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Affective responses to urban but not to natural scenes depend on inter-individual differences in childhood nature exposure

Mika Koivisto [a,*], Simone Grassini [b,c]

[a] Department of Psychology, University of Turku, Assistentinkatu 7, 20014, Turku, Finland
[b] Department of Social Studies, University of Stavanger, Uis. Kjell Arholms Gate 41, 4021, Stavanger, Norway
[c] Department of Psychology, NTNU, Norwegian University of Science and Technology, Høgskoleringen 1, 7034, Trondheim, Norway

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ABSTRACT

Do humans have a hard-wired tendency to respond with positive affects to nature or do individual's meanings and learning experiences moderate the affective responses to natural or urban scenes? We studied the relative contributions of inherited dispositions and individual factors (childhood and current nature exposure, nature connectedness) on immediate affective responses to nature and urban scenes with Affect Misattribution Procedure (AMP). In the AMP, the participants ($N = 316$) judged the valence of their affective responses to Chinese characters, which were preceded by nature or urban prime images. Individual factors (childhood and current nature exposure, nature connectedness, gender, age) did not predict immediate affective responses to nature, but childhood nature exposure moderated reported affects following urban images. The results suggest that humans may have an inherited hard-wired tendency to respond with positive affects to nature, whereas the affective responses to urban scenes are more influenced by individual factors.

1. Introduction

Exposure to natural environments is linked to psychological benefits, such as stress reduction, mood enhancement, and restoration from cognitive and attentional strain, and better mental health (Berman et al., 2008; Hartig et al., 2014; Kaplan & Kaplan, 1989; Ulrich et al., 1991). Just viewing natural landscapes or images, videos, and other simulations of nature may produce positive psychological effects (Gaekwad et al., 2022; Ohly et al., 2016; Shuda et al., 2020; Velarde et al., 2007). These effects are usually explained from evolutionary perspective, which assumes that humans have an innate tendency to respond positively to unthreatening natural environments, because that has been useful for adaptive purposes when evolving in nature. An important psycho-evolutionary theory, the Stress Reduction Theory (SRT) (Ulrich, 1983; Ulrich et al., 1991), emphasizes the immediate physiological and emotional effects human experiences when being exposed to unthreatening natural environments. According to SRT, exposure to nature automatically and immediately elicits positive affects which counteract negative affective states and leads to restoration and recovery from stress. Attentional Restoration Theory (ART) (Kaplan & Kaplan, 1989) assumes that the features in natural environments capture bottom-up attention via soft fascination and allow directed (top-down) attention to restore. Joye and Van den Berg (2011) have criticized the evolutionary views because exposure to many different kinds of natural environments have been shown be restorative, also ones which do not support survival. They suggest a Perceptual Fluency Account (PFA), arguing that natural stimuli have features (e.g., fractals) which are processed fluently and effortlessly. The positive affective responses to nature are by-products of this easy, fluent processing. Thus, according to PFA, stress reduction (product of immediate positive affect in SRT) and attention restoration (product of fascination in ART) are by-products of fluent processing. It is notable that the concept of "fascination" in ART and the concept of "perceptual fluency" in PFA resemble each other as both refer to ease of processing.

An alternative or complementary view for the evolutionary views and PFA - that can be referred as "constructivist" perspective - assumes that individuals make sense of their experiences and interactions with world by creating conceptual schemas that organize ideas and experiences (Myers, 2012). Recent constructivist accounts on the psychological effects of natural environments (Egner et al., 2020; Haga et al., 2016; Van Hedger et al., 2019) propose that the psychological effects of nature depend on individual factors, such as the associations and meanings individuals attribute to the physical attributes of nature, rather than on hard-wired tendencies developed during biological evolution. For

* Corresponding author. University of Turku, University of Turku, 20014, Finland.
E-mail addresses: mikoivi@utu.fi (M. Koivisto), simone.grassini@uis.no (S. Grassini).

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example, the Conditioned Restoration Theory (CRT) (Egner et al., 2020) is based on the idea that environments, either natural or urban ones, can be restorative due to prior learning. This theory explains the restorative effects of nature by conditioning. People are conditioned to associate nature with positive affect and relaxation, because they have experienced relaxation and positive emotions during leisure activities in forests, parks, beaches, and mountains. Consequently, nature alone starts to elicit the same affects as the original experiences. Similarly, other environments (e.g., urban environments) can become associated with positive experiences and so conditioned to elicit relaxation and positive affect. Therefore, this account predicts inter-individual variations based on previous interactions with environments. Indeed, previous research has found that some non-natural environments, for example outdoor historical sites (Masullo et al., 2021), can be restorative. However, the CRT does not explicitly exclude the possibility that humans may have an innate tendency to respond positively to nature.

Empirical studies have rarely tested the mechanisms that psycho-evolutionary theories assume to be responsible for the psychological effects of nature exposure (Schiebel et al., 2022). The hypothesis that humans respond automatically with positive affects to nature has not yet been tested adequately. Experiments using implicit or indirect measures such as affective priming, in which observers respond to an affective target presented after environmental images, have provided preliminary evidence for rapid positive affective responses to nature (Hietanen et al., 2007; Hietanen & Korpela, 2004; Korpela et al., 2002). A study (Joye et al., 2013) made use of the Affect Misattribution Procedure (AMP) (Payne, 2008) in which a prime image representing natural or urban scene was followed by a neutral Chinese character, the valence of which the observers had to judge. This procedure is based on the idea that the affect produced by the prime image is misattributed to the neutral target (i.e., Chinese character). The results showed that the judgements were more positive when the Chinese pictographs were preceded by nature images than when they were preceded by urban images. The methodological limitation in these studies (Hietanen, 2007; Hietanen & Korpela, 2004; Joye et al., 2013; Korpela et al., 2002) was that they did not include any direct/explicit tasks structurally identical to the indirect task, in which the observers would have responded to the environmental images instead of the targets, while keeping constant other aspects of the task. Such a direct task would help to control for the confounding effects of explicit evaluation of the environmental images and thus for the possible "nature-positive" bias (Corazon et al., 2019).

It remains unclear whether humans respond immediately with positive affects to unthreatening nature. We approached this problem by using the AMP as an indirect task in combination with structurally identical explicit task in which the valence and arousal in response to the environmental images were judged directly. The responses in the direct task were then used as covariates at item level to partial out the effects of explicit evaluation of the images on the judgements in AMP. In the present study we explored with indirect AMP task whether humans' immediate responses to natural scenes are more positive than those to urban scenes when explicit evaluations are controlled for. Especially we were interested in whether the immediate affects in response to nature would or would not depend on a number of individual factors.

