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Urban development type, biodiversity and the extinction of experience

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ABSTRACT

Humans currently suffer a phenomenon called the extinction of experience by which we are losing interactions with the natural world. This process, particularly worrying in urban areas and rapidly expanding, is mainly due to the lack of orientation towards nature (i.e. connection with nature) and the lack of opportunities to experience it. Urban areas vary along a gradient from compact cities with large parks separated from residential areas (land-sparing extreme of the gradient) to sprawled-design with single-family homes and gardens and street vegetation (land-sharing extreme). This gradient and its feature variables are related to differences in biodiversity levels and the way people interact with nature, thus, it is expected that this configuration will influence the extinction of experience of citizens. Our study investigates this important question by integrating sociological data (818 questionnaires) and ecological data (bird diversity) from 9 cities across Europe and carrying out structural equation models. Our results empirically support the extinction of the experience framework. We found that living in land-sparing areas, as well as areas with more green cover and larger green patches, is positively associated with time spent in nature. These findings highlight the importance of large parks in bringing urban dwellers closer to nature. Furthermore, disconnection from nature is favored by other factors such as the lack of childhood experiences or living in biodiversity-poor neighborhoods. Politicians and urban planners should consider these factors to revert the increasingly worrying extinction of experience that entails important conservation consequences.

1. Introduction

We are experiencing an increasing disconnection between humans and nature. This lack of interactions with the natural environment is even more acute in highly developed countries, having severe negative consequences for conservation (Miller, 2005; Soga and Gaston, 2024, 2016). This phenomenon of disconnection, known as the "extinction of experience" is defined as the progressive loss of humans' interactions with nature, and it is suggested to affect more deeply urban dwellers (Gaston and Soga, 2020; Miller, 2005). Urban citizens follow daily routines with minimal direct contact and experiences with nature, which may reduce their ability to enjoy the natural environment and benefit from it (Cox et al., 2017; Liu et al., 2022; Turner et al., 2004). Human-nature interactions impact individuals' willingness to coexist with nature and to actively preserve it, thereby contributing to the conservation of biodiversity (Castillo-Huitrón et al., 2020; Prévot et al.,

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2018; Randler and Koch, 2025; Soga and Gaston, 2024). Therefore, the future seems quite concerning if this phenomenon is not reverted, given that the planet is becoming increasingly urbanized, with over half of the world's population now living in cities (United Nations, 2023). Thus, understanding the phenomenon of the extinction of experience and promoting human connection to nature in order to reverse it is particularly important (Schuttler et al., 2018; Soga and Gaston, 2024, 2016).

However, the study of the extinction of experience is complex, as it encompasses a series of cause-effect relationships between multiple variables gathered in a theoretical framework (Colléony et al., 2020; Gaston and Soga, 2020). The extinction of experience cannot be measured or estimated with a single variable, and it is mainly based on the experiences of people in nature. There are multiple ways of measuring the experiences in nature which are usually based on the duration and frequency of visits to natural areas even though some authors like Colléony et al. (2020) points out the need to consider also the frequency of practicing outdoor activities as a proxy of the quality of the visits. These experiences in nature and, in fact the extinction of the experience, could be mainly caused by a loss of orientation towards nature and the lack of opportunities to engage with it (Colléony et al., 2020; Nisbet et al., 2009; Soga and Gaston, 2016). Regarding the loss of orientation, measured as the connection of individuals to nature (Nisbet et al., 2009; Soga and Gaston, 2016), it is known to directly affect the experiences we have in nature (both number of experiences and quality). Furthermore, Soga and Gaston (2016) in their theoretical framework indicated the possible existence of a feedback loop in which natural activities affect self-orientation towards nature (connection with nature). In contrast, the lack of opportunities to experience nature normally depends on the access to experience it (Colléony et al., 2020; Soga and Gaston, 2016) or the presence/abundance of natural elements (e.g. wildlife) in the environment (Soga and Gaston, 2020). Other factors such as the experiences in nature during childhood also play a role in this context by shaping the adulthood orientation towards nature and the election of a more natural place to live in (Colléony et al., 2020; Soga and Gaston, 2016; Thompson et al., 2007). Interestingly, these three components (i.e. orientation, opportunity and experiences in nature) are shaped also by socio-demographic factors such as gender, age or income (Awoyemi et al., 2024; Cox et al., 2017; Lin et al., 2014; Oh et al., 2021), showing that we need comprehensive approaches to investigate this topic.

Urbanization is one of the most widespread and intense forms of environmental change, presenting a significant threat to biodiversity and shaping important changes in community composition (Fragkias et al., 2013; Ibáñez-Álamo et al., 2017; Piano et al., 2020; but see Møller and Díaz, 2018). This important biodiversity loss, added to the fact that urban dwellers have less nature around them, might considerably reduce their opportunities to experience nature (Cox et al., 2018b; Cox and Gaston, 2018; Miller, 2005; Soga and Gaston, 2016). Therefore, studying how urbanization and its consequent loss of biodiversity affect the extinction of experience is vital to understand its drivers and to be able to develop more efficient conservation plans.

Nevertheless, cities are heterogeneous, and the opportunities to experience nature and how people interact with it vary depending on where they live. The place of living is an important factor in the interactions between people and nature (Cox et al., 2017; Shanahan et al., 2014). In this context, the way cities are developed (urban development type) could range it in a gradient between two extremes depending on how clumped the landscape elements are (i.e. buildings and green spaces). Both extremes of the urban development gradient differ related to the availability of nature around citizen's homes and their opportunity to experience nature (Shanahan et al., 2017; Soga et al., 2014). On one extreme of the gradient, we will find land-sharing urban areas (typical from city sprawl) that are mainly characterized by low-density housing (e.g. family houses), low population density and small and fragmented green patches (e.g. backyards or street vegetation). The characteristics of these areas provide instant access to green spaces, enhancing the opportunities to experience nature (Shanahan et al., 2014; Soga et al., 2015). On the other extreme, we will find land-sparing urban areas (clumpy and aggregated areas) having high-density housing, high population density and large green patches (e.g. parks) separated from buildings (Lin and Fuller, 2013). The presence of these large green areas could increase the number of outdoor activities (Rey-Gozalo et al., 2019; Sarı and Bayraktar, 2023; Wang et al., 2019), although most inhabitants will be far from these vegetated areas reducing the opportunities to connect with nature (Cox et al., 2017). Furthermore, urban development type is also related to changes in biodiversity levels and community composition (Youngsteadt et al., 2023). For example, in the case of birds, a multi-city study in Europe found that land-sharing areas are related to higher taxonomic biodiversity levels (Ibáñez-Álamo et al., 2020). According to the theoretical framework of extinction of experience, the lack of opportunities results from not only limited access to natural areas, but also from a decline in the quality of natural areas and the quality in the expose to nature, often by an impoverishment of local flora and fauna (Cox and Gaston, 2018; Schuttler et al., 2018; Soga and Gaston, 2016). Thus, changes in community composition such as those that occur along the urban development type gradient will create different opportunities to enjoy nature, potentially affecting human-nature interactions (Soga and Gaston, 2020). Moreover, people living in high-diverse areas might have positive perceptions about nature (Cox et al., 2018a; Cox and Gaston, 2018), increasing their attitudes towards nature (Carrus et al., 2015; Härtel et al., 2024; Marselle et al., 2021), such as spending more time in nature or practicing more outdoor activities.

