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Unpacking the causes and consequences of the extinction of experience

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ABSTRACT

Urbanization and urban lifestyle are progressively diminishing individuals' opportunity (e.g., nature exposure) to experience and orientation (affinity) towards nature, ultimately reducing people's experiences of nature. This process has been described as the 'extinction of experience' (EoE), and it was suggested that it can alter the way people benefit from, interact with, learn about, emotionally connect with and commit to protect the natural world. The EoE is underpinned by interconnected relations between the drivers, nature experiences and outcomes, yet to date most research have focused on bilateral relations (e.g. between opportunity and well-being). Here we adopt a holistic approach to jointly explore the network of relationships suggested by the EoE theory. We conducted a survey of 523 inhabitants of a large metropolis, Tel Aviv, Israel, living in neighborhoods varying in nature intensity levels, and explored their orientation, health, well-being, environmental attitudes and conservation behaviors. Using a structural equation model, we empirically demonstrated the validity of the theoretical model of the EoE, but also showed more complex relationships. For instance, opportunity to experience urban nature was only related to health and well-being benefits, while orientation towards nature was related to well-being, conservation attitudes and behaviors in different contexts. Thus, providing opportunities to experience nature seems to be less sufficient than strengthening people's orientation to avert the EoE, as the latter can simultaneously enhance nature experiences, conservation behaviors and provide social benefits. This knowledge is pivotal if we are to promote policies that achieve the behavioral changes needed to mitigate the biodiversity crisis.

1. Introduction

Land use changes, such as urbanization, and urban lifestyles are increasingly isolating humans from the experience of the natural world surrounding them (Miller, 2005). This 'extinction of experience' is a major environmental concern, as it alters the way people interact with, learn about, and emotionally connect with the natural world, which hinders the ability to achieve the behavioral change needed to mitigate the biodiversity crisis (Colléony et al., 2019; Soga and Gaston, 2016). Furthermore, mounting empirical evidence demonstrate that nature experiences provide a wide range of health and well-being benefits (reviewed by Keniger et al., 2013) and promote pro-environmental attitudes and behaviors (Prévot et al., 2018). The extinction of experience is therefore profoundly concerning, as it threatens both human health and biodiversity conservation. Despite growing research interest in the topic, only few empirical studies have set to explore the relationships between the causes and consequences of the extinction of experience (Soga and Gaston, 2016).

The term 'extinction of experience' was first introduced by Robert Pyle (1978) and recently Soga and Gaston (2016) theorized a framework describing this deleterious phenomenon (Fig. 1). According to their framework, the loss of opportunities to experience nature and orientation (i.e. affinity) towards nature are the causes that diminish experiences of nature. As a result, individuals' health and well-being related to nature experiences can be reduced, as well as pro-environmental attitudes and behaviors (Soga and Gaston, 2016). These deleterious consequences further affect the causes of the extinction of experience, creating a pervasive cycle of impoverishment of nature experiences (Fig. 1). However, this framework has never been empirically tested, as to date, there is no research looking at the whole network of relationships in a single study. Existing research effort has been predominantly focused on the consequences for either humans (i.e. health and well-being) or indirectly for the environment through changes in environmental attitudes and behaviors. However, nature experiences may not affect health and well-being the same way they affect environmental attitudes. Indeed, while studies showed positive relationships between time spent in nature and health or well-being (Shanahan et al., 2016), recent studies showed no correlation between time spent in nature and environmental attitudes and conservation behaviors (Colléony et al., 2019; Richardson et al., in press). It is

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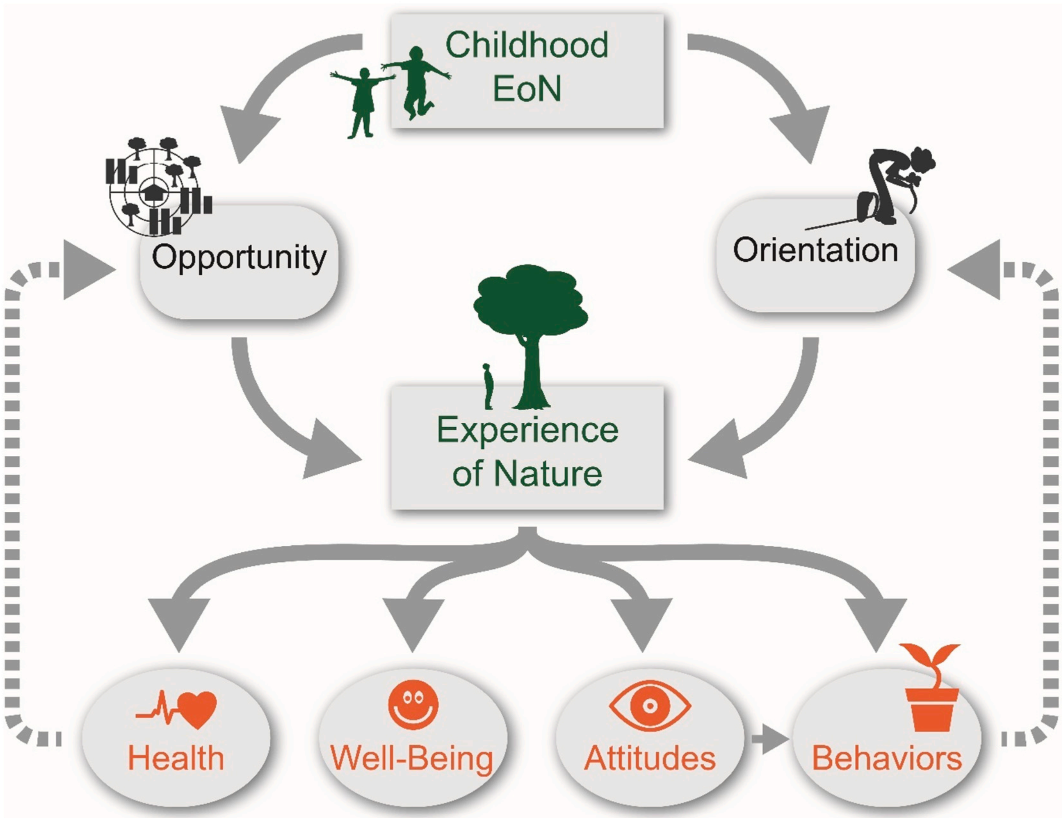