Previous research shows that the positive psychological effects of nature exposure depend on individual factors. Retrospective reports (Jimenez et al., 2021; Pensini et al., 2016; Wood & Smyth, 2020) suggest that nature exposure during childhood correlates with psychological benefits of nature. A systematic review (Li et al., 2021), comprising primarily longitudinal studies, supports an overall beneficial role of early nature exposure on later mental health. Although it is well-known that spending time in natural environments has positive health effects, the typical experimental studies on the mechanisms underlying the effects of nature have largely neglected the contribution of possible inter-individual differences in childhood and adulthood exposure to nature. It is not clear whether all humans immediately respond with positive emotions to nature, as assumed in evolution-based theories, or whether such responses have been learned during childhood or adulthood nature exposure, as assumed by constructivist theories. In addition, individuals vary in their nature connectedness, that is, their affective connection and feeling of belonging to nature (Tam, 2013). Nature connectedness can be interpreted as the individual's construction of the relationship between self and nature. It is a trait-like feature which is relative stable over time (Mayer & Frantz, 2004), but short exposures to nature can produce short-term state-like fluctuations in it (Mayer et al., 2009). Connectedness to nature correlates positively with the frequency of time spent in nature and outdoors (Nisbet et al., 2009) and with the psychological well-being (Mayer et al., 2009; Pensini et al., 2016). The relation of nature connectedness to the immediate affective responses to nature remains unstudied.

This study aimed to examine human's spontaneous, immediate affective responses to natural and urban scenes, and whether such emotional responses depend on inter-individual differences in self-reported childhood and adulthood nature exposure, connectedness to nature, age, or gender. We examined emotional responses with the AMP, an "implicit" or indirect procedure in which a photograph of nature or urban setting was briefly presented, followed by a Chinese character. The participants were asked to evaluate the valence and arousal of their response to the Chinese character and not to let their reactions to the photograph to influence their evaluations of their responses to the Chinese characters. We assumed that despite the instruction, the emotional response to the photograph will automatically be misattributed to the evaluation of the valence (and arousal) related to the character. The explicit (direct) task was structurally identical to the indirect task, but the participants evaluated their emotional responses to the photographs of nature and urban settings. The explicit evaluations were not of primary interest in the present study, because they may be subject to nature-positive bias, but the valence and arousal responses for each stimulus in the indirect task were included as covariates in the analyses of the results from AMP to partial out the effects of explicit processing of the stimuli.

If humans have an intrinsic disposition to respond automatically with positive affects to nature, one expects that valence ratings after nature images in AMP would not depend on individual factors, and that responses after nature images would in general be more positive than after urban images. On the other hand, if humans' immediate affective responses to nature are products of learning or the meanings associated to environments, as suggested by the constructivist frameworks, one would expect that childhood or adulthood exposure to nature, or nature connectedness, would modify the valence ratings after nature and urban images. Also, a combination of the two views is a logically possible: if humans have been intrinsically prepared to respond positively to nature, but interaction with environments would modify the affective responses to them, one could expect that the valence ratings after nature images would in general be more positive than after urban images, but the strength of the difference would depend on individual factors. We performed first an experiment with young adults. Then we tested whether the results would replicate and extend to middle-aged participants.

2. Material and methods

Two experiments were conducted, Experiment 1 for young adults (18–35 years old) and Experiment 2 for middle-aged participants (36–55 years old), with age as the only difference between the experiments. The methods and analysis plans were formally preregistered at OSF.io (https://osf.io/z7dh8/?view_only=6dff972ef4124075bedba96529ea77bf and https://osf.io/vhmfq/?view_only=2878ff8e0b71452bb0be18c7e16c1d65). For compactness, here we report only the analyses and results for the combined results on all the participants with age as a continuous variable, whereas in Supplemental Material we report in detail the results separately for each experiment. The survey and experiment scripts and materials, complete R analysis scripts, and data are available at OSF.io (https://osf.io/autmz/?view_only=757d49bc

2a054369b770ebc45493440d).

2.1. Participants

Participants with age between 18 and 55 years (18–35 years in Experiment 1; 36–55 years in Experiment 2), normal or corrected to normal vision, without any self-reported neurological injuries or psychiatric problems were recruited via Prolific (https://prolific.co) in exchange for 2.50 £. Older than 55 years old participants were not recruited because the present tasks used relatively short stimulus durations and several perceptual abilities are known to diminish with age (Faubert, 2002). The Prolific advertisement of the study was directed to potential participants living in Europe or North America to keep the sample comparable to those used in most previous relevant studies. Unlike stated in the preregistration of Experiment 1, being a student was not an inclusion criterion, because we decided to run the study also on middle aged participants in Experiment 2. Although the Prolific advertisement was sent to European countries and North America, we got participants only from Europe (England, Scotland, Ireland, Northern Ireland, Poland, and Portugal). The participants had to use desktop or laptop computer with a real keyboard, and they were not allowed to understand Chinese. Instructions were given in English, so being fluent English was required to participate to the experiment.

The sample size for separate analyses of Experiments 1 and 2 was determined on basis of a pilot study ($N = 26$; 13 males, 13 females) whose data were simulated with simr package (Green & MacLeod, 2016) in R (R Core Team, 2018). The simulation suggested that for detecting the effects of environment (nature vs. urban images) and its possible interactions with continuous scales on valence ratings in the indirect task (unstandardized effect size: $B = -0.02$, alpha level: 0.05, power: 80%), 140 participants were needed when controlling for valence in the direct task and arousal in the indirect and direct tasks.

It is important in online studies to exclude participants who demonstrate lack of regard for the instructions or who perform the tasks without sufficient attention to task simply to get the promised expense. Therefore, a relatively substantial number of participant exclusions was expectable (e.g., Mann et al., 2019). In both experiments, first we recruited 140 participants as planned. Then we screened out the participants who did not fit the preregistered criteria and estimated how many more participants should be recruited to obtain the needed sample size. Then we continued recruiting until at least 140 participants fulfilled the preregistered requirements. As a result, we got 283 participants (143 for Experiment 1; 140 for Experiment 2) who were eligible for inclusion. One of the participants reported being 61 years old and therefore was excluded. None of the participants performed the study faster than 12 min total time, which was an exclusion criterion. Following the plan in the preregistration, participants who gave consistently the same valence or arousal rating in the indirect or direct task in more than 10 experimental trials in succession (e.g., selecting rating 1 more than ten times in succession) were replaced by new ones. From the 402 participants who completed the study, 119 had to be rejected due to this criterion, resulting in 283 participants who passed all the criteria. However, during screening the results we noticed that many of the rejected participants ($N = 33$) performed as expected and showed variability not only in the valence ratings of both indirect and direct tasks but also in the arousal ratings of the direct task; they repeated the same arousal rating too many times in succession in the indirect task only. They either must have had difficulties in finding differences in their arousal responses to the Chinese characters or they were not aroused by the characters to any subjectively notable degree. We thought that both of such patterns of responding are plausible and could be considered as acceptable, because the Chinese characters are typically considered as neutral stimuli and therefore suitable for serving as stimuli in AMP paradigm (in non-Chinese speakers). Thus, we decided to deviate from this specific criterion that was reported in the study pre-registration document and accepted the data from the participants who judged their arousal with the same rating in the indirect task more than 10 times in succession. The final sample consisted of 316 participants (183 female, 133 male) with mean age of 34.6 years (SD = 10.9, range 18–55).