But despite its relevance, only a few studies have examined how people interact with nature across urban development gradients, showing contrasting results. While Shanahan et al. (2017) did not find differences between the time spent in nature and urban development type, Soga et al. (2015) found that people living in land-sharing urban areas use urban green spaces more frequently. Conversely, Sushinsky et al. (2017) found that, in a compact city scenario, people living in land-sparing areas will have higher levels of connection with nature. These pioneering studies are very interesting and helped us to better comprehend the extinction of experience. However, these three studies are geographically restricted (i.e. single city studies) and used a restricted approach (e.g. few variables) to investigate the topic. Thus, a broader empirical approach considering multiple cities and additional variables is needed to obtain more general conclusions about how landscape configuration influences this phenomenon.

In this study, we used a holistic approach using sociological (e.g. questionnaires) and ecological data (e.g. bird diversity, green space configuration) from multiple European cities to examine how the elements interact within the extinction of experience framework. Specifically, we tested how childhood experiences, orientation towards nature and several variables related to differences in opportunities to experience nature (i.e. urban development type gradient, urban feature variables and biodiversity levels) interact among them within the extinction of experience framework, as well as with some socio-demographic variables. To do so, we used a double methodological (non-exclusive) approximation:

First, we investigated whether urban development type gradient influences citizens' extinction of nature experience. Based on previous studies (see above), we predict that people living in the extreme of land-sharing urban areas will have more experiences with nature (both frequency and quality of activities in nature) and more connection with nature (due to the positive feedback loop), ultimately reducing its levels of extinction of experience. This knowledge will be crucial to understand how this gradient affects the way people interact with nature and would allow us to compare our findings with those of previous studies.

Second, we directly explored which urban feature variables (e.g. urban greenspace aggregation) are associated with changes in the citizens' extinction of experience. These variables are related to the amount of greenness, the availability of large vegetated areas and the availability of integrated vegetation around houses. According to several studies (Rey-Gozalo et al., 2019; Sarı and Bayraktar, 2023; Wang et al., 2019), we will predict that people living in urban areas with more vegetation (e.g. large parks) will increase the frequency of outdoor activities. In addition, citizens living in urban areas with more integrated vegetation (e.g. more street vegetation) will be associated with people having more experiences in nature (i.e. time spent in nature) (Shanahan et al., 2017; Soga et al., 2015). This complementary and detailed approach will help understand the mechanisms underlying the differences in human-nature interactions within the urban areas. Additionally, this second methodological approach will provide clear recommendations for city planners and practitioners to promote direct actions to revert the extinction of experience in their cities.

Simultaneously, we investigated if biodiversity levels around houses could affect citizen's extinction of experience. Biodiversity levels could influence by themselves by modifying the opportunity to experience nature (Cox and Gaston, 2018; Soga and Gaston, 2020). Thus, we predict that higher biodiverse areas can offer more opportunities to experience nature. We used birds to evaluate this effect because, in the urban context, encounters with birds are more common than with other taxa (Cox and Gaston, 2018), favoring human biophilia and citizens' engagement with nature (Cox and Gaston, 2015; Soga et al., 2016b). Also, because birds are positively perceived by people as providers of multiple ecosystem services, increasing citizen's well-being (Belaire et al., 2015; Methorst et al., 2021; Wenny et al., 2011).

2. Methods

2.1. Study area

We collected bird data and conducted sociological surveys in land-sharing and land-sparing areas in nine European cities, from the north of Finland to the south of Spain (i.e. Rovaniemi, Turku, Poznan, Prague, Munich, Groningen, Madrid, Toledo and Granada; Fig. 1). In each city, we selected ten 500 m × 500 m squares to carry out both sociological surveys and bird censuses. Squares were separated by a mean of 570 ± 65 SD m to ensure their independence in terms of bird communities. We used the index developed by Ibáñez-Álamo et al. (2020) to assign each square a value within the urban development gradient that goes from fully land-sharing urban areas to fully land-sparing urban areas. We used this index in all subsequent statistical analyses (see below). The calculation of the index implied the following steps. First, we divided each square into 100 cells of 50 × 50 m each and used satellite images to evaluate the percentage of green and built surface for each cell (to the nearest 10 %). Second, we used this information to calculate the following urban feature variables for each 500 m × 500 m square: (1) percentage of high vegetation cells (those with >50 % green area) in a single patch, (2) number of green patches, (3) percentage of built cells of all vegetated cells, (4) percentage of only vegetated cells of all vegetated cells, and (5) number of cells with vegetated surfaces. Third, we used these five variables to conduct a Principal Component Analysis (PCA) and extracted the first principal component (PC1) as the numerical value for the index. Negative values of the index indicate that the square generally fall within the land-sharing configuration while positive values correspond to a land-sparing urban organization. Because the level of urbanization could affect socio-ecological variables (e.g. Cox et al., 2018b; Shanahan et al., 2017), we confirmed that the squares did not differ in their urbanization level, by calculating a frequently used urbanization index (Liker et al., 2008). For further details about the squares selection procedure, please see (Ibáñez-Álamo et al., 2020).

Fig. 1. Map of the location of the study site with the nine cities surveyed for this study.

