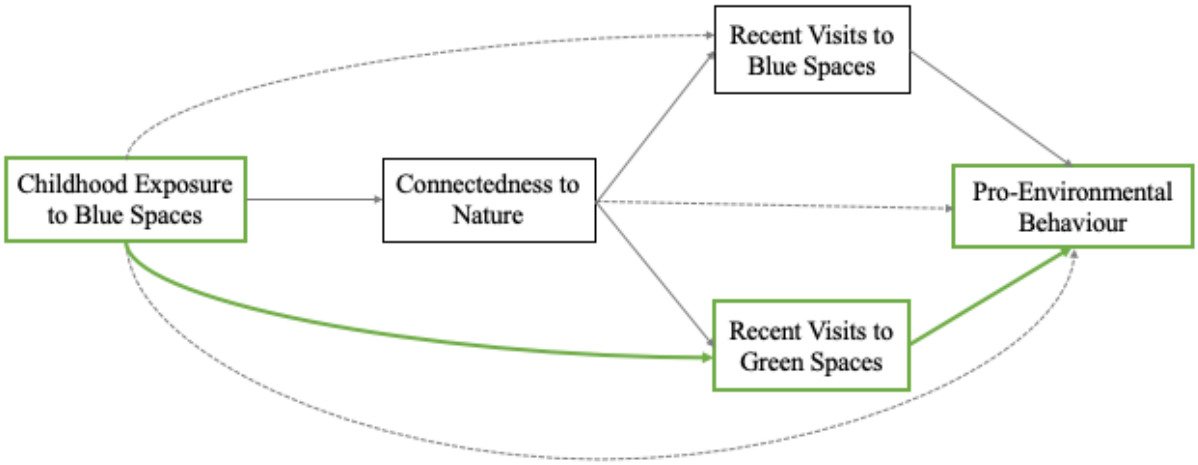
Visualization of indirect effect 1, Childhood Exposure to Blue Spaces on Adult Pro-Environmental Behaviour via Nature Connectedness (Estimate = 0.05, 95% CI [0.03, 0.06]), effect significant.



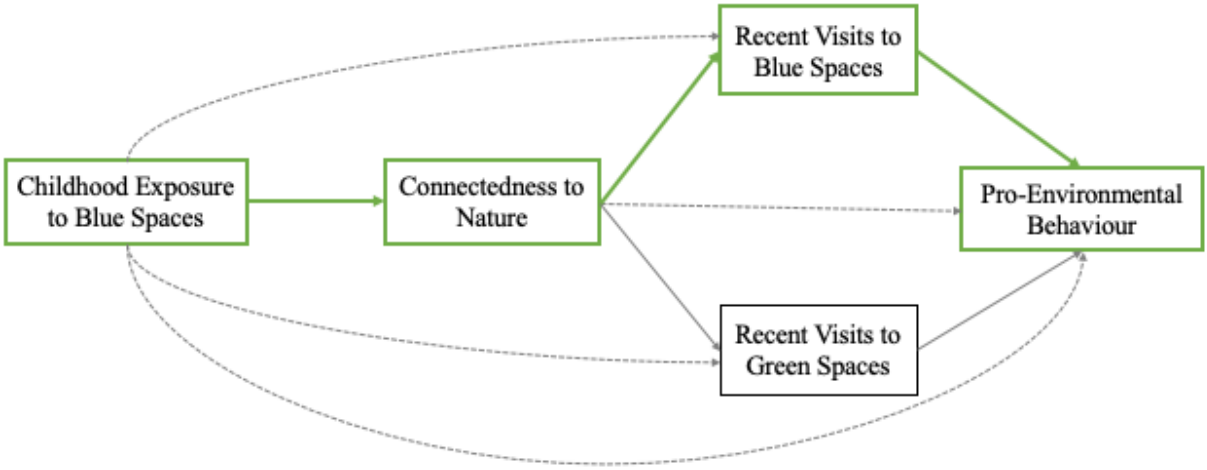
Visualization of indirect effect 2, Childhood Exposure to Blue Spaces on Adult Pro-Environmental Behaviour via Recent Visits to Blue Spaces (Estimate = 0.01, 95% CI [< -0.01, 0.02]), effect not significant.



