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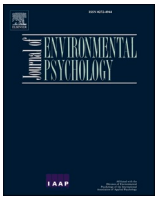

Exposure to nature scenes mitigates the adverse effects of adolescents' social ostracism

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ABSTRACT

Ostracism is a socially painful and detrimental experience commonly suffered in daily life. The objective of this study is to examine the possible restorative effects that visual exposure to nature has on adolescents who suffer from ostracism. We conducted a 2 (Ostracism: social exclusion/inclusion) x 2 (Environmental condition: natural; non-natural) x 3 (Time: baseline; manipulation; intervention) experiment. We measured positive affect, perceived social competence, and attention at three different time periods. At T0, baseline levels were measured; at T1, ostracism was induced; and at T2, restoration was induced via the presentation of natural stimuli and non-natural stimuli. Participants were 304 Spanish adolescents (M_{age} = 14.66 years; SD = 1.39). Our findings show that participants' positive affect and perceived social competence were depleted in the social exclusion condition but attention remained virtually the same. From T1 to T2, ostracized participants' positive affect and perceived social competence improved after exposure to nature scenes. Attention improved independently of the kind of stimuli participants were exposed to, probably due to a learning effect. Altogether, these findings suggest that visual nature exposure can be a potential positive mechanism for adolescents to recover diminished resources due to social ostracism.

1. Introduction

Being a member of a social group is vitally important for people's wellbeing (Appau et al., 2019; McClelland, 1987). Humans are born into groups and tend to become members of different collectives throughout their lives, such as friend groups, work groups, and sports groups. Social integration is associated with higher life satisfaction (Wakefield et al., 2016), better mental health (Kroh & Prechsl, 2023), and a longer life span (Trudel-Fitzgerald et al., 2020). Hence, being socially included in one or several groups is an integral part of the human condition, and social exclusion can lead to devastating consequences for people's mental and physical health (Baumeister & Leary, 1995). Social ostracism (i.e., the act of ignoring and excluding a person from a group), is an extended behavior among humans (Williams & Nida, 2011) and non-human animals (Goodall, 1986). Some of its detrimental consequences for people include stress (Satici, 2020) and physical pain insensitivity (Bernstein & Claypool, 2012). Even a brief experience (2–3 min) of ostracism leads to negative feelings such as sadness and anger (Williams & Nida, 2011). Moreover, social exclusion activates the same brain areas as physical pain (Eisenberger et al., 2003). This is especially relevant for adolescents as they are more severely affected by ostracism than older populations (Pharo et al, 2011) and suffer greater adverse effects due to it, such as increased delinquency (Sullivan et al., 2006), social anxiety (Storch et al., 2005) or depression (Niu et al., 2016). This can be partially explained by the fact that adolescents are greatly influenced by their social groups (Sullivan et al., 2006); thus, it is important to look for strategies that help adolescents deal with the ubiquitous experience of ostracism.

Given the detrimental consequences that ostracism has on people's health and wellbeing, socially excluded individuals look for different strategies to cope with the adverse situation they are immersed in. According to Williams and Nida (2011), one way ostracized individuals deal with social exclusion is by trying to be reincluded in the group. When the person perceives that regaining inclusion is not possible, s/he

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will generally behave in ways that make her feel in control of the situation and, at the same time, force others to acknowledge his or her existence. These behaviors involve being aggressive to others and less likely to offer help. Another coping strategy ostracized people might look for is distancing themselves from the situation, looking for solitude, and avoiding social interactions. Several studies have found that personal and situational variables can enhance coping strategies, thus helping individuals regain their sense of belonging. For instance, Krill et al. (2008) observed that those who scored higher on empathizing personality struggled more with lack of control when involved in a situation of social exclusion. Moreover, Tobia et al. (2017) found that children with lower self-esteem and popularity were more affected by a social exclusion task. Arslan (2018) observed that academic self-regulation (i.e., the ability by which learners transform their mental abilities into academic skills), partially mediated the effects of social exclusion on mental health and wellbeing. Related to the current study, nature exposure seems to help socially excluded individuals deal with the pain caused by ostracism (Poon et al., 2016; Yang et al., 2021).