2.2. Bird surveys and biodiversity variable

In each square, we carried out bird surveys in 6–7 point count stations randomly distributed across the squares during the breeding season 2016 (April–June) and the wintering season of 2016–2017 (December–February). We surveyed birds two times per season in each survey station, and we used these point counts (separated by a month) to capture possible differences within the season (e.g., due to early and late breeders or migrants). We used a fixed-radius (50 m) census method, and we counted all the birds detected by sight or sound within 5 min of sampling (Bibby et al., 1992; Voříšek et al., 2008). We excluded over-flying birds not landed within the survey circle. Distance between point counts are separated by at least 100 m to minimize the possibility of counting the bird twice. We used the observed bird species richness (number of bird species detected; BSR) as an estimate of the bird diversity. We estimate this measure pooling the data of both seasons and estimate the overall number of species per point count. We removed bird species considered as ecosystem disservices providers from this pool of species because they do not contribute to increase the positive perceptions towards birds (McGinlay et al., 2018) and, consequently, probably do not promote spending more time spent in nature or carry out more outdoor activities. We identified the species to be removed by using the list of disservice providers from (Cox et al., 2018a) which presents this information for a representative group of European bird species (including all the species used in our analyses). Finally, we calculated the BSR for each square as the average of all the point-counts.

2.3. Questionnaire design

We surveyed people living in the same areas from which bird diversity data was collected to evaluate their levels of extinction of experience. In each square, we conducted face-to-face surveys (818 in total; average of 91 ± 15.6 SD per city; see Table S1 for more information about the specific number of questionnaires per city) between April and August 2022. We surveyed adults (≥ 18 years old) by approaching them randomly in the squares and inviting them to voluntarily participate in the study. We only surveyed people who lived within each square (at least one month) to capture the influence of the place of living in connection with nature. In five squares (out of the total 90) where it was impossible to survey inhabitants because no people were living there (e.g. industrial area), we surveyed citizens living in the closest inhabited area (average distance from the edge of squares of 219 ± 98 SD m). These nearby surveyed areas were always of the same urban development type (land-sharing or land-sparing). To have a good representation of each city's society, we collected data from a wide range of age, educational levels and gender (see Table S1 for more information about the percentage of people surveyed for each category).

The questionnaire was available in 7 languages (Spanish, Dutch, German, Polish, Czech and Finnish) corresponding to the main languages of each study country, and also in English, taking 10–15 min to be completed. The questionnaire was designed based on other previous validated studies on the topic (e.g. Soga and Akasaka, 2019; Colléony et al., 2020; Ishibashi et al., 2020). We used LimeSurvey software (Limesurvey GmbH, 2025) for carrying out the questionnaires.

The questions tried to capture information about four aspects of the extinction of the experience framework to compute a structural equation model: (1) childhood experiences with nature, (2) nature orientation, (3) opportunities to experience nature, (4) adulthood experiences with nature and (5) other socio-demographic factors. Except for the urban feature variables used for opportunities to experience nature, we measured all these aspects using a compilation of questions. Thus, when possible, and to reduce the number of variables, we merged them into a single variable following two approaches. First, if the pool of questions had the same structure and domain, we averaged the scores. In these cases, to confirm the reliability and the internal consistency of the constructs, we used the Cronbach's alpha index (i.e. high consistency values are always above 0.7), although values between 0.5 and 0.7 are considered as acceptable for merging the items according to Taber (2018). Secondly, if it was not possible, we calculate them as latent constructs in the posterior SEM.

2.3.1. Childhood experiences with nature

To capture information about childhood experiences with nature, we created a latent variable by using three variables: the frequency of visits to natural places during childhood, the place of living, and the presence/absence of a garden during childhood.

The frequency of visits to natural places during childhood was based on Ishibashi et al. (2020), and consisted in a 5-Likert scale question asking about the frequency of visits to green spaces (e.g. parks, forests, natural areas, gardens). The place of living was based on Soga and Akasaka (2019), and we asked how natural the place of living was during childhood and the options were: urban, suburban or rural. The presence/absence of a garden during childhood was extracted from Colléony et al. (2020) and we asked whether the participant had access to a private garden or not during childhood.

2.3.2. Nature orientation

To measure orientation towards nature, we employed the commonly used Nature Relatedness Scale designed by Nisbet et al. (2009) to capture the levels of connection of people to nature. We chose the extended scale consisting of 21 questions (NR-21) instead of the reduced one (NR-6) to have a more detailed representation of the natural relatedness of the individual. We created the variable orientation to nature by averaging the scale's scores (Cronbach's alpha = 0.83).

2.3.3. Opportunities to experience nature

We used a complementary approach to measure the opportunities of citizens to experience nature. First, we directly asked in the questionnaire if the person interviewed has a garden. This variable has been previously linked to increased probability to interact with nature (de Bell et al., 2020; Oh et al., 2022). Second, we tested the potential effect of urban development type on the extinction of experience as it can potentially affect the opportunity component (see introduction). To do so, we used the variable urban development type index in our analyses (see above), which indicates the level of sparingness/sharingness of each square where people live.

Third, we focused on investigating the potential effect of specific urban feature variables on the extinction of experience. These five variables, used also to calculate the urban development index (see above), were highly correlated (Table S6). Based on this information and the theoretical framework, we decided to use only three of them: (1) percentage of high vegetation cells in a single patch (i.e. more vegetation in a single patch) potentially indicating the presence of large parks or gardens in the square; (2) percentage of built cells of all vegetated cells indicating how integrated are natural and artificial structures in the square; and (3) number of cells with vegetated surfaces that is a proxy the greenness of the square. All of these variables have been previously associated with experiences in nature (e.g. Cox et al., 2017; Rey-Gozalo et al., 2019; Shanahan et al., 2017).

2.3.4. Experiences with nature (time in nature)

We estimated the variable time in nature based on the bibliography (Colléony et al., 2020) as a latent variable from the posterior SEM using two variables: frequency of visits to nature and time spent in nature. Both variables were estimated also using a pool of questions asking about the frequency and the time spent on six different types of green spaces (i.e. Lake/River/Sea, Urban green spaces, Forest/Picnic area, Agricultural area, Nature reserve/National Park and Private garden). By doing so, we collected as much information as possible about different types of experiences in nature and then we averaged the scores. The reliability was moderate for both time spent in nature (Cronbach's alpha = 0.60) and frequency of visits (Cronbach's alpha = 0.61), so we averaged the scores.

2.3.5. Experiences with nature (outdoor activities in nature)

We estimated activities in nature using nine questions about how frequently the respondent practiced activities related to natural places (e.g., listening to birds, feeding animals, observing or smelling flowers, picnics, bathing). These questions were based on Colléony et al. (2020). The reliability inter-item was moderate (Cronbach's alpha = 0.65), thus, it allows us to average the scores (Taber, 2018).