The experiments were conducted in accordance with the Declaration of Helsinki and with the understanding and consent of each participant. The study was accepted by Ethics Committee for Human Sciences at the University of Turku.

2.2. Study design and questionnaires

The experiments involved Task (2: indirect, direct) and Environment (2: nature, urban) as within-participant variables; in addition, exposure to nature in adulthood/currently, connectedness to nature, and age were continuous between-participant variables and gender was a categorical variable.

Nature connectedness was measured with the Extended Inclusion of Nature in Self scale (EINS, Martin & Czellar, 2016). EINS consists of four pictorial items (overlap, size, distance, centrality), each having seven alternatives, and the participants select the alternative that best describes their relationship with natural environments. The score could vary between 4 and 28, with high scores referring to strong nature connectedness.

Childhood exposure to nature and current level of exposure to nature were measured with Retrospective Nature Exposure Scale (RNES) and modified Nature Exposure scale (NES) (Wood et al., 2019), in which participant's exposure to nature in childhood and currently was rated on Likert scale from 1 (*low/not much*) to 5 (*high/a great deal*). Both scales included 6 items: two items assessed exposure to nature in everyday life, two items assessed exposure outside of everyday environments, and two items assessed nature exposure during physical exercise. Thus, the sum score in each scale could vary between 6 and 30 points.

2.3. Apparatus and stimuli

For online data collection, the software PsyToolkit 3.3.2 was used (Stoet, 2010, 2017) and participants used their own computers. PsyToolkit excluded the use of mobile phones and tablets. The pictorial stimuli were 20 nature and 20 urban color photographs from Grassini et al. (2019) (Fig. 1). Their size was 600 x 450 pixels. Grassini et al. (2019) had taken the nature photographs by themselves or from freely available online pictures. The nature images were from four categories (5 per category): desert, forest, snow, and water landscapes. The urban

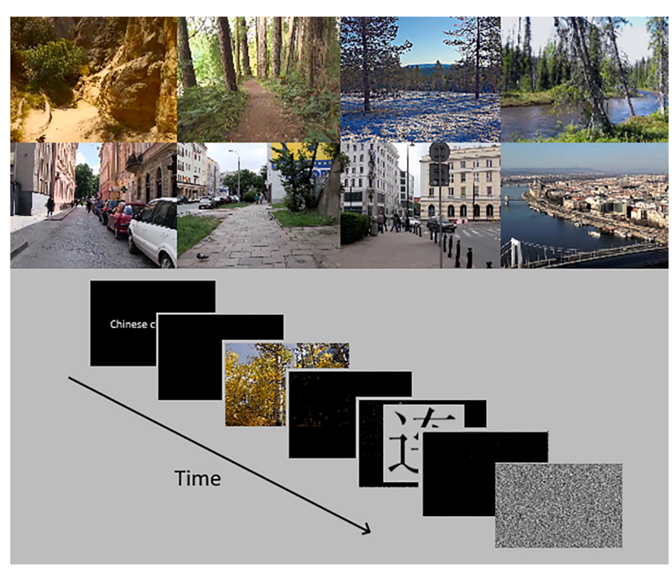

Fig. 1. Examples of the stimuli and the flow of stimulation.

photos were from European or Asian cities, avoiding images that included numbers, letters, and faces. Because humans have been often reported to prefer environments containing water (White et al., 2010), five of the urban images contain water settings to balance the presence of water in the depicted environments. In addition, there were 2 nature and 2 urban images for the practice blocks. The images were equalized for luminance with SHINE_color toolbox (https://github.com/RodDalBen/SHINE_color) running under Matlab (The MathWorks, Inc., Natick, MA). In addition, the experiment involved 20 Chinese characters (+4 characters for practice blocks) from Payne (2005).

2.4. Procedure

When the participants had clicked the link leading to the study, they were asked "Please check what applies to you: 1) I understand Chinese language, 2) I understand Chinese characters, 3) None of the above." The study ended if the participant selected one of the other alternatives than the third one (it was stated in the study information that people who understand Chinese cannot participate). For participants selecting the 3rd alternative, the experiment began after responding to the questions about their age, gender, and current country of residence.

In the beginning of the experiment, the participants were informed following the instructions of Payne (2008): "In this study, we are interested in how well people are able to avoid distraction. In the experimental tasks, you will be shown a photograph followed by a Chinese character. In one series of task, you are asked to rate your reaction to the Chinese character, while trying to ignore the influence of the photograph; in one series of task, you are asked to rate your reaction to the photograph, while trying to ignore the influence of the Chinese character." Four practice trials were performed in both tasks before the actual experimental trials.

Both tasks involved the same stimulus items, so that the valence and arousal in the direct task could be used at item level as covariates in the indirect task, and vice versa for the indirect task. The order of indirect and direct tasks was counterbalanced by the randomization function of PsyToolkit. In the beginning of the indirect task, the participants were told that "In this round of judgements, you should rate the Chinese characters. Please note that sometimes the photos flashed prior to the characters can influence people's ratings of the Chinese characters. Please try your best not to be influenced by the photographs. Instead, please give us an honest judgement of how pleasant or unpleasant is your reaction to each Chinese character. After having judged the pleasantness of your reaction to the Chinese character, you are asked to rate how aroused (excited, stimulated) your reaction to the Chinese character was." In the direct task, the instructions were otherwise the same as in the indirect task, but the participants were asked to rate their reactions to the photographs and to avoid the influence of the Chinese characters.