Fig. 1. Theoretical framework of the causes and consequences of the extinction of experience, based on Soga and Gaston (2016). Opportunity to experience nature (e.g. access to green spaces) and orientation (e.g. sense of connection to nature) are acknowledged are the main causes of the extinction of experience; childhood experiences of nature (EoN) influence sense of connection to the natural world at later stages in life (Chawla, 1988). In turn, the extinction of experience affects individual health, well-being, and attitudes and behaviors towards conservation. Attitudes can also be translated into behaviors (Stern and Dietz, 1994). The feedback loop from the consequences to the causes of the extinction of experience is shown with dotted arrows. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

therefore crucial to assess the various consequences of the extinction of experiences in a comparable manner, to help identify strategies aiming to encourage nature interactions that benefit both people and the environment. To date, this has not been done, which hinders our ability to avert the extinction of experience.

The framework of the extinction of experience is also mainly based on indirect evidence. The challenge in studying the causes and consequences of the extinction of experience is the need of temporal studies comparing environmental variables, experiences of nature and various outcomes (e.g., health or well-being) over time. Since there is currently no research based on such long-term datasets, the pathways of the framework were inferred mainly based on empirical evidence of positive relationships between environmental characteristics (e.g., vegetation cover), orientation (affinity towards nature), nature experiences and various outcomes. The relationship between opportunity and experiences of nature has been explored either through nature exposure (public and private green spaces) or access to nature (public green spaces) (Lin et al., 2014; Soga et al., 2015), yet access to nature and nature exposure are not synonyms (Jarvis et al., 2020). For instance, although they contribute to nature exposure, some green spaces are not publicly accessible. The extent to which simply providing a greener environment differ from providing accessible green spaces to individuals in terms of nature experiences and outcomes is not well understood.

There is mounting empirical evidence that affinity towards nature is a strong driver of nature experiences (e.g., Lin et al., 2014), and that nature experiences provide a wide range of health and well-being benefits and foster pro-environmental attitudes and behaviors (Collado et al., 2015; Cox et al., 2017; Prévot et al., 2018; Shanahan et al., 2016). Therefore, nature experiences could mediate the relationship between orientation and health, well-being and indirect conservation benefits, but research exploring these relationships remains scarce (but see, Colléony et al., 2020). Finally, research on nature experiences has almost exclusively focused on frequency and duration of visits (quantity), and although the quality of the experience (*how* individuals interact with nature) is increasingly acknowledged as important (Colléony et al., 2019; Gaston et al., 2018), it has been largely overlooked. Recent studies showed that individuals who really engage or interact deeply with nature (e.g., smell flowers, observe wildlife) retrieve stronger well-being benefits from the outdoor experience (Colléony et al., 2020) and act more for the conservation of biodiversity than others (Prévot et al., 2018). Integrating the qualitative dimension of the nature experience in our understanding of the relationships with drivers and outcomes of nature experiences is thus important for guiding adequate landscape management or conservation strategies.

Our understanding of the extinction of experience therefore remains largely limited, with several knowledge gaps on the relationships between causes and consequences and, most importantly, no empirical assessment to validate the overall framework. The extinction of experience represents a key contemporary issue for both social and environmental health, and such knowledge gaps seriously undermine our ability to avert or mitigate this deleterious phenomenon. Here, we empirically test, for the first time, the overall framework and unpack the network of relationships that drive the extinction of experience. To achieve this goal, we explored all causes and consequences stated in the theoretical framework in a single study. We surveyed inhabitants of a large metropolis, Tel Aviv, Israel, from different types of neighborhood varying in the levels of opportunity to experience nature (exposure and access to nature), explored the extent to which and how they experience nature, their orientation to do so, their well-being, health, environmental attitudes and conservation behaviors, and used a structural modelling approach to test the overall framework.

2. Method

2.1. Study design

We conducted a survey of 523 adults along a gradient of urban development in the Tel-Aviv metropolis. To ensure equivalent representation of individuals with high, medium or low exposure to nature in our survey, we first defined three types of neighborhoods based on levels of greenness, using Ward Hierarchical Clustering analysis based on Normalized Difference Vegetation Index (NDVI) and land use maps. Land use maps were obtained from the GIS department of the municipality of Tel Aviv (Tel Aviv GIS Department, 2018). For NDVI, we used a cell size of 30 m and obtained data from Landset 2011 (Hamaarag, 2018). To pilot the questionnaire, 10 students and lab members filled-up an early draft of the questionnaire and were then interviewed about each question to ensure their validity and improve formulation. The survey was administered in Spring 2018 through a market research company (iPanel). To ensure balanced distribution of respondents across the three clusters, we listed all streets within Tel Aviv metropolis and identified the cluster each street was affiliated to (i.e. green, moderate or grey), and we set quotas per cluster on the question asking respondents to provide their address (see Section 2.2.1). In return for participation, iPanel offered respondents to receive incentives. Permission for this survey was granted by the Technion Social and Behavioral Sciences Institutional Review Board (approval number 2018-025), and the research was performed in accordance with relevant guidelines and regulations. All participants were provided a brief description of the study and gave informed consent for study participation. All responses were anonymous.

2.2. Questionnaire design

The questionnaire survey was designed to capture all aspects of the framework of the extinction of experience: (1) opportunity (access and exposure), (2) orientation, and (3) childhood experiences of nature were set to capture the causes of the extinction of experience; (4) experiences of nature; and (5) nature related health and well-being measures, and (5) environmental attitudes and behaviors were used to assess the consequences of the extinction of experience. All the variables measured in this study are described in Table 1. The questionnaire was distributed in Hebrew (see online supplementary material A for English version of the questionnaire).