2.3.6. Socio-demographic questions

Finally, we included questions to obtain some socio-demographic information such as age, gender, educational level or income to control for possible effects of these variables in the extinction of experience framework (Awoyemi et al., 2024; Cox et al., 2017; Lin et al., 2014; Oh et al., 2021). Gender refers to the self-identification of gender and, during the questionnaire, we asked the options "woman", "man" and an open option for adding other genders. We pooled all the open options into a new category "other" to facilitate the statistical analysis. Also, regarding the educational level, we adjusted the level in each country to standardize them using a scale from 1 to 8. We also asked for the income by using ranges adjusted to the values per country, and we used a scale from 1 to 5 to standardize all the values.

2.4. Analytical framework

We used Structural Equation Modelling (SEM) for statistical analyses to obtain an integrative view of the complex relationships among all variables (Thakkar, 2020). This methodological approach is ideal as it allows understanding causal relationships quantifying direct and indirect effects (Thakkar, 2020). We designed eight possible theoretical frameworks for the extinction of experience based on literature, and we tested them (Fig. 2). All the models were mainly based on Colléony et al. (2020) and Soga and Gaston (2016). We used urban development type/urban feature variables, the presence of a garden and biodiversity levels (bird species richness) as measures of opportunities to experience nature. In a first set of models, we included urban development type gradient while, in a second set of models (using the same theoretical design) we included our three urban feature variables instead of the index to obtain direct information on the landscape features that better influence the extinction of experience. Also, in all models we included connection to nature as a measure of orientation towards nature. Both opportunities and orientation affect the experiences in nature (i.e. time spent in nature and frequency of outdoor activities). We separated in the analyses these two variables contrary to Colléony et al. (2020). Also, we

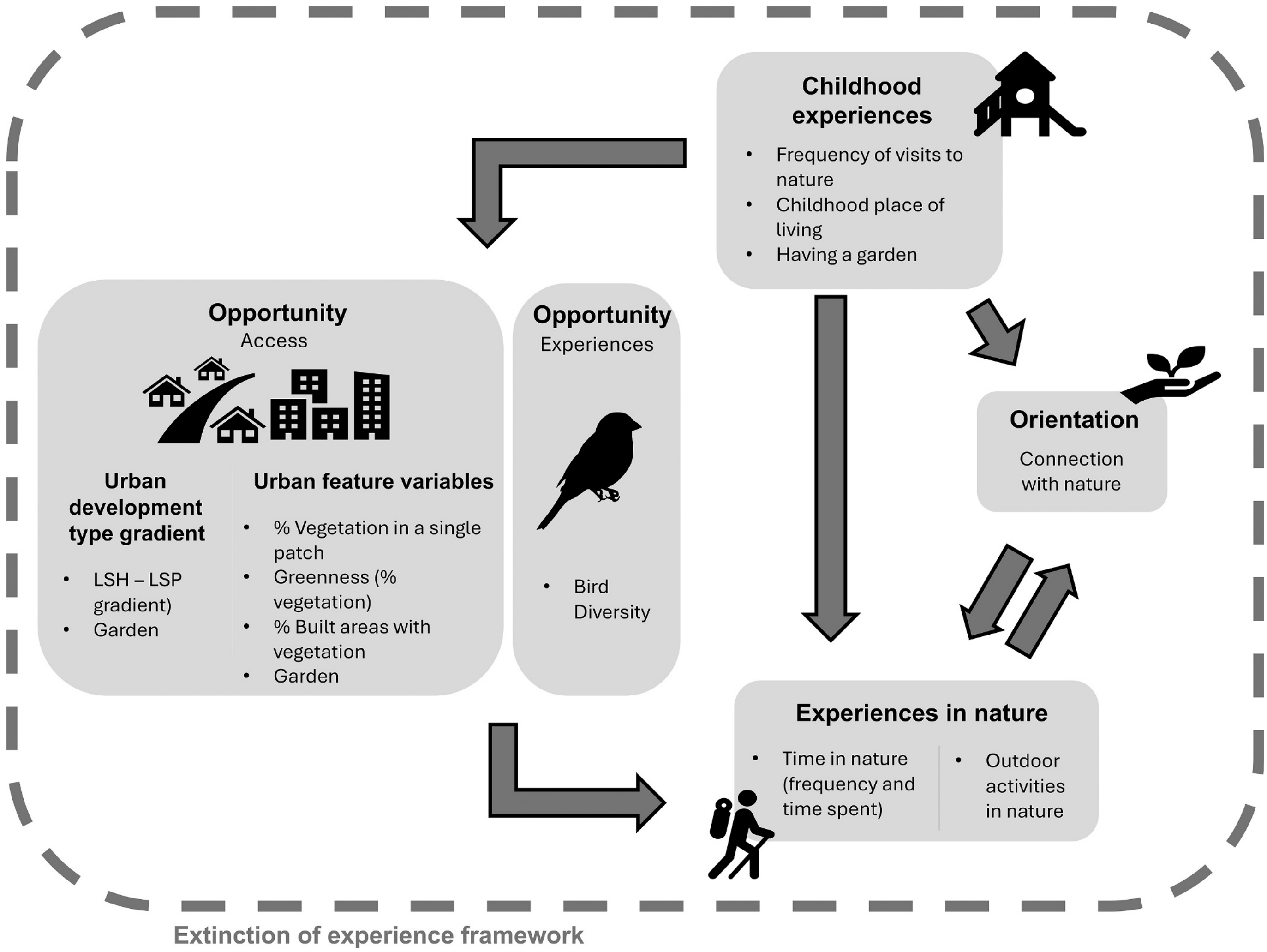

Fig. 2. Conceptual framework of the study that reflects the extinction of experience framework (in the grey square) in which experiences in nature (i.e. time spent in nature and the frequency of outdoor activities) is the result of the opportunity to experience nature (i.e. urban development type gradient/urban features and the access to a private garden) and the nature orientation (i.e. connection with nature). Childhood experiences with nature also affect the way people experience nature. The framework includes bird diversity levels that can alters people's experiences with nature.

included childhood experiences affecting urban development type/ feature variables, garden and orientation towards nature (Colléony et al., 2020), and in some of the models, we also included a direct effect of childhood experiences on adulthood experiences in nature (Soga and Gaston, 2016; Thompson et al., 2007). In some of the models, we also included the feedback loop between nature contact (time and activities) with orientation towards nature (Soga and Gaston, 2016) (refer to Fig. S1 and Table S5 for more details). We added the effect of urban development type on BSR due to the differences in bird community composition found in a previous study (Ibáñez-Álamo et al., 2020).