Each trial began with the warning signal (either words "Chinese character" or "Photo," depending on the task) presented for 1500 ms in the centre of the screen, and after 500 ms blank interval, the photograph was presented for 100 ms (Fig. 1). After 100 ms blank interstimulus interval the Chinese character appeared for 100 ms, so that stimulus-onset asynchrony (SOA) was 200 ms.[1] The Chinese character was followed by a 100 ms blank period and a white noise mask for 500 ms. Then the valence manikin (Lang, 1980), consisting of 9 point-scale from 1 (*very unpleasant*) to 9 (*very pleasant*), was presented. After participant's valence response, arousal was assessed with the arousal manikin (1 = *unaroused*, 9 = *aroused*). The valence and arousal selections were indicated by clicking with computer mouse. In the indirect and direct tasks, if the participant did not respond within 10 s after the stimuli, the response was scored as −1 and such trials were removed from the analyses.

After completing both task versions, the participants filled in the Extended Inclusion of Nature in Self scale (EINS, Martin & Czellar, 2016) and the modified NES and RNES scales (Wood et al., 2019). In the end, the participants were thanked for their time and debriefed about the purpose of the study.

2.5. Statistical analyses

First, we computed descriptive statistics (mean, *SD*, CI) for the EINS, NES, and RNES scales, analysed their Cronbach's alphas, and then we computed Spearman's correlations between the scales. Before moving to the preregistered linear mixed-effect analyses, we computed standard Task (2: direct, indirect) x Environment (2: nature, urban) repeated measures analyses of variance (ANOVAs) for valence and arousal to display the results without using any covariates in the analyses.

For the preregistered analyses of the valence ratings, we used linear mixed-effect models with R-package lme4 (Bates et al., 2015) and lmerTest (Kuznetsova et al., 2017) on single trials. Packages ggplot2 (Wickham, 2016) and sjPlot (Lüdecke, 2019) were used for illustrating the results. In each model, the random effect structure involved random slope for Environment and random intercept for items (photograph - Chinese character combination). Because the hypotheses were related to the indirect task, and we wanted to avoid overfitting, we analysed the valence in the indirect and direct task separately. Nature served as intercept in each model. We focused first on the indirect task and tested the fixed effects of Environment, EINS, Age, and their interactions in Model 1, and then the fixed effects of Environment, Age, and their interactions with nature exposure (RNES and NES) in Model 2. Model 3 included Environment, Gender, and Age with their interactions as fixed effects; female category served as intercept. The fixed effects of arousal and valence in the direct task and arousal in the indirect task were included as covariates at item level in each model. The scores in continuous variables (age, EINS, RNES, and NES) were centred before

[1] Because the experiment was run with the participants' own computers, the real stimulus duration and SOAs varied few milliseconds between participants depending on the computers. We assessed the durations with PsyToolkit's timestamp function, which stores the precise timing between two events in participant's browser. According to this procedure, the mean stimulus duration was 106 ms (*SD* = 3.5, range: 101–119) and the mean SOA was 212 ms (*SD* = 7.4, range: 201–258). AMP is robust to presentation speed (Payne et al., 2005), so we assumed that the observed variability in the presentation duration should not influence the results. It is common to present a mask in the AMP (Joye et al., 2013; Payne et al., 2008). Therefore, we followed this tradition, although the function of the mask is unclear in these experiments. The Chinese character – mask SOA in AMP is typically relatively long (212 ms in the present study, 100 ms in Payne et al., 2008, and 200 ms in Joye et al., 2013) so that one cannot expect it to suppress conscious perception of the preceding Chinese character; suppression would require a stimulus duration of about 20 ms and a mask presented immediately after the stimulus so that the SOA is not much longer than 20 ms (Breitmeyer & Ogmen, 2006).

they were added to the linear mixed-effect models.

The models on the results of the direct task were identical to those on indirect task, with the exception that the fixed effects of arousal and valence in the indirect task and arousal in the direct task were included as covariates.

3. Results

3.1. Descriptive statistics and observed data

Table 1 presents the descriptive statistics for the scales, their Cronbach alphas, and their intercorrelations. The distribution of scores was not normally distributed in any of these scales (Shapiro-Wilk, p-values $<$ .05), therefore their intercorrelations were analysed with Spearman's correlation. The correlations indicate that the participants with higher-than-average exposure to nature during childhood also had a higher-than-average exposure to nature in adulthood, and that the more the individuals tended to be exposed to nature in childhood and in adulthood, the stronger the individuals' nature connectedness was.

We also computed the Spearman-Brown split-half reliability with 5000 permutations for the valence ratings in the indirect and direct experimental tasks using splithalf package (https://github.com/sdparsons/splithalf) in R. In the indirect task, it was 0.87 for the nature condition and 0.88 for the urban condition. In the direct task, the values were 0.89 for the nature condition and 0.90 for the urban condition.

Valence rating was the outcome variable in our main analyses using linear mixed-effect models, while arousal ratings were as covariates. Therefore, it is important to study how their observed scores were distributed. Fig. 2 plots the observed ratings of valence aggregated for items as a function of arousal for each item (i.e., nature and urban condition) (A) in the indirect task and (B) in the direct task. Fig. 3 summarises the observed distribution of (A) the valence ratings and (B) the arousal ratings in the indirect and direct tasks aggregated for participants. Environment (2) x Task (2) repeated measures analysis of variance (ANOVA) on valence did not detect a statistically significant main effect for Task, $F(1,315) = 3.13$, $p = .078$, $\eta_p^2 = .010$. The main effect of Environment ($F(1,315) = 1499.73$, $p < .001$, $\eta_p^2 = .83$) and the Task × Environment interaction ($F(1,161) = 1241.32$, $p < .001$, $\eta_p^2 = .80$) showed that the difference in ratings between natural and urban environments was larger in the direct task than in the indirect task. The effect of Environment was, however, statistically significant in both tasks (indirect: $F(1, 315) = 60.7$, p $< .001$, $\eta_p^2 = .16$; direct: $F(1,315) = 1733$, $p < .001$, $\eta_p^2 = .85$).

For arousal ratings, the main effect of Task ($F(1,315) = 5.18$, $p = .024$, $\eta_p^2 = .02$) was statistically significant. The main effect of Environment ($F(1, 315) = 32.31$, $p < .001$, $\eta_p^2 = .09$), and the Task × Environment interaction ($F(1,315) = 27.21$, $p < .001$, $\eta_p^2 = .08$) were statistically significant. In both tasks, the effect of Environment was statistically significant (indirect task: $F(1,315) = 6.51$, $p = .011$, $\eta_p^2 = .02$; direct task: $F(1,315) = 32.1$, $p < .001$, $\eta_p^2 = .09$), suggesting that the nature images elicited higher arousal ratings than the urban images, and more so in the direct task.