2.2.1. Opportunity and orientation

We measured opportunity to experience nature through measures of nature exposure and greenspace access around participants address. We measured urban nature exposure following Lin et al. (2014): we asked each respondent to provide an approximate address (street and range of numbers for house; e.g., Hagalil street, number [50–75]), to enable spatial analyses based on participants' exposure to nature; then, we used environmental layers of Normalized Difference Vegetation Index (NDVI), number of trees, and area (in m^2) of green spaces, defined buffers of 250 m, 500 m and 1000 m around each respondent's address (based on Lin et al., 2014) and calculated an average Normalized Difference Vegetation Index (NDVI) score, the number of trees and the green space area within each buffer size (250 m, 500 m and 1000 m) for each respondent. Buffer sizes were selected based on previous research on drivers of park visitation (Lin et al., 2014; Soga and Akasaka, 2019) and importance of providing green spaces within 300 m from one's home (Barbosa et al., 2007). We measured non-urban nature exposure by calculating the distance (in meters) to the nearest non-urban open green space (nature reserve, picnic area or KKL forest, agricultural area or sea or lake, see below). We reverse-coded those distance to derive measures of proximity (high value for high proximity). We then selected the proximity to the most visited non-urban open green space (see *2.2.2 experience of nature* section) as the measure of *opportunity*

Table 1
Variables that are included in latent constructs for the structural equation models, their range of values and mean ± standard deviation.

Latent construct	Variable	Range	MEAN ± SD
Opportunity – nature exposure	NDVI Buffer 250/500/1000 m (*urban model*)	[−0.02–0.34] / [−0.04–0.33] / [−0.13–0.30]	0.19 ± 0.07 / 0.19 ± 0.06 / 0.17 ± 0.07
	Number of trees Buffer 250/500/1000 m (*urban model*)	[0–757] / [27–2851] / [73–7191]	153.26 ± 103.70 / 904.70 ± 490.69 / 3146 ± 1565
	Green spaces areas (m^2) Buffer 250/500/1000 m (*urban model*)	[40.11–157,880] / [512.2–507,474] / [53542–1,916,660]	37,154.67 ± 28,131.66 / 164,902.4 ± 112,705.8 / 722,940 ± 467,293.5
	Proximity to most visited non-urban green space (meters) (*non-urban model*)	[35–12,370]	4283 ± 3572.3
Opportunity – access	Proximity to urban green spaces (*urban model*) / Proximity to non-urban green spaces (*non-urban model*)	[0–60] / [0 − 120]	51.12 ± 9.18 / 92.21 ± 24.32
Childhood experiences of nature	Proximity to open green spaces	[0–120]	110.80 ± 10.49
Orientation	Nature relatedness (Nisbet and Zelenski, 2013)	[1–5]	3.13 ± 1.00
Experience of nature	Frequency of visits to urban green spaces (*urban model*)/ Frequency of visits to non-urban green spaces (*non-urban model*)	[0 − 30]	8.28 ± 6.60 / 3.76 ± 5.99
	Duration of visits to urban green spaces (*urban model*) / Duration of visits to non-urban green spaces (*non-urban model*)	[0–420]	109.46 ± 72.09 / 80.02 ± 98.32
	Nature interactions (quality)	[1–7]	3.95 ± 1.38
Health	Depression (Following Shanahan et al., 2016)	[0 − 21]	17.06 ± 4.60
	Stress (Cohen et al., 1983)	[10–50]	33.20 ± 7.32
	Body Mass Index (index)	[1–3]	2.45 ± 0.69
	Number of days of physical activity in the past week	[1–7]	2.33 ± 1.62
Well-being	Neighborhood well-being (Luck et al., 2011)	[1–5]	3.48 ± 0.93
	Personal well-being (Luck et al., 2011)	[1–5]	3.61 ± 0.74
Environmental attitudes	New Ecological Paradigm (Dunlap et al., 2000)	[1–5]	3.71 ± 0.69
Conservation behaviors	Environmental behaviors (Cooper et al., 2015)	[1–5]	3.67 ± 0.93
	Conservation behaviors (Cooper et al., 2015)	[1–5]	2.01 ± 0.79

(nature exposure) to non-urban nature.

Access to nature was recorded by asking respondents to report the average time (0–120 min) it takes them to reach the closest of each of the following types of open green space: 'urban green space (urban park, public garden, sidewalk)', 'nature reserve', 'picnic area or KKL forest', 'agricultural area' and 'sea or lake'. We transformed the variable of time to travel into a variable of reported proximity to open green spaces by reverse-coding the values of time to travel; that is, a low score of time to travel (e.g., 5 min) becomes a high score (in this case, 115) of reported proximity to open green spaces. For each participant, we reported the value of proximity to urban green spaces as a measure of *access to urban nature*. We considered nature reserve, picnic area or KKL forest, agricultural area and sea or lake as non-urban nature, since those open green spaces are not found within Tel Aviv metropolis; we verified this by comparing scores of time to travel to reach each of those sites using Wilcoxon paired tests (see Fig. B1 in supplementary material B). We retained the value of reported proximity to the most frequently visited (see *2.2.2 experience of nature* section) non-urban open green space as a measure of *access to non-urban nature*.

We measured orientation using the short version of the Nature Relatedness Scale (NR-6; Nisbet and Zelenski, 2013), designed to capture individuals' affinity towards nature. Inter-item reliability was high (Cronbach's alpha = 0.88), so we averaged scores of the six items to derive a single measure of *Orientation*.