2.5. Statistical analysis

Before the analysis, due to the high number of missing values of the income variable, we carried out a multiple imputation of data using the 'mice' package (van Buuren and Groothuis-Oudshoorn, 2011). This allowed us to create a new dataset estimating the missing values and then use it in the SEM. This procedure is a more appropriate method than other alternatives, especially when dealing with categorical data (Enders, 2023). Missing values were imputed 15 times (because the missing data corresponded to 15 % of values) by using the "polr" method for ordinal variables. Additionally, due to gender variable has three categories, we created two dummy variables that allowed us to better analyze the data in the SEM without missing the data of all the categories.

We used Diagonally Weighted Least Squares (DWLS) as the estimator because most of the variables were ordinal, meaning no AIC was provided in the analysis. To assess the robustness of the model, we used several estimators that indicate the goodness of fit (Hu and Bentler, 1999): (1) the comparative fit index (CFI), (2) root mean square error of approximation (RMSEA), and (3) standardized root mean square residual (SRMR). The standard significance level was set to $p < 0.05$. To select the best model, we tested the eight theoretical models developed based on the literature. We chose the model with the best fit according to the different estimators. All the SEM analyses were conducted using the 'lavaan' package (Rosseel, 2012). Lastly, we verified the assumptions, including multicollinearity (VIF), by extracting running linear models using the same pool of variables as in the model and the vif function. No variable was excluded due to low VIF values (all values < 1.2).

3. Results

Our data includes the results of 818 interviews, with 55.6 % of respondents being women, 43.6 % men and 0.8 % other gender. The average age of respondent was 41.3 years (men: 41.5; women: 41.2). See Table S1 for more socio-demographic details about the respondents.

3.1. Urban development type gradient

Regarding the SEM analysis including urban development type gradient, we chose the one that has higher goodness of fit (Model 8: Fig. S1) between the eight theoretical models according to the different estimators ($\chi 2 = 140.35$, df = 51, CFI = 0.93, RMSEA = 0.05, SRMR = 0.02; table S5).

In relation to the opportunities to experience nature, the variable urban development type is positively affected by childhood experiences with nature and income. This implies that people who had more experiences with nature during childhood and currently have higher incomes inhabit urban areas that are more often classified towards the land-sparing end of the gradient (Fig. 3). Regarding BSR, it is affected by urban development type showing that more land-sharing urban areas have higher bird species richness (Fig. 3).

This model also showed that nature orientation (connection with nature) is positively affected both by childhood experiences and performing more outdoor activities (Fig. 3). Moreover, the time people spend in nature was also positively affected by orientation towards nature and urban development type (i.e. people living in more land-sparing urban areas spend more time in nature; Fig. 3). Additionally, this latent variable was also negatively affected by age (i.e. older people spend less time in nature) and positively by income. Finally, the variable frequency of outdoor activities is positively affected by BSR and gender (i.e. women practice more outdoor activities than other genders). Detailed statistical information about the results of the SEM is available in Tables S3 and S4.

3.2. Urban feature variables

Out of our second set of analyses, those including feature variables instead of the gradient, model 8 was also the best fit ($\chi 2 = 174.81$, df = 69, CFI = 0.93, RMSEA = 0.04, SRMR = 0.03; Table S9).

Results from this model show that two feature variables (i.e. greenness and vegetation in a single patch) are positively associated with childhood experiences with nature and income. The variable having a garden is also positively affected by childhood experiences but not by income (Fig. 4). BSR was positively influenced by greenness and negatively by vegetation in a single patch and green-buildings integration (Fig. 4).

Orientation towards nature was significantly and positively affected by childhood experiences and by the frequency of outdoor activities, while it was negatively affected by the time spent in nature. Additionally, time spent in nature was significantly associated to age (negatively), orientation towards nature (positively) and two feature variables (positively; i.e. vegetation in a single patch and greenness). Finally, the frequency of outdoor activities was significantly and positively affected by BSR, but negatively associated with greenness and gender (i.e. women practice more outdoor activities than other genders). For more detailed statistical information on these SEMs check Tables S7 and S8.

Finally, due to our SEM analysis does not capture the possible differences between cities and, regarding its importance, we also included graphical results of the different variables depending on the city (Fig. S2). Connection with nature and outdoor activities practically does not vary between the nine cities. Conversely, there are visual differences in the frequency of visits and the time spent in nature.