3.2. Linear mixed-effect models

3.2.1. Indirect task

The results of the three models on valence in the indirect task are presented in Table 2. Valence in the direct task and arousal in the indirect task were statistically significant covariates. In all the models, the effect of Environment was significant, suggesting that the emotional responses to the Chinese characters were rated more positively after nature images than after urban images. Given that nature was the reference category, the finding that the fixed effects related to individual factors (EINS, RNES, NES, Age, Gender) were not statistically significant suggests that valence judgements given after nature images were not statistically significantly related to individual factors.

The only significant effect relating to individual factors was the Environment × RNES interaction (Fig. 4A), suggesting that nature exposure during childhood modulated the effect of environment. As childhood nature exposure did not influence responses after nature images, which would have been indicated by a fixed effect of RNES, the Environment × RNES interaction suggest that the higher the nature exposure during childhood was, the less positive were the responses after urban images. This effect was not moderated by age, although in the separate analyses of the experiments the interaction was statistically significant ($p = .010$) only in the young adults in Experiment 1 (Supplemental Material, Table S1). Separate analysis of the results of participants with lower than average childhood nature exposure ($N = 137$) did not reveal a statistically significant effect for Environment, $B = -0.077$, $SE = 0.069$, 95% CI [−0.212, 0.057], $t(90) = -1.129$, $p = .262$, whereas participants with higher than average childhood nature exposure ($N = 179$) showed more positive valence responses after nature than urban images, $B = -0.185$, $SE = 0.07464$, 95% CI [−0.333, −0.039], $t(90) = -2.479$, $p = .015$).

3.3. Direct task

The results of the three models on valence in the direct task are presented in Table 3. Valence in the indirect task and arousal in the direct task were statistically significant covariates. In all the models, the effect of Environment was highly significant, showing that emotional responses to images of nature were rated more positively than emotional responses to urban images.

Nature connectedness (EINS), childhood nature exposure (RNES), and gender were not related to the valence judgements in the direct task. The fixed effect of current nature exposure (NES) was statistically significant (Fig. 4B), suggesting that the higher the current nature exposure was, the more positive were the emotional responses to nature images. The interaction between environment and current nature exposure shows that the higher the current nature exposure was, the less positive were the responses to urban images as compared with those to nature images. This interaction did not depend statistically significantly on age; it is also clear from the confidence intervals in Fig. 4B that the difference between responses to nature and urban images was present also in participants with lower-than-average current nature exposure. However, the difference between the responses to nature and urban images increased as a function of age, as suggested by the significant interaction between environment and age.

Finally, as childhood nature exposure interacted with environment in the indirect task but not in the direct task, and current nature exposure showed interaction with environment only in the direct task, we tested whether the differences between tasks were statistically significant by adding Task (indirect vs. direct) with its interactions as a fixed effect to a model otherwise similar to Model 2 (valence ~ Environment*RNES*NES*Age*Task + Arousal + (Environment|Id) + (Item|Id)). Both the Environment x RNES x Task ($B = 0.037$, $SE = 0.007$, 95% CI [0.022, 0.051], $t(24436) = 4.880$, $p < .001$) and the Environment x NES x Task ($B = -0.053$, $SE = 0.010$, 95% CI [−0.072, −0.034], $t(24439 = -5.417$, $p < .001$) interactions were statistically significant, confirming that the differences between the tasks were reliable. In addition, the Environment x Age × Task interaction, $B = -0.018$, $SE = 0.004$, 95% CI [−0.025, −0.011], $t(24437) = -4.959$, $p < .001$, confirms that ageing was related to more negative valence responses to urban than natural images more strongly in the direct than in the indirect task.

4. Discussion

Evolutionary theoretical frameworks have proposed that humans have been biologically prepared to automatically, or even unconsciously, to respond with positive affects to unthreatening natural

Table 1
Descriptive statistics and correlations for study scales.

Scale	M	SD	95% CI	min	max	α	1	2	3
1. EINS	18.78	4.19	[8.31, 19.24]	4	28	.85			
2. RNES	20.90	5.43	[20.30, 21.50]	6	30	.87	.25*	–	
3. NES	22.38	4.15	[21.92, 22.84]	10	30	.77	.56*	.36*	–

*p < .001.

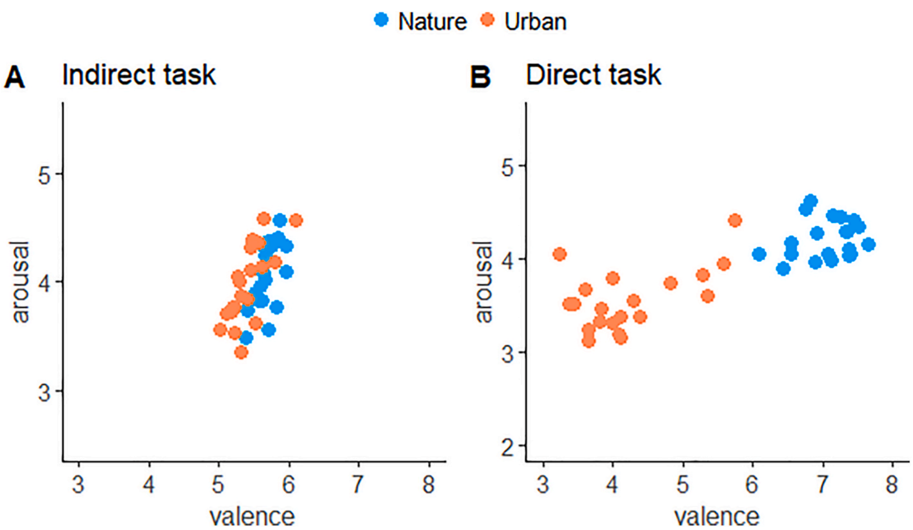

Fig. 2. The distribution of the mean ratings of items as a function valence and arousal in the indirect and direct tasks (N = 316). The dots in the indirect task (A) represent ratings given in the indirect task to Chinese characters when they followed nature or urban images. The affect misattribution effect is demonstrated by the higher valence ratings when the Chinese characters followed nature images (blue dots) than when they followed urban images (orange dots). In the direct task (B) the dots represent ratings given directly to the nature or urban images. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