2.2.2. Current and childhood experiences of nature

We measured the quantity of current experiences of nature by adapting frequency and duration measurements (used in, Cox et al., 2017; Shanahan et al., 2016) as continuous scales. As a measure of frequency of visits, we asked respondents to estimate the average number of days per month (0 to 30) they visit the five types of open green spaces listed above during the spring. As a measure of duration of visits, we asked respondents to estimate the average duration of each visit to each of the five open green space, in a scale ranging from 0 to 420 min (7 h). We derived a measure of *frequency of visits to urban green spaces and a measure of duration of visits to urban green spaces* for urban nature experiences. For non-urban nature experiences, frequency of visits largely varies between one place to another, as correlations between frequency of visits to two different places range from 0.34 to 0.77 (Spearman). Therefore, an average would potentially misrepresent the respondents' actual experiences of nature. Therefore, for each participant, we selected the most visited non-urban site and derived a measure of *frequency of visits to non-urban green spaces* (score of the most visited site between the four), and a measure of *duration of visits to non-urban green spaces* (score of the most visited site between the four).

To assess the quality of experiences of nature we developed a scale of nature interactions. We recorded the extent to which, on average, participants perform different nature-related behaviors during their visits to urban and non-urban green spaces during Spring, from 1 for never, to 7 at each visit. The different nature-related behaviors were watch animals, observe flowers, bathe, pick flowers, go on camping, take pictures of nature, listen to bird chirp, smell flowers, go on a hike, feed animals, picnic or go on a jeep tour. For each participant, we average the scores of nature behaviors to derive a score of *nature interactions* (Cronbach's alpha = 0.88).

For childhood experiences, we thought that asking respondents about their frequency and duration during childhood would not provide reliable data, since it is unlikely that they remember accurately the frequency and duration of visits during childhood. We therefore only collected data on access to green spaces (opportunity) as measure of potential experience of nature during childhood. Similar to the approach presented in opportunity section, we first asked respondents to report the average time (0–120 min) it used to take them to reach each of five types of open green spaces during their childhood (6–12 years old). We transformed the variables of time to travel to open green spaces into variables of proximity to open green spaces by following the same procedure presented above (see *2.2.1 opportunity* section). For each participant, we reported the value of proximity to the nearest open green space as a single measure of *proximity to open green space during childhood,* a proxy for childhood experiences of nature.

2.2.3. Health and well-being

We measured health with two different variables. First, we used the short version of the Depression, Anxiety and Stress Scale (DASS-21; following Shanahan et al., 2016) and asked respondents to report the extent to which they felt each of a list of 7 statements during the past week, from 0 – not at all, to 4 – most of the time. We tested inter-item reliability (Cronbach's alpha = 0.89), reversed the scores of each item and summed them to derive a single positive measure of *depression,* with high score for respondents who have low depression, i.e. better mental health. We also measured stress, with the Perceived Stress Scale (Cohen et al., 1983), and asked respondents to rate how often they felt each of a list of 10 statements during the past month, from 1 – never to 5 – very often. Inter-item reliability was high (Cronbach's alpha = 0.86). Items were reversed and summed to derive a single positive measure of *stress*, with high score for respondents with low level of stress, i.e. better mental health. Finally, following Shanahan et al. (2016), we also asked respondents to report their weight and height, for *Body Mass Index* (BMI) calculation (BMI = body mass/(body height)^2), and the number of days they performed a physical activity for more than 30 min during the past week, as a measure of *physical activity*. We built an index of BMI ranging from 1 poor to 3 good health condition, attributing 1 to obese individuals (BMI > 30), 2 to individuals underweight (BMI < 18.5) and those overweight (25 < BMI < 29.9) and 3 to individuals with normal weight (18.5 < BMI < 24.9).

Following Luck et al. (2011), we used two different scales to measure subjective personal (PWB) and neighborhood well-being (NWB). PWB scale consists in nine items that represent different aspects of overall satisfaction with one's life. NWB scale consists in nine items that represents residents' level of satisfaction with living in their neighborhood. For both measures, respondents ranked each item from 0 – completely dissatisfied to 4 – completely satisfied. Inter-item reliability was high for both PWB and NWB (Cronbach's alphas = 0.88 and 0.94, respectively) and we averaged scores of items to derive the two variables (i.e. *PWB* and *NWB)*.

2.2.4. Environmental attitudes and behaviors

Environmental attitudes were assessed through the 5-item reduced version (Stern et al., 1999) of the New Ecological Paradigm (Dunlap et al., 2000). Respondents were asked to what extent they agreed on each of the statement, from 1 – strongly disagree to 5 – strongly agree. Inter-item reliability was moderate (Cronbach's alpha = 0.60). We averaged scores of items to derive a single measure of *environmental attitudes*.

We measured conservation behaviors based on Cooper et al. (2015), with a subscale assessing environmental lifestyle behaviors (3 items; e.g., 'I recycle paper, plastic, metal') and another assessing conservation behaviors (6 items; e.g., 'I made my yard or my land more desirable for wildlife'). Respondent were asked to report how frequently they perform each behavior, from 0 – never to 4 – very often. Inter-item reliability was high for environmental lifestyle and conservation behaviors (Cronbach's alphas = 0.74 and 0.82) and we averaged scores of each subscale to derive two scores of *environmental* and *conservation behaviors*.

2.2.5. Demographics

We also recorded age, gender, education (4-point scale; below high school, high school, Bachelor or professional diploma, above Bachelor) and income. We reported that the average monthly income per household in Israel is 15,000NIS, and asked each participant to rate, from 0 for low to 10 for high, their own household's income. Finally, based on participants' address, we recorded the socioeconomic status of the statistical area they live in (10-point scale, 1 low to 10 high socioeconomic status) (Tel Aviv GIS Department, 2018).

2.3. Statistical analyses

All spatial analyses were done using ArcGIS 10.5.1, and statistical analyses using R 3.6.0 (Core Team, 2013). We tested the overall framework of the extinction of experience using a Structural Equation Model (SEM), with lavaan package (Rosseel, 2012). The starting model included the hypothesized unidirectional direct and indirect paths among the variables (as in Fig. 1). In order to increase the model fit during the step-by-step improvement process, new paths were added by taking into account the modification indices that were theoretically justifiable. Conventionally considered fit indices in SEM literature have been taken into account to assess the model fit, such as the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI) and the Standardized Root Mean Square Residual (SRMR) (Schreiber et al., 2006). Because data did not follow normal distribution, we used maximum likelihood (ML) for estimating the model parameters, robust standard errors based on a sandwich-type covariance matrix and the Satorra-Bentler scaled test statistic to correct the model test statistics (Rosseel, 2012).