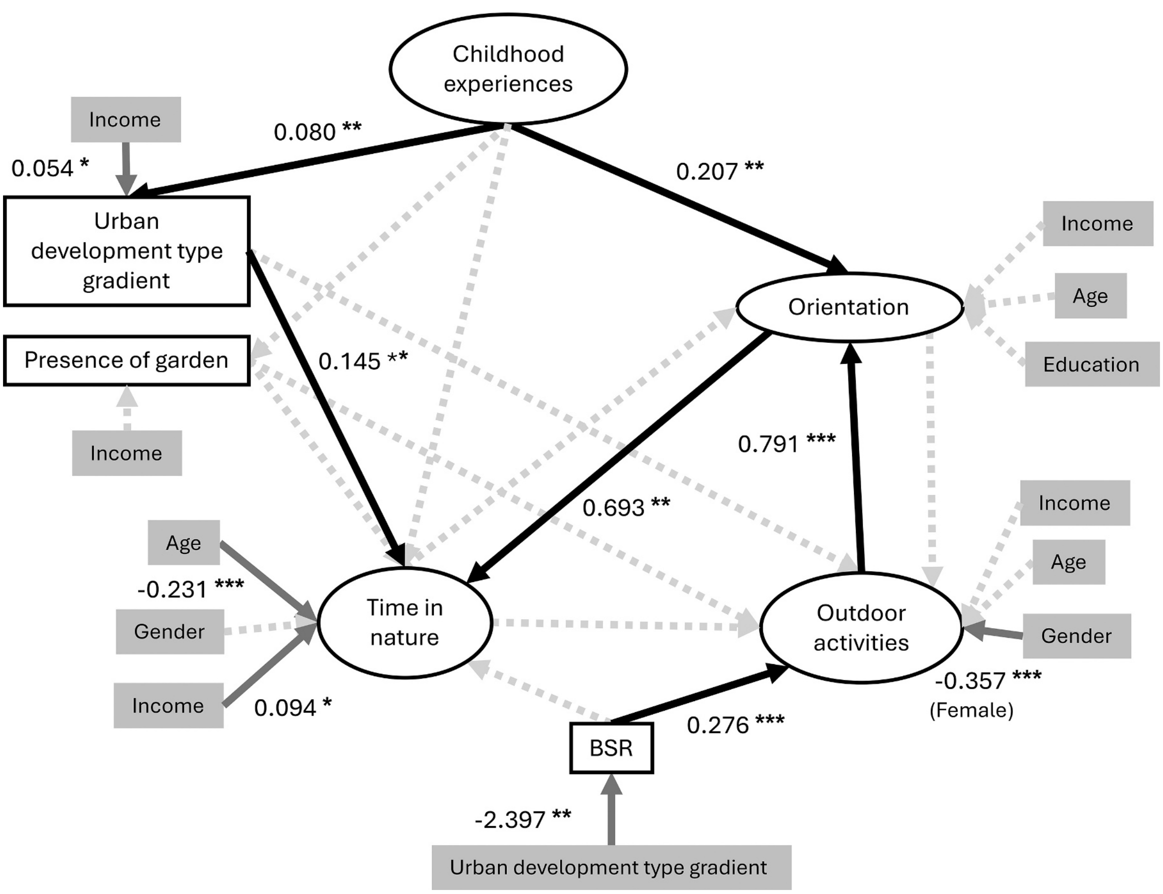

Fig. 3. Result of the final SEM selected for testing the effect of the urban development type gradient. Latent variables are represented in a circle, while observed variables are indicated in a rectangle. Black arrows represent significant relationships. Grey arrows represent significant variables as covariates. Dashed arrows represent the non-significant relationship between the variables. Standardized path coefficient estimates and levels of significance (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

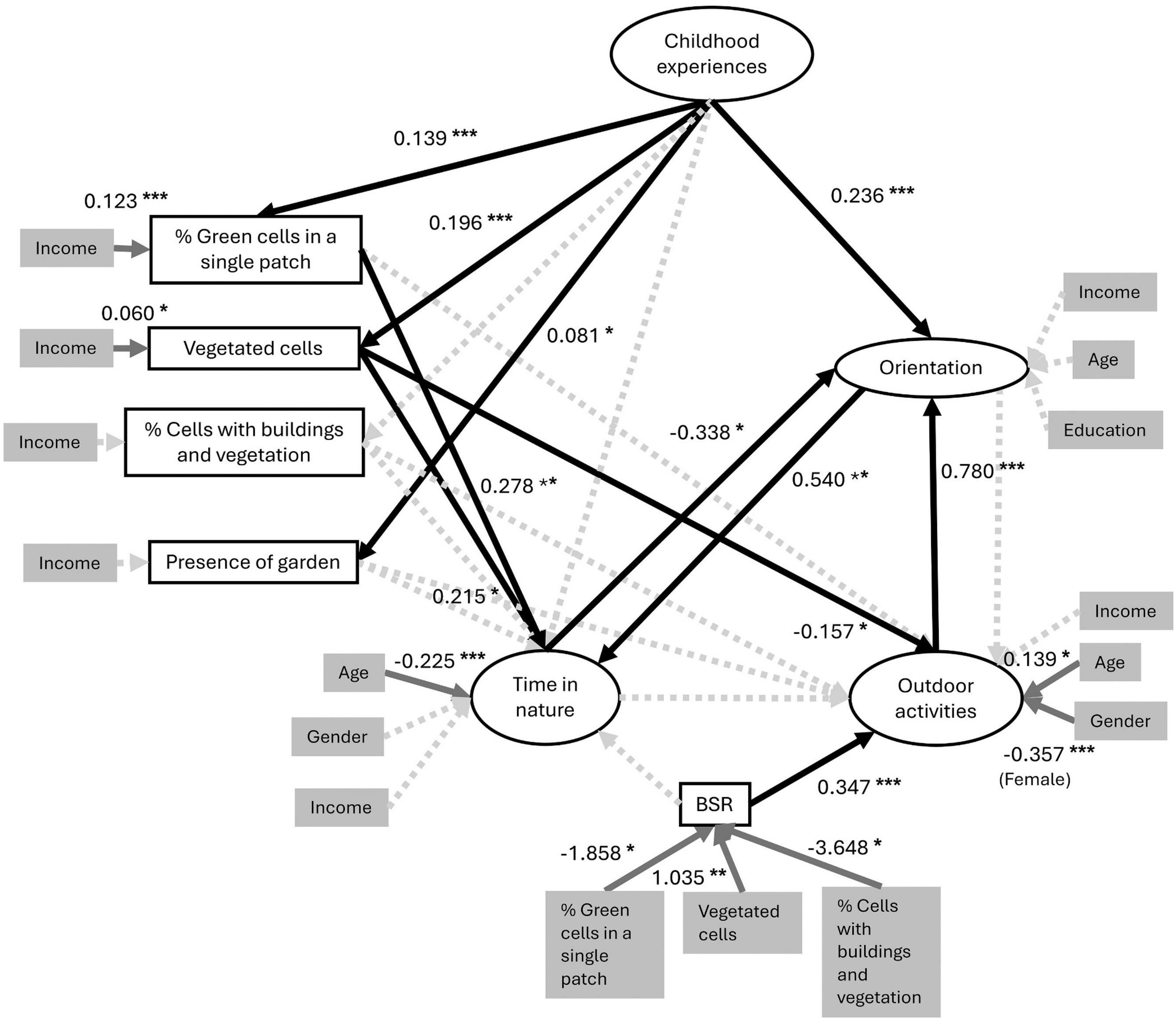

Fig. 4. Result of the final SEM selected for testing the effect of specific urban features. Latent variables are represented in a circle, while observed variables are indicated in a rectangle. Black arrows represent significant relationships. Grey arrows represent significant variables as covariates. Dashed arrows represent the non-significant relationship between the variables. Standardized path coefficient estimates and levels of significance (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).

4. Discussion

Our empirical study provides new insights on the processes underlying the progressive loss of connection and attitudes towards nature currently happening in urban areas, also known as the extinction of experience. Our findings indicate that the interactions between urban dwellers and nature are complex and multifactorial, generally supporting the theoretical approach of the extinction of experience framework at the European level (Colléony et al., 2020; Soga and Gaston, 2016).