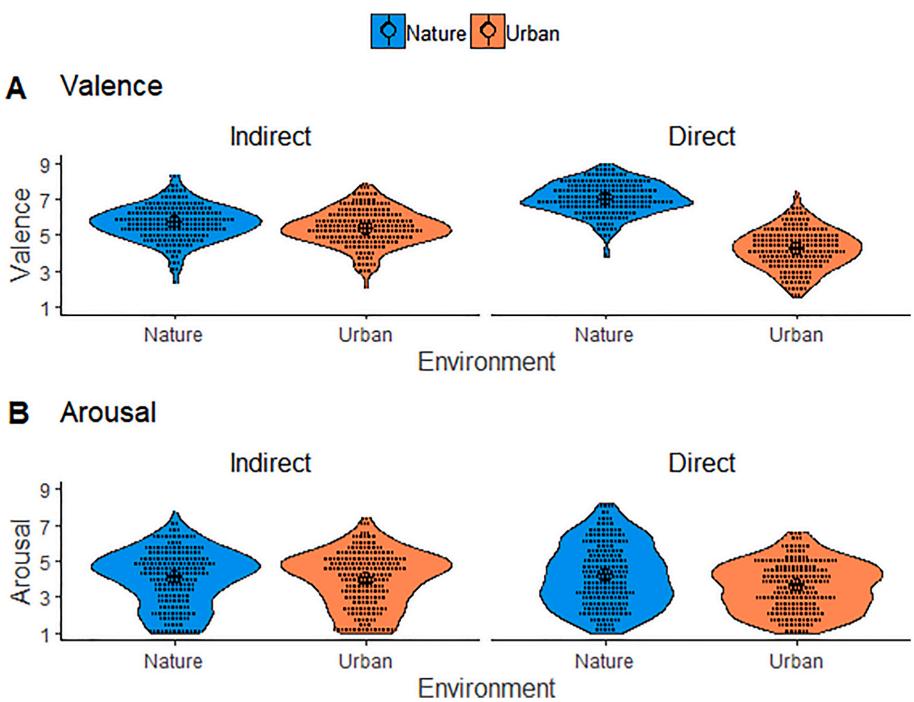

Fig. 3. Valence (A) and arousal (B) ratings in the indirect and direct task. The small dots represent individual participants and large dot shows the group's mean (N = 316). In the indirect task(A), the ratings were given in response to Chinese characters following a nature or urban image, whereas in the direct task (B) the ratings were given directly to the nature and urban images.

environments which signal survival (Kellert & Wilson, 1993; Ulrich et al., 1991). In addition, Perceptual Fluency Account (PFA) suggest that natural stimuli are processed fluently and effortlessly, which is accompanied with positive affects (Joye & Van den Berg, 2011). The present study tested the automaticity of the affects by making use of an indirect task, Affect Misattribution Procedure (AMP). The results of AMP showed an effect favouring nature: the valence of emotional responses to Chinese characters were judged as more positive after nature images than after urban images. This result replicates the AMP effect reported by Joye et al. (2013) who did not, however, control for the influence of

Table 2
The fixed effects in the models on valence judgements in the indirect task (N = 316).

Predictors	Model 1			Model 2			Model 3		
	B	CI	p	B	CI	p	B	CI	p
(Intercept)	5.61	5.49–5.74	**<.001**	5.60	5.47–5.73	**<.001**	5.65	5.50–5.81	**<.001**
Environment	−0.15	−0.26–−0.03	**.013**	−0.15	−0.26–−0.03	**.014**	−0.19	−0.32–−0.07	**.003**
EINS	−0.01	−0.03 – 0.02	.583						
Age	−0.00	−0.01 – 0.01	.742	−0.00	−0.02 – 0.01	.369	−0.00	−0.01 – 0.01	.997
Valence, direct task	0.04	0.02–0.05	**<.001**	0.04	0.02–0.06	**<.001**	0.04	0.02–0.05	**<.001**
Arousal, direct task	0.01	−0.00 – 0.03	.161	0.01	−0.00 – 0.03	.157	0.01	−0.01 – 0.03	.199
Arousal, indirect task	0.28	0.27–0.30	**<.001**	0.28	0.27–0.30	**<.001**	0.29	0.27–0.30	**<.001**
Environment * EINS	0.01	−0.00 – 0.03	.121						
Environment * Age	−0.00	−0.01 – 0.00	.720	−0.00	−0.01 – 0.01	.794	0.00	−0.00 – 0.01	.237
EINS * Age	0.00	−0.00 – 0.00	.928						
Environment *EINS * Age	0.00	−0.00 – 0.00	.879						
RNES				−0.00	−0.03 – 0.02	.690			
NES				0.02	−0.01 – 0.05	.138			
Environment * RNES				−0.01	−0.03–−0.00	**.037**			
Environment * NES				0.01	−0.01 – 0.03	.199			
RNES * NES				0.00	−0.00 – 0.01	.595			
RNES * Age				−0.00	−0.00 – 0.00	.871			
NES * Age				0.00	−0.00 – 0.00	.685			
Environment * RNES * NES				−0.00	−0.00 – 0.00	.715			
Environment * RNES * Age				0.00	−0.00 – 0.00	.335			
Environment * NES * Age				0.00	−0.00 – 0.00	.144			
RNES * NES * Age				0.00	−0.00 – 0.00	.504			
Environment * RNES * NES * Age				−0.00	−0.00 – 0.00	.836			
Gender							−0.09	−0.31 – 0.13	.407
Environment * Gender							0.09	−0.04 – 0.22	.184
Gender * Age							−0.01	−0.03 – 0.01	.543
Environment * Gender * Age							−0.01	−0.02 – 0.00	.086

Note. Model 1 = Environment * EINS * Age + covariates; Model 2 = Environment * RNES * NES *Age + covariates. Model 3 = Environment * Gender * Age + covariates. EINS = Extended Inclusion of Nature in Self (Martin & Czellar, 2016). RNES = Retrospective Nature Exposure Scale (Wood et al., 2019); NES = Nature Exposure Scale (Wood et al., 2019).

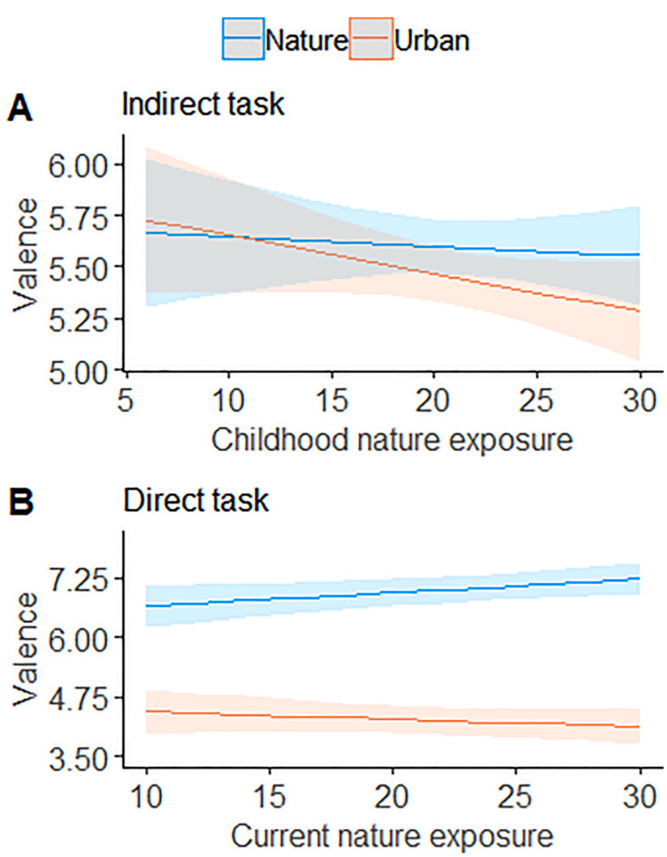

Fig. 4. Valence judgements after nature and urban images in the indirect task as a function of childhood nature exposure (RNES) in the indirect task (A) and as a function of current nature exposure (NES) in the direct task (B).