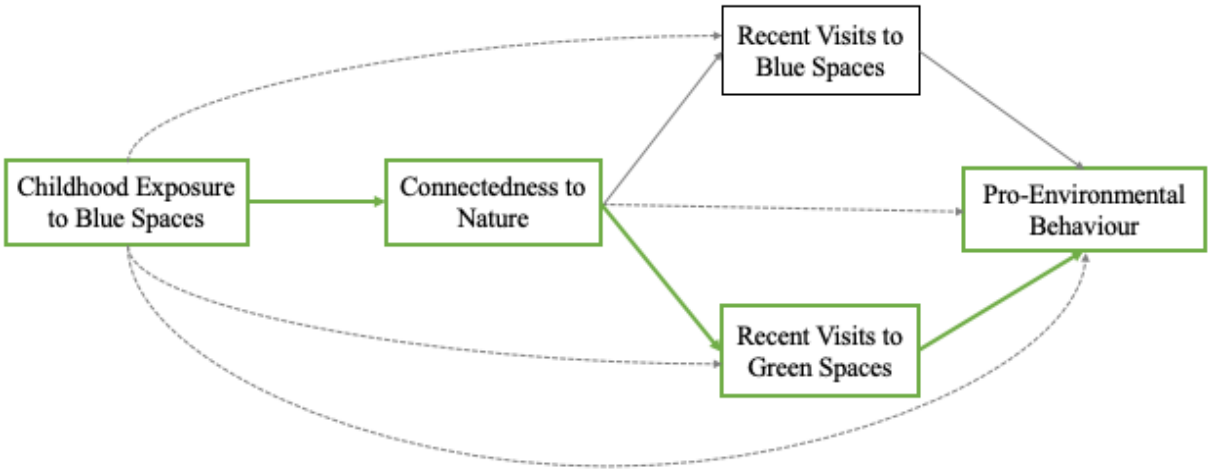
Visualization of indirect effect 3, Childhood Exposure to Blue Spaces on Adult Pro-Environmental Behaviour via Recent Visits to Green Spaces (Estimate = 0.03, 95% CI [0.02, 0.04]), effect significant.



Visualization of indirect effect 4, Childhood Exposure to Blue Spaces on Adult Pro-Environmental Behaviour via Nature Connectedness and Recent Visits to Blue Spaces (Estimate < 0.01, 95% CI [< 0.01, < 0.01]), effect significant.



Visualization of indirect effect 5, Childhood Exposure to Blue Spaces on Adult Pro-Environmental Behaviour via Nature Connectedness and Recent Visits to Green Spaces (Effect = 0.01, SE < 0.01, 95% CI [< 0.01, 0.01]), effect significant.



Abstract

Experiences with nature in childhood have been argued to predispose pro-environmental behaviours (PEB) later in life. The underlying mechanisms of this relationship are the focus of this study. A serial-parallel mediation model from childhood exposure to blue spaces, via nature connectedness and recent visits to green and blue spaces to adult PEB is proposed, using a representative sample from Austria ($N = 2370$). Results indicate a significant relationship between childhood exposure to blue spaces and PEB which is partially mediated by all proposed factors. The model provides significant direct as well as indirect effects, while controlling for known individual- and area-level covariates. Findings should be considered in the context of limitations associated with the cross-sectional study design and a possible recall bias for childhood memories. Despite these limitations, the findings highlight the potential importance of childhood contact to blue spaces as well as life-long nature contact for improving nature connectedness and PEB. The results further emphasize the need to protect and maintain natural water bodies and to improve their safety, so that outdoor recreation around those spaces can be expanded to positively affect nature connectedness and PEB.

Zusammenfassung

Es besteht die Annahme, dass Naturerfahrungen in der Kindheit umweltfreundliches Verhalten (PEB) im späteren Leben begünstigen. Die dieser Beziehung zugrunde liegenden Mechanismen sind der Fokus dieser Studie. Anhand einer repräsentativen Stichprobe aus Österreich (N = 2370) wurde ein seriell-paralleles Mediationsmodell entwickelt, das den Zusammenhang zwischen Kontakt mit Gewässern in der Kindheit, via Naturverbundenheit und Frequenz von aktuellen Besuchen zu Gewässern und Grünflächen, zu PEB im Erwachsenenalter beschreibt. Die Ergebnisse deuten auf einen signifikanten Zusammenhang zwischen dem Kontakt mit Gewässern in der Kindheit und PEB im Erwachsenenalter hin, der durch alle vorgeschlagenen Faktoren partiell mediiert wird. Das Modell liefert sowohl signifikante direkte als auch indirekte Effekte, während für bekannte Kovariaten auf individueller und objektiver Ebene kontrolliert wird. Die Ergebnisse müssen vor dem Hintergrund von Limitationen wie dem Querschnittsdesign der Studie und möglichem Recall Bias für Kindheitserinnerungen betrachtet werden. Das Modell zeigt, wie wichtig der Kontakt zu Gewässern in der Kindheit und genereller Naturkontakt während des gesamten Lebens, im Hinblick auf Naturverbundenheit und PEB, ist. Die Ergebnisse unterstreichen außerdem die Notwendigkeit, natürliche Gewässer zu schützen und erhalten, und ihre Sicherheit zu verbessern, damit Freizeitaktivitäten um diese Räume herum gefördert werden können, welche zu positiven Effekten im Hinblick auf Naturverbundenheit und PEB führen können.