We built two separate models for urban nature experiences and for non-urban nature experiences, entering alternatively the variables of nature experiences (frequency, duration and quality) relative to urban green spaces or those relative to non-urban green spaces, to explore potential differences in the network of relationships driving the extinction of experience between urban and non-urban nature experiences. For the urban nature experiences, we used one model per buffer size (250 m, 500 m, 1000 m) for spatial data. We used each concept of the framework of the extinction of experience as latent constructs (Fig. 2): for instance, health was entered in the model as a variation combining the score of depression (Table 1). Demographics (i.e. age, education, income, gender and socioeconomic status) were included as covariates to demonstrate that the predicted relationships were not driven by sociodemographic differences. Frequency and duration of visits to non-urban nature were highly correlated (r = 0.74), nature relatedness and nature interactions, and personal well-being and stress (reversed-coded, high value for low level of stress) were also strongly correlated (0.58 and 0.52, respectively); other correlations were below 0.50 (see Table B1 in supplementary material B). To build the latent variable ‘experience of nature’, we did not include frequency and duration of visits together in the model for non-urban nature experiences and kept only duration, given the high correlation between those two variables.

3. Results

Respondents were mostly female (65%), on average 41 ± 13 years old, mostly highly educated (81% above Bachelor) and estimated their income slightly below average (mean = 4.86 ± 2.62, on a scale of 0 to 10). The sample size was relatively balanced across the three types of neighborhoods (28.29%, 36.52%, and 35.18% of respondents in green, moderately green and grey neighborhoods, respectively; Fig. B2 in supplementary file B).

3.1. Model fit

The model fit was considered good for the model exploring urban nature experiences with a 250 m buffer size for spatial data (Robust indices; χ^2 = 353.88, df = 155, CFI = 0.90, RMSEA = 0.05, SRMR = 0.05; Fig. 3; Table B2a-c), a 500 m buffer size for spatial data (χ^2 = 375.35, df = 155, CFI = 0.90, RMSEA = 0.05, SRMR = 0.05; Table B3a-c), and a 1000 m buffer size for spatial data (χ^2 = 363.59, df = 155, CFI = 0.90, RMSEA = 0.05, SRMR = 0.05; Table B4a-c) (Hu and Bentler, 1999). Models tested for urban nature experiences showed similar results for the three buffer sizes, here we present only results based on a 250 m buffer size (Fig. 3). The model fit was also considered good for the model exploring non-urban nature experiences (χ^2 = 264.95, df = 96, CFI = 0.87, RMSEA = 0.06, SRMR = 0.05; Fig. 4; Table B5a-c).

3.2. Structural results

We found positive relationships between orientation and experiences of nature for both SEM models, suggesting that individuals who feel more connected to nature experience nature more, in terms of quantity and quality) than individuals who feel less connected to nature (Figs. 3–4). Experiences of nature were also positively related to well-being, pro-environmental attitudes and conservation behaviors, for both urban and non-urban nature experiences (Figs. 3–4).

Opportunity was only related to nature experiences in the non-urban nature model (Figs. 3–4). This suggests that proximity to non-urban green spaces positively influences the extent to which individuals visit those places. Opportunity was directly related to health and well-being for urban nature experiences, but this relationship was not significant for non-urban nature experiences. Alternatively, opportunity was related to conservation behaviors for non-urban nature experiences and not for urban experiences. The relationship between opportunity and health and well-being was only significant for access to urban nature, and not for urban nature exposure. This suggests that individuals who live closer to accessible urban green spaces demonstrated higher health and well-being than residents who have lower access to urban green spaces. Access to urban green spaces was significantly lower than access to non-urban green spaces (see Fig. B1 in supplementary material B). It is therefore likely that only close proximity with nature has a significant effect on health and well-being.

Although we did not find a relationship between childhood experiences of nature and orientation, we found that they were related to respondents' access to urban or non-urban nature, suggesting that individuals who grew up closer to open green spaces were more likely to also live closer to accessible green spaces at adulthood (Figs. 3–4). For both urban and non-urban nature experiences, health and attitudes were not related to experiences of nature, suggesting that the extent of nature experiences does not directly affect health and attitudes. Attitudes and behaviors were positively related in both our models, suggesting that individuals who have high pro-environmental attitudes also reported acting more to conserve the natural world.

Finally, we identified significant indirect positive relationships between orientation and well-being and behaviors through nature experiences, for both urban and non-urban nature experiences (Figs. 3–4, dashed arrows). In other words, respondents with a high orientation towards nature, and with higher experiences of nature (quantity and quality) reported being happier and acting pro-environmentally more often.

4. Discussion

The increasing alienation of people from the experience of nature represents a key contemporary issue that threatens both human health and biodiversity conservation (Soga and Gaston, 2016). Averting the deleterious cycle of impoverishment of nature experiences can be vital to restore or enhance the multitude of health and well-being benefits nature provides to people, and foster affinity and care for the natural world. Although this phenomenon is receiving increasing attention, empirical evidence remains scarce and existing research does not cover the whole network of relationships of the extinction of experience framework. Here, we empirically validate the relationships underpinning the theoretical framework of the extinction of experience as a whole, covering causes and consequences on both social and indirect ecological outcomes (through conservation behaviors). Our results provide