explicit judgements. The misattribution effect in our study was most likely based on automatic affective responses because the contribution of explicit evaluations of the environmental images was controlled for by the covariates, including valence ratings in the direct task. Importantly, affective responses were modulated by self-assessed exposure to nature during childhood: only participants with higher-than-average childhood nature exposure showed the AMP effect, that is, the difference between the affective responses to nature images and those to urban images in the indirect task. The childhood nature exposure was related to valence ratings given after urban images only, not to ratings after nature images. The higher the exposure in childhood, the lower were the valence ratings after urban images, whereas nature images elicited similar ratings independent of exposure level.

According to evolutionary models (e.g., SRT, Ulrich et al., 1991) and PFA, all humans are expected to respond positively to nature. The results support these views in the sense that none of the variables measuring individual factors (nature connectedness, exposure to nature during childhood or currently, age,[2] gender) were reliably related to the affective responses after presentation of nature images in AMP. In each model, the average valence scores after nature images were on the higher side of the valence scale than its "neutral" midpoint (i.e., the estimates of the intercept were above 5, see Table 2), suggesting that humans in general respond similarly with immediate positive affects to nature. These findings are similar to that of Schiebel et al. (2022) who

[2] In separate analyses of the experiments (see Supplementary material) childhood nature exposure interacted statistically significantly with environment in Experiment 1 (18–35 years old participants), but not in Experiment 2 (36–55 years old). Nonetheless, in the combined data from both experiments, the interaction stayed significant and was not modulated by age. It remains possible that our study (*N* = 316) did not have enough statistical power to detect the effect of age. Anyway, if such effect would exist in older people in a more powerful experiment, it would probably be very small and might reflect irrelevant factors, for example the quality of childhood memories.

Table 3
The fixed effects in the models on valence judgements in the direct task (N = 316).

Predictors	Model 1			Model 2			Model 3		
	B	CI	p	B	CI	p	B	CI	p
(Intercept)	6.99	6.72–7.27	**<.001**	7.01	6.73–7.29	**<.001**	6.96	6.67–7.25	**<.001**
Environment	−2.72	−3.10–−2.33	**<.001**	−2.76	−3.14–−2.37	**<.001**	−2.71	−3.11–−2.31	**<.001**
EINS	0.01	−0.02 – 0.03	.639						
Age	0.01	−0.00 – 0.02	.141	0.00	−0.01 – 0.01	.436	0.01	−0.00 – 0.02	.229
Valence, indirect task	0.02	0.01–0.03	**.008**	0.02	0.01–0.03	**.009**	0.02	0.01–0.03	**.009**
Arousal, direct task	0.18	0.17–0.20	**<.001**	0.18	0.17–0.19	**<.001**	0.18	0.17–0.20	**<.001**
Arousal, indirect task	−0.00	−0.02 – 0.01	.712	−0.00	−0.02 – 0.01	.659	−0.00	−0.02 – 0.01	.708
Environment * EINS	−0.01	−0.04 – 0.02	.475						
Environment * Age	−0.02	−0.03–−0.01	**.001**	−0.02	−0.03–−0.01	**.001**	−0.02	−0.03–−0.00	**.048**
EINS * Age	−0.00	−0.00 – 0.00	.319						
Environment * EINS * Age	0.00	−0.00 – 0.00	.539						
RNES				−0.01	−0.03 – 0.01	.261			
NES				0.03	0.00–0.06	**.040**			
Environment * RNES				0.02	−0.00 – 0.05	.067			
Environment * NES				−0.04	−0.08–−0.01	**.011**			
RNES * NES				−0.00	−0.01 – 0.00	.084			
RNES * Age				0.00	−0.00 – 0.00	.366			
NES * Age				0.00	−0.00 – 0.00	.681			
Environment * RNES * NES				0.01	−0.00 – 0.01	.055			
Environment * RNES * Age				−0.00	−0.00 – 0.00	.970			
Environment * NES * Age				−0.00	−0.00 – 0.00	.968			
RNES * NES * Age				0.00	−0.00 – 0.00	.250			
Environment * RNES * NES * Age				0.00	−0.00 – 0.00	.674			
Gender							0.05	−0.16 – 0.26	.645
Environment *Gender							−0.03	−0.29 – 0.24	.842
Gender * Age							−0.00	−0.02 – 0.02	.946
Environment *Gender * Age							−0.01	−0.04 – 0.01	.277

Note. Model 1 = Environment * EINS * Age + covariates; Model 2 = Environment * RNES * NES *Age + covariates. Model 3 = Environment * Gender * Age + covariates. EINS = Extended Inclusion of Nature in Self (Martin & Czellar, 2016); RNES = Retrospective Nature Exposure Scale (Wood et al., 2019); NES = Nature Exposure Scale (Wood et al., 2019).

showed with implicit tasks that, consistent with the assumptions of evolution-based theories, humans tend to approach nature; they did not, however, study whether this tendency was related to individual factors. Our results are also partly consistent with constructivist view on human-environment interaction because previous childhood experiences with nature were related to the valence of responses to the urban environments. The higher the self-rated exposure to nature during childhood was, the less positive were the affective responses to the urban environments; conversely, the lesser the exposure to nature was during childhood, the more positive were the responses to urban environment. Thus, the misattribution effect was modulated by the variation in the responses to the urban environments only. However, the failure to detect any association between inter-individual factors and the immediate affects elicited by natural scenes is not in line with the predictions of the constructivist accounts, for example those of the Conditioned Restoration Theory (CRT) (Egner et al., 2020), assuming that previous exposure to nature modifies the responses to nature. Nevertheless, the NES and RNES scales did not measure the emotional valence, but only the frequency, of the previous encounters with nature, therefore it remains open whether previous positive or negative emotions during interaction with nature would differently modulate the present affective responses to natural stimuli.