4.1. Orientation towards nature

Regarding the first main cause of people's extinction of experience (i.e. orientation towards nature), we found that it is mainly affected by the experiences in nature during childhood. This result agrees with multiple studies on the topic, highlighting the necessity to enhance children's experiences with nature as a key tool for reversing the extinction of experience phenomenon (Aota and Soga, 2024; Colléony et al., 2020; Rosa et al., 2018; Schuttler et al., 2018; Soga and Gaston, 2016). Also, according to the extinction of experience framework and in agreement with previous studies, our results also show that people's orientation towards nature directly affects the time spent in nature (Colléony et al., 2020; Lin et al., 2014; Shanahan et al., 2017; Soga and Gaston, 2016). However, contrary to our expectations and the extinction of the experience framework (Colléony et al., 2020; Soga et al., 2016b), we did not find any significant association between the connection with nature or the time spent in nature with the type of outdoor activities. One possibility is that people spend time in nature for other purposes not included in our questionnaire regarding outdoor activities (e.g. chilling or relaxation) (Zwierzchowska et al., 2018). Another non-exclusive reason is that, despite people's connection with nature, urban dwellers do not have enough time to practice some outdoor activities (e.g. camping in natural places) because of the generalized tight schedules (Awoyemi et al., 2024; Boyd et al., 2018). Thus, in contrast to Colléony et al. (2020) who treated time spent in nature and the frequency of outdoor activities as only one item, our study reflects the importance of including both as separated terms due to the differences in the interaction between variables (see above). Lastly, our results support the feedback loop found by other studies. We found that the frequency of nature activities positively affect people's orientation towards, which agree with previous studies on the topic (Scott et al., 2014; Szczytko et al., 2020). However, our analyses revealed that time spent in nature and connection with nature are negatively associated. This result was unexpected and contrasts with previous published literature (Hatty et al., 2022; Scott et al., 2014). A potential explanation is that only the amount of time spent in nature may not be sufficient to strengthen people's connection to it. Instead, the emotional connections lead by those experiences could play a more decisive role (Soga et al., 2016a). Thus, even if individuals spend considerable time in natural environments, such interactions might lack the emotional connection necessary to foster a stronger bond with nature.

4.2. Opportunities in nature

Urban development type gradient could affect extinction of experience variables by affecting the opportunities to experience nature. This is partially supported by our results that show significant effects on the time spent in nature but not outdoor activities. People living in urban areas towards the land-sparing side of the gradient spend more time in natural places. This highlights the importance of (large) urban green spaces for connecting people with nature through increasing the time on it. The result contrasts with a previous study that did not find differences between urban development types (Shanahan et al., 2017), or another finding that land-sharing dwellers visit more frequently natural environments (Soga et al., 2015). One possible explanation for this discrepancy is that differences in opportunities to experience nature between urban development types could be due to other factors linked to the differences in urban sprawl (e.g. socio-economic differences) (Sushinsky et al., 2017). It could be possible that land-sparing urban areas in Europe are placed in less deprived areas that are known to provide easier access to nature, for example, by including large parks (Shanahan et al., 2014; Sushinsky et al., 2017). These less deprived areas are normally related to a larger amount of green cover around the home (Shanahan et al., 2014, 2017; Sushinsky et al., 2017) or the proximity to green spaces that allow them to spend time in nature (e.g. parks or gardens) (Shanahan et al., 2017; Soga et al., 2015). This explanation matches also our findings regarding urban features variables (i.e. spending more time in nature is affected by the amount of greenness of the urban area as well as the proportion of vegetation in a single patch). Also, it is aligned with the positive association between urban development type/landscape features and income.

These differences in deprivation and green access along the urban development type gradient and landscape feature variables could also explain the relationship observed between these opportunities in nature with childhood experiences. We found that having more experiences in nature during childhood is positively related to living in land-sparing areas, as well as living in more green areas with larger green patches and having a garden. These results agree with the theoretical framework as people who experienced nature more frequently during childhood will choose to live in more natural places (Colléony et al., 2020).

However, it is important to highlight that we found that practicing more outdoor activities is negatively affected by living in more vegetated urban areas. Previous studies found that citizens living in such areas have increased opportunities to experience nature (Cox et al., 2017), although this does not necessarily imply increased possibilities to practice outdoor activities (e.g. due to the lack of large, vegetated areas or many private lands with reduced accessibility options). Urban planners should design urban areas that ensure the proximity of (accessible) urban parks to citizens. Several possibilities for achieving it could be the new concepts of urban design and urban planning on how to develop more sustainable cities (e.g. 15-minute cities or the rule of 3–30–300 for easy access to public green areas; Moreno et al., 2021; Browning et al., 2024).

Our findings also support the idea that the opportunities to experience nature depend on other natural factors, such as biodiversity levels (Sushinsky et al., 2017). We found that people living in neighborhoods with higher bird diversity levels practice more outdoor activities. Birds are directly linked to several outdoor activities such as birdwatching or bird feeding that help to promote a higher connection with nature, increased willingness to preserve nature as well as enhanced human well-being and health (Cox and Gaston, 2016; Sekercioglu, 2002; Sekercioglu et al., 2016). In contrast, low-biodiversity neighborhoods offer fewer wildlife interactions, potentially reducing nature affinity and conservation engagement (Ngo et al., 2022; Soga and Gaston, 2020; Zhang et al., 2014). It is important to highlight that the perceived biodiversity could have a more important role in nature connectiveness than the real values of species richness (Dallimer et al., 2012; Shwartz et al., 2014). Thus, future studies should address these relationships. Our analyses also confirmed the positive association between BSR and urban development type indicating that urban areas that are more towards the land-sharing extreme of the gradient hold higher bird diversity levels, which agrees with (Ibáñez-Álamo et al., 2020). This was expected considering that both studies used the same database although different methodological approximations (e.g. we used here a SEM method or a gradient approach for evaluating the urban development type effect while Ibáñez-Álamo et al. (2020) used generalized linear models and a dichotomous approach). Overall, this matching in results provides consistency to our findings. Regarding BSR and urban features, we found that bird diversity was higher in areas with more vegetation, which agrees with multiple studies on the topic (Beninde et al., 2015; Hughes et al., 2022; Morelli et al., 2021). In contrast, our analysis revealed that BSR levels are negatively associated with big green patches and a higher green-buildings integration. The former result could be explained by the fact that urban areas holding big green patches also hold large extensions of land densely covered by built surfaces, which ultimately will determine (an important reduction in) the total bird diversity of the square (Morelli et al., 2021; Palacio et al., 2018; Sushinsky et al., 2013; Tratalos et al., 2007). The later result could be related to higher levels of habitat fragmentation and human disturbances that can reduce biodiversity (Beninde et al., 2015; Leveau et al., 2019; Sushinsky et al., 2013; Zhu et al., 2024). Therefore, city planners and urban practitioners should consider including as much greenspace as possible and use an intermediate design that will guarantee higher bird diversity levels, enhancing positive human-nature interactions of its inhabitants.