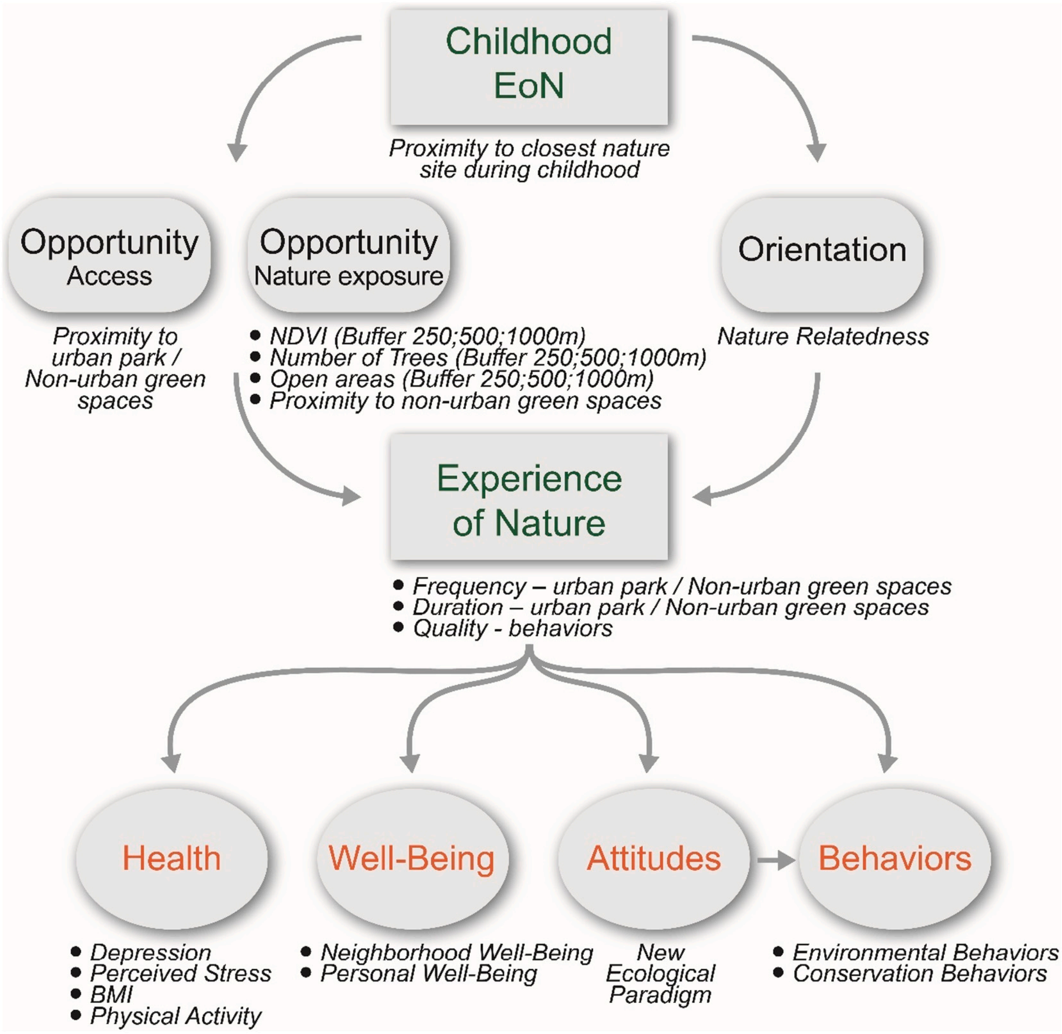

Fig. 2. Variables used to assess each element of the framework. For opportunity and experience of nature, different variables were used for urban and non-urban nature settings.

support to the overall framework, but also demonstrate that the network of relationships driving the extinction of experience is complex and inconsistent. While opportunity is only related to health and well-being, orientation is related to both well-being and conservation behaviors, via nature experiences (i.e. medicated by). Moreover, the whole network of relationships driving the extinction of experience varies with the context in which the nature experiences happen (i.e. urban or non-urban experiences). Our analysis provides a more sophisticated approach for exploring the extinction of experience and highlights the importance of orientation in driving this phenomenon. We argue that planning and conservation policies should also be directed to connecting individuals with nature rather than solely providing more opportunities, to safeguard both well-being and biodiversity conservation.

Opportunity is one of the key drivers of nature experiences (Lin et al., 2014; Soga et al., 2015; Soga and Gaston, 2016). Consistently, our model showed that proximity (exposure) to non-urban nature sites was positively related to the extent to which individuals visit those sites. There is evidence that nature intensity (e.g., proportion of vegetation cover, species richness) is positively associated with various health and well-being outcomes, although this relationship appear to be complex and sometimes non-linear (Pett et al., 2016; Shanahan et al., 2015). Our results provide support to the importance of opportunity to experience nature for individual health and well-being, as it was previously demonstrated, but also showed that this relationship is not as straightforward as originally theorized. Health and well-being were associated with access to nature but not with more objective measures of nature exposure, suggesting that greening cities may not be enough to provide social benefits and access should be also considered. Another potential explanation for the inconsistent results we found between access and exposure lies in the different measures we used to explore opportunity (spatial analyses for exposure, self-reports for access). Thus, the perception of what nature individuals have access to could potentially play a potential role in the delivery of health and well-being benefits. Indeed, inequalities in green spaces access (i.e. green gentrification) is a known phenomenon (Wolch et al., 2014), and perception of these inequalities can potentially affect individuals' well-being. This highlights the importance of promoting green spaces accessible to all people in cities, to facilitate nature experiences and enhance or restore health and well-being benefits.