The finding that individuals with low nature exposure during childhood showed equally positive affective responses to urban scenes than to nature scenes undermines the traditional nature-good vs. urban-bad narrative. As Hartig (2021) notes, people are relatively well adapted to urban settings, and urban environments need not to be the source of stress. Hartig builds a larger theoretical framework which considers that humans have adapted biologically and culturally to broad range of environmental conditions. The framework stresses the contribution of relational (interpersonal aspects of relationships) and social collective resources on restoration in interaction with different environments. This is consistent with the CRT (Egner et al., 2020), suggesting that also urban environments can be associated with restoration and positive affect. One may speculate on basis of our results that the individuals who have had less than average nature exposure during childhood may have emotionally adapted to nature-deprived environments (i.e., urban settings), learned positive associations with them, and therefore they do not respond as negatively to urban scenes as individuals who have grown up mostly in nature-rich environments. Thus, they may have constructed a buffer against responding emotionally negatively to urban settings. In fact, there is indirect evidence consistent with such mechanism. Migration from rural environments to urban environments is associated with lowering of mental health as compared with urban residents and their rural counterparts (Li et al., 2009; Lu, 2010). From the constructivist perspective, one may speculate that the participants who grew up in rural environments have not learn to associate urban settings with positive emotions and constructed a buffer against urban settings, and therefore they respond more negatively to urban environments. Of course, the change in the presence or absence of natural elements may be only one of the many factors (e.g., noise, pollution, social networks and interactions, housing, etc.) which change during migration from rural to urban environment. However, in constructivist perspective such factors also may contribute to the affective responses to visual stimuli via the associations and meanings individuals attribute to environmental settings.

Theoretically, the overall pattern of our results supports an evolutionary-constructivist hypothesis, according to which humans in general respond in similar ways to nature (an evolutionary effect), whereas the responses to urban environments depend on individual learning experiences (constructivist effect). The immediate positive affective responses to nature may be one of the mechanisms explaining the restorative psychological effects of nature exposure, as suggested by SRT and PFA. However, we did not study restoration, so it is not possible to assess the practical significance of our results.

Explicit judgements, on the other hand, were predicted by current nature exposure which increased the positivity of the responses to nature and decreased the positivity of the responses to urban images. It is logical that persons who evaluate natural scenes more positively than urban scenes prefer to spend time in nature. However, the explicit evaluations were not of primary interest here: it is possible that they are influenced by the nature-positive bias (Corazon et al., 2019), the influence of which was controlled by the covariates in the analyses of the results in the indirect task.

Although in the present results section we have presented the combined results from 18 to 55 years old participants, the data for the present study was collected in two preregistered waves. First the young adults (18–35 years, Experiment 1) were tested. This was followed by an attempt to replicate and extend the Environment × RNES interaction observed in young adults ($B = -0.02$, $p = .009$) to middle-aged participants (36–55 years old, Experiment 2). Separate analyses of the two groups are reported in Supplementary Materials. They showed that in the younger group the effect size corresponded to the targeted $B = -0.02$, which was suggested by the power simulation based on a pilot study. The interaction in the middle-aged group was not statistically significant and the observed effect size ($B = -0.003$) was smaller than the minimal detectable effect size (MDES) with 80% power (MDES = −0.023, based on simulation of the data from the middle-aged group). For the case that the interaction would not be replicated in the middle-aged group, our preregistered analysis plan involved analyses of the data from the combined group by repeating the models with age and its interactions as fixed effects to study the possible effects of ageing. The Environment × RNES interaction in the combined sample remained statistically significant and the sensitivity to detect the two-way interaction (MDES = −0.018) did not clearly change compared to the analysis involving only the young group (MDES = −0.02). It is, however, evident that the non-significant effect of age on the influence of childhood nature exposure on valence ratings was so small ($B = 0.0006$) that the present study did not have power to detect it (MDES = 0.002). We conclude that if age has an effect in the studied age range, it hardly has any practical significance.

The study was conducted online. The experimenters could not directly monitor what the participants were doing while the experiment was running. Therefore, it was important to set *a priori* criteria for excluding participants who with a high probability were not concentrating on the task and following the instructions conscientiously. One of the preregistered criteria was that participants who gave consistently the same valence or arousal rating in the indirect or direct task in more than 10 experimental trials in succession should be rejected and replaced by new participants. However, after having screened the data, we realized that the criterion in the case of arousal ratings was too tight, because some of the participants repeated the same rating (usually one of the lowest scores or a score in the middle of the rating scale) too many times in succession only for the arousal ratings in response to the Chinese characters in the indirect task, while they otherwise performed adequately. The Chinese characters are used as stimuli in AMP precisely because they are thought to be relatively neutral stimuli. Therefore, we considered it logical that some of the participants were not aroused by the "neutral" characters or could not clearly discriminate slight differences in their arousal between the trials. We thought that it would be more ethical to accept the results of such participants rather than reject them. After this change in the analyses, the Environment × RNES interaction remained practically the same in the larger group, $B = -0.014$, 95% CI [−0.027, −0.001] compared with that in the original group, $B = -0.014$, 95% CI [−0.028, −0.0004], showing that our decision to deviate from the preregistered plan did not change the result.

The present sample of participants was limited to European young adults and middle-aged people to guarantee the comparability of the results with those in previous relevant studies on psychological effects of environments which have been conducted mostly in the Western world. We do not know how familiar the participants were with the natural or urban environments depicted on the pictures, but an interesting line for further research would be to study the role of familiarity in the psychological effects of the environments. Another reason for the selection of this sample was that the participants were not allowed to be familiar with the meanings of the Chinese characters, stimuli frequently used in AMP. Thus, the results are not directly generalizable to populations in other parts of the world. Inhabitants in countries with various levels of urbanization may respond differently to the questionnaires on nature exposure, which might be reflected in the associations between the exposure scores and the effects of environment on valence judgements in AMP and the direct task. The evolutionary-constructivist hypothesis in the form suggested by the present results would predict, however, that automatic affective responses to nature would be similar independent of the place of inhabitation, whereas the responses to urban environments might differ. One should also note that we studied affective responses in adulthood, therefore the results concerning the retrospectively assessed childhood nature exposure do not necessarily generalize to children, but empirical studies also employing children as participants is needed to test whether children's level of nature exposure is related to their affective responses to different environments.

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Credit author statement

Mika Koivisto: Conceptualization, Methodology, Software, Data curation, Formal analysis, Investigation, Writing- Original draft preparation, Writing- Reviewing and Editing. **Simone Grassini:** Conceptualization, Methodology, Writing- Reviewing and Editing.

Declaration of competing interest

We have no conflict of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2022.101840.

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