4.3. Sociodemographic factors

Finally, it is also important to highlight that other socio-demographic factors influence variables directly associated with the extinction of experience phenomenon. Firstly, and in agreement with Oh et al. (2021), we found that older people spend less time in natural places. This is so even though we found that they practice outdoor activities more frequently, compensating for the possible lack of time in nature. It is possible that the availability or accessibility to green spaces in European cities is insufficient to enjoy nature for certain age groups as some studies suggested (Biernacka et al., 2022). Thus, promoting indirect experiences with nature (i.e. street vegetation) and facilitating the accessibility of elderly people to public green spaces in urban areas would enhance their nature experiences, ensuring higher connectiveness towards it (Biernacka et al., 2022; Cox et al., 2017). In addition, time spent in nature is also positively associated with income levels matching other studies that highlight the relevance of socio-economic inequalities in the access to green spaces in the city (Awoyemi et al., 2024; Shanahan et al., 2014). Lastly, in terms of outdoor activities, we found that women practice them more frequently than other gender, which is contrary to previous studies (Godtman Kling et al., 2020; Moore et al., 2008; Rosa et al., 2023). Fear is usually the main reason for this gender bias in the access/use of urban green spaces (Zanon et al., 2013). However, we can speculate that, in our case, women could feel more secure practicing some outdoor activities asked in the pool of questions, or maybe that there are some cultural differences compared to the interviewed people in other studies (e.g. Europe vs Africa). New studies are required to understand gender inequalities in access to urban green spaces and associated recreational outdoor activities.

4.4. Study limitations

Finally, we would like to acknowledge that our study has limitations that should be considered for future studies on the topic. Regarding the measures of biodiversity, our study focuses exclusively on bird richness. Future studies should consider also the interactions between human perceptions, bird richness and species abundances. The mismatch between perceived biodiversity and real measures in the extinction of experience framework seems also an important future research avenue. Additional research on other animal taxa (e.g. insects) would be particularly interesting given the potential differences in human perception (Fukano and Soga, 2021; Soga et al., 2023; Soga and Gaston, 2020). Our study addresses the extinction of experience in Europe trying to find general findings but without explicitly considering differences between countries and cities (but see Fig. S2). New studies exploring these differences within Europe and/or other regions with different socio-economic contexts (e.g. Global South) (Awoyemi et al., 2024; Gaston and Soga, 2020) will be particularly interesting. Finally, although our approach allowed us to capture interactions between people, local biodiversity, and urban form, further studies across different spatial contexts are needed to examine how additional factors (e.g. urban mobility or access to green spaces beyond the residential area) influence human-nature interactions. Such research would help to extrapolate our findings and support urban planners in designing more nature-inclusive urban environments.

5. Conclusions

Our study provides an integrative (direct and indirect factors), empirical and large-scale (multicity) approach to evaluate the extinction of experience theoretical framework in Europe. Regarding the first component of the extinction of experience (i.e. lack of orientation), we found important direct factors influencing it, highlighting childhood experiences with nature. Therefore, conservation plans need to focus on kids' education through environmental education campaigns to encourage them to practice more activities in nature (Liefländer et al., 2013; Schuttler et al., 2018; Soga and Gaston, 2016), increasing their affinity to nature (Savolainen, 2021).

Regarding the lack of opportunity, we found that the more an urban area is organized as land-sparing the more likely citizens will access to nature facilitating a higher expenditure of time in it. In our exploration of the specific urban features promoting such association, we found that greenspace and size of green patches are the two main factors explaining it. Additionally, our results support the importance of living in a biodiversity-rich environment (also in urban areas) to increase the opportunities to experience nature, improving also nature connectiveness (at least regarding birds). All this information would help city planners and urban practitioners to carry out actions to reduce the extinction of experience among citizens by increasing their opportunities to interact with nature in urban environments.

Finally, our results showed that experiences in nature differ according to certain sociodemographic factors (e.g., income and gender), suggesting potential biases in access to nature and the need for targeted actions to address them.

Fighting against the extinction of experience is important considering that this process negatively affects urban dwellers' well-being and health (Colléony et al., 2020; Soga and Gaston, 2016) as well as their pro-environmental behaviours and the willingness to conserve biodiversity among citizens (Castillo-Huitrón et al., 2020; Prévot et al., 2018; Soga and Gaston, 2024). Understanding this change will certainly help in protecting biodiversity within and outside urban areas (Díaz et al., 2022).

CRediT authorship contribution statement

Lucía Izquierdo: Writing – review & editing, Visualization, Software, Investigation, Data curation, Writing – original draft, Validation, Methodology, Formal analysis, Conceptualization. **Anna Ramos-Chernenko:** Writing – review & editing, Investigation. **Jukka Jokimäki:** Writing – review & editing, Investigation. **Piotr Tryjanowski:** Writing – review & editing, Investigation. **Yanina Benedetti:** Writing – review & editing, Investigation. **Mario Díaz:** Writing – review & editing, Investigation. **Marja-Liisa Kaisanlahti-Jokimäki:** Writing – review & editing, Investigation. **Federico Morelli:** Writing – review & editing, Investigation. **Tomás Pérez-Contreras:** Writing – review & editing, Investigation. **Enrique Rubio:** Writing – review & editing, Investigation. **Philipp Sprau:** Writing – review & editing, Investigation. **Jukka Suhonen:** Writing – review & editing, Investigation. **Juan Diego Ibáñez-Álamo:** Writing – original draft, Resources, Methodology, Funding acquisition, Writing – review & editing, Supervision, Project administration, Investigation, Conceptualization.

Ethical statement

No personal data that could be used to identify the respondents were retrieved, thus constituting a complete anonymous survey for which no approval from an ethical committee was needed.

Declaration of competing interest

All the authors declare no conflict of interest.

No personal data that could be used to identify the respondents were retrieved, thus constituting a complete anonymous survey for which no approval from an ethical committee was needed.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2025.111417.

Data availability

Data will be made available on request.

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