In this study the relationship between opportunity and health and well-being benefits was significant for urban nature context, and not for a non-urban nature, highlighting the importance of daily nature interactions. Urban dwellers experienced urban nature regularly, while visits to nature reserves or other non-urban nature sites were relatively more occasional. For these occasional visits, distance to travel or to reach a nature site influenced the extent of nature experiences. On the other hand, higher amount of nearby nature did not play a role on the extent to which individuals go to nature, and other factors may drive nature experiences. For instance, orientation, or affinity towards nature, is

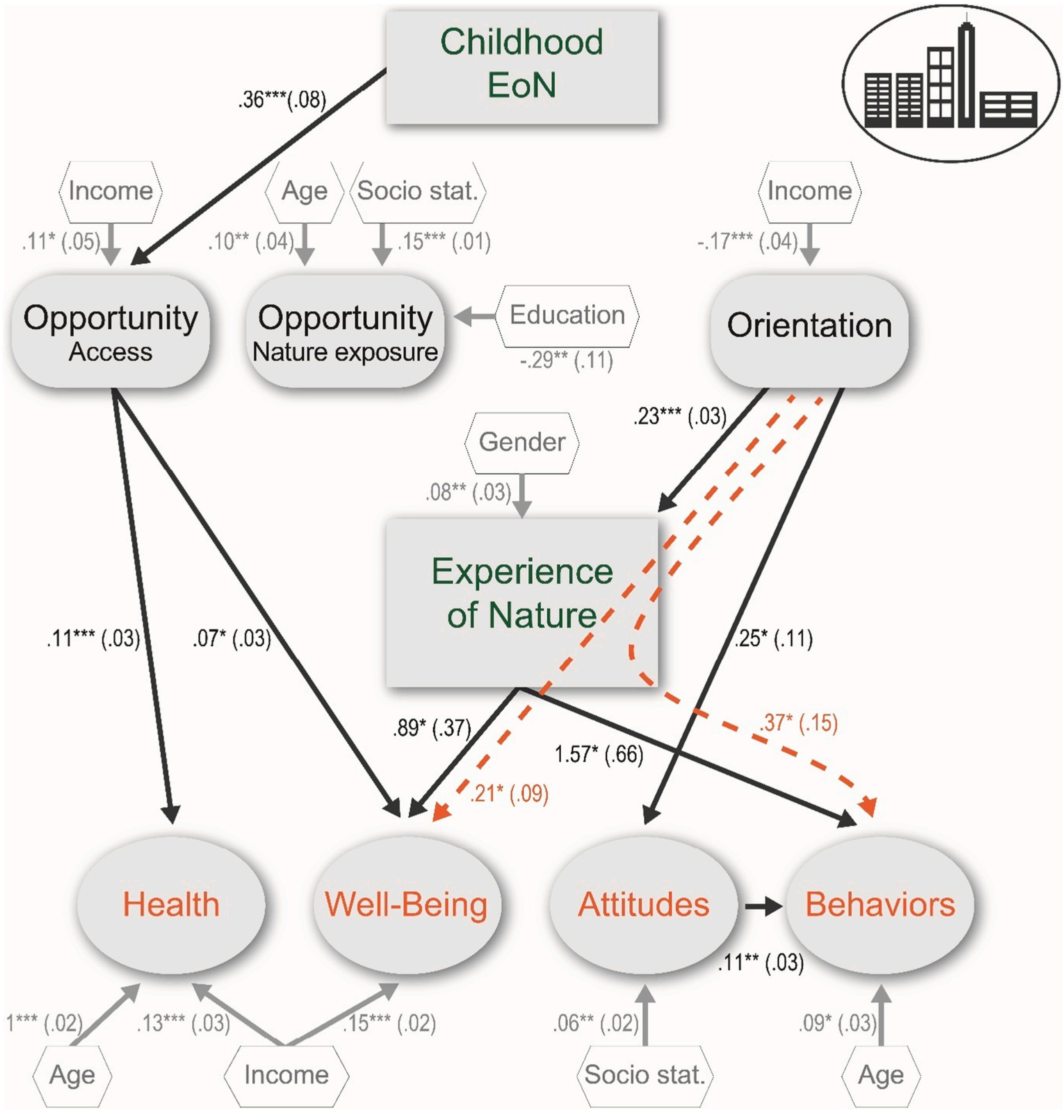

Fig. 3. Structural Equation Model of the tested framework for urban experiences of nature (buffer 250 m for spatial analyses on nature exposure). Arrows represent significant relationships; direct relationships are displayed in black, mediation effects with orange dashed arrows. Estimates (standard errors) and levels of significance (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$) are given.

another known driver of nature experiences, and there is growing empirical evidence showing that orientation is a much stronger driver of nature experiences than opportunity (Lin et al., 2014; Soga and Akasaka, 2019). Our study showed consistent results, highlighting the importance of orientation for promoting nature experiences and both social (well-being) and indirect ecological benefits (attitudes and behaviors for conservation). Additionally, nature experiences were related with well-being and conservation behaviors, but also mediated the relationship between orientation and those outcomes. This suggests the importance of enhancing affinity towards nature as a means to promote nature interactions and outcomes. Given the importance of planning sustainable cities that benefit both people and biodiversity (e.g. through Nature-Based Solutions; Colléony and Shwartz, 2019), we argue that landscape planners and architects should focus on enhancing affinity towards nature and nature interactions rather than simply providing more opportunities (i.e. green spaces) to experience nature.

One way to enhance affinity towards nature is to provide opportunities for people to have meaningful nature interactions. For instance, investing in biodiverse green spaces that allow close interactions with nature on its complexity, and encouraging individuals to engage with nature (e.g., observe wildlife, smell flowers) was suggested as means for designing biophilic cities (Beatley, 2010). Recent research also showed that reducing psychological distance from nature, e.g. through 'cues to experience' nature, could situationally induce affinity towards nature, enhance the quality of nature interactions (e.g., smell flowers, touch natural elements) and in turn improve positive affect (Colléony et al., 2020). Strategic landscape design can also help reduce psychological distance from nature, e.g. prioritizing native flowering species in public places can provide individuals more opportunities to smell flowers. This can be particularly useful in an urban context, where opportunities to interact with nature are more limited than in more rural areas. The quality of nature interactions is also positively associated with conservation behaviors (Richardson et al., in press). Consistently, our study, which integrates measures of quantity and quality of nature interactions, shows that promoting nature interactions of high quality can help address both social (well-being) and indirect ecological issues (conservation behaviors) of the extinction of experience.

This study represents the first attempt to empirically test the whole network of relationships underpinning the extinction of experience. Therefore, one should be cautious with any generalization of results from our study case. However, our results are overall consistent with previous studies. The absence of significant relationship between nature

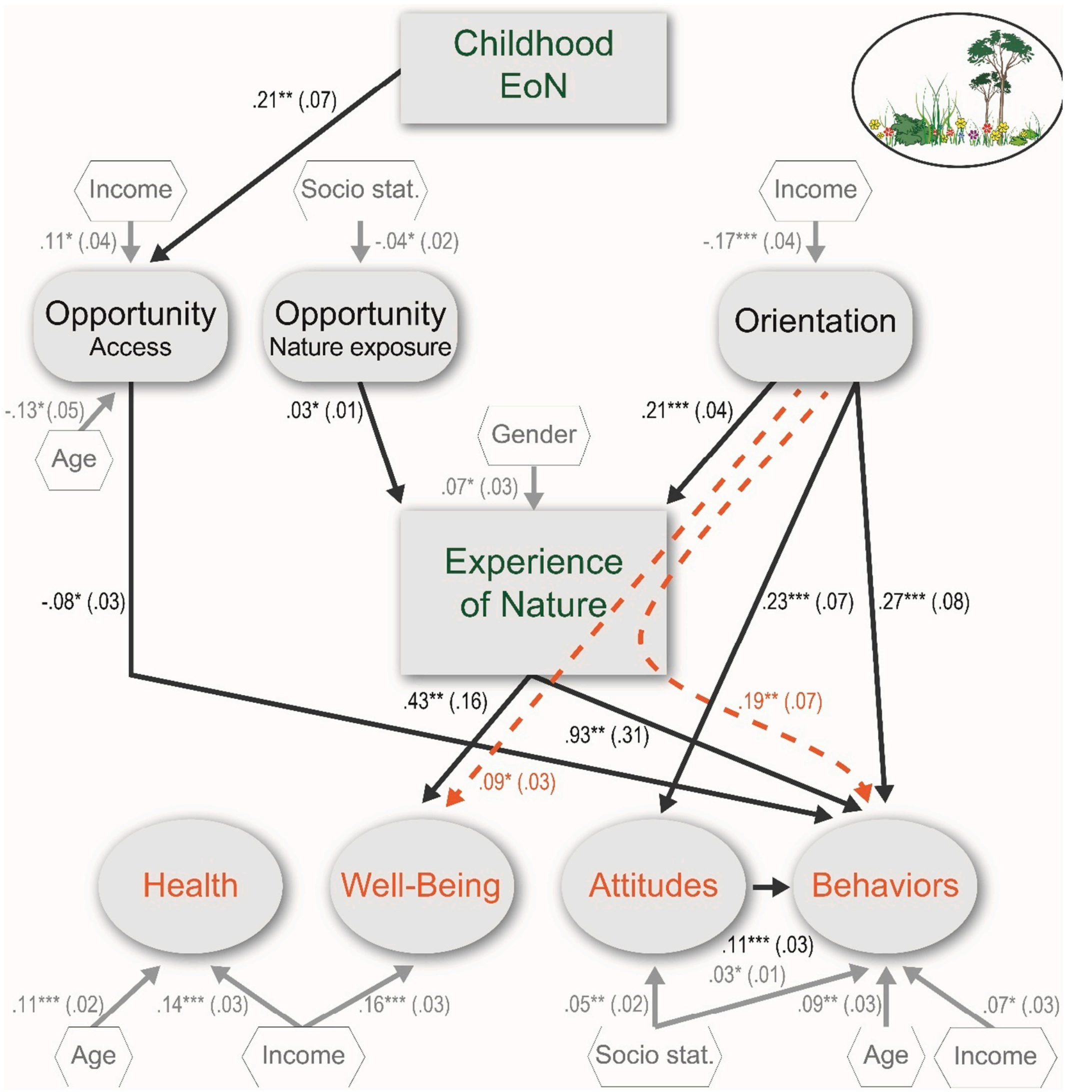

Fig. 4. Structural Equation Model of the tested framework for non-urban experiences of nature. Arrows represent significant relationships; direct relationships are displayed in black, mediation effects with orange dashed arrows. Estimates (standard errors) and levels of significance (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$) are given.

experiences and environmental attitudes contrasts with previous research (e.g., Stern et al., 1999; Whitburn et al., 2018) and may be due to the measure we used (NEP), for which internal validity was relatively low. Replications of our study in other geographical or cultural contexts and with larger audience will prove valuable to deepen our understanding of the extinction of experience phenomenon worldwide. Finally, although the results are consistent with the theoretical framework and other previous studies, our analysis relies on correlational data, and cannot establish causality. It is now important to design and implement experimental studies that test causal links between loss of experiences of nature and various outcomes, for instance by controlling for the level of experience of nature of participants and environment in which they roam (e.g., through virtual reality).

More importantly, we call for research effort focusing on the implementation of long-term monitoring programs for nature interactions and their outcomes for health, well-being and biodiversity conservation. It is crucial to establish datasets that will enable clear assessments of changes in experiences of nature and their outcomes over time. Additionally, research investigating how individuals interact with the natural world is highly needed, but remains scarce (Colléony et al., 2020; Richardson et al., in press; Soga and Gaston, 2020). For instance, as nature experiences are currently shifting towards more indirect, virtual experiences (Clayton et al., 2017; Truong and Clayton, 2020), it is important to also investigate causes of this shift, and the associated outcomes for individual health and biodiversity conservation. One should explore whether and the extent to which virtual experiences of nature could compensate the loss of direct nature interactions and help safeguard individual health and biodiversity conservation. Finally, monitoring of nature interactions should be complemented with monitoring of the impacts of those interactions on biodiversity, to ensure that the benefits of connecting people with nature for fostering conservation behaviors exceeds the potential direct costs on biodiversity.

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CRediT authorship contribution statement

Agathe Colléony: Data curation; Formal analysis; Investigation; Methodology; Writing – original draft; Writing – review & editing

Ronit Cohen-Seffer: Data curation; Formal analysis; Methodology; Visualization; Writing – review & editing

Assaf Shwartz: Conceptualization; Funding acquisition; Investigation; Methodology; Writing – review & editing; Supervision; Project administration

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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