Several studies have shown that contact with nature can ameliorate the adverse consequences of daily difficulties, enhancing a sense of being away from daily demands (Moran, 2019), and reducing stress (Yao et al., 2021) and anxiety (Browning et al., 2023). Nature exposure can also promote social cohesion (Henderson et al., 2024) and pro-sociability (Dopko et al., 2019). For example, Henderson et al. (2024), observed that collaborating on a search task taking place in a natural environment enhances social cohesion to a greater extent than conducting the same task in an urban setting. Considering ostracism, Poon et al. (2016) found that people show a strong desire to connect to nature when they encounter the interpersonal setbacks of being ostracized. Socially excluded individuals might seek contact with nature as a coping strategy, as nature represents a source of belonging and connection (Kellert & Wilson, 1993); people will not feel rejected by nature, and exposure to nature can help people distance themselves from the uncomfortable situation of being ostracized. Moreover, Poon et al. (2016) found that visual exposure to nature scenes (vs. urban scenes) significantly reduces aggressive urges (e.g., assigning a long cold-water hand immersion to an unknown person), due to ostracism.

Even though exposure to nature seems to help individuals cope with being socially excluded, little is known about the psychological mechanisms responsible for this effect. Psychological restoration has been suggested as a promising candidate (Poon et al., 2016; Yang et al., 2021) but, to our knowledge, it has not been specifically studied. To fill this gap in the literature, we examined whether psychological restoration experienced after exposure to nature can lessen the social pain produced by being ostracized.

1.1. Psychological restoration and ostracism

One possible mechanism behind the positive effects that exposure to nature has on ostracized people is psychological restoration. Restoration refers to the process of recovering adaptive resources (both psychological and physiological) that become depleted due to the demands of daily life (Hartig, 2004). It has been widely documented that contact with nature can promote numerous benefits for individuals (Cleary et al., 2017; Hartig et al., 2014; Martin et al., 2020). Some specific examples of these psychological and physiological benefits of exposure to nature are lower blood pressure (Kelz et al., 2015) and lower heart rate (Laumann et al., 2003), increased attentional capacity (van denBogerd et al., 2020) and fewer symptoms of anxiety and depression (Romans et al., 2011).

The two main theoretical frameworks that have guided research on restoration are attention restoration theory (ART; Kaplan & Kaplan, 1989) and stress reduction theory (SRT; Ulrich, 1983; Ulrich et al., 1991). On one hand, ART focuses on the renewal of directed attention in restorative environments, proposing that direct and/or visual exposure to such environments allows for the recovery of this capacity. On the other hand, SRT is centred on stress reduction because of non-threatening nature exposure. It proposes that individuals experience more positive emotions, fewer negative emotions, and a decline in physiological arousal and stress indicators (e.g., blood pressure) during the process of recovery. While these well-known theories highlight different antecedent conditions for restoration, their integration has been widely recognized (Collado et al., 2017; Hartig, 2021), and studies exploring the restorative potential of nature exposure often consider cognitive, affective, and sometimes physiological benefits simultaneously (Taylor & Kuo, 2009). Although the variety of stimuli and environments that can induce restoration is extensive, those that contain natural elements tend to induce higher levels of restoration.

In addition to the traditional restoration theories (i.e., ART and SRT), Hartig (2021) recently proposed the relational restoration theory (RRT). RRT suggests that the resources requiring restoration go beyond the cognitive, emotional, and physiological aspects proposed by ART and SRT. Specifically, RRT emphasizes the recovery of social resources, such as support from friends, through interactions between dyads or small groups and natural environments. According to this theory, transactions between people and the restorative environments can also enhance the inclination to exchange social support. In their study, Poon et al. (2016) hypothesized that it is this social transaction, and the restorative effect of nature exposure, that diminished ostracized people's aggressive behaviour. In a later study, Yang et al. (2021) examined the effect that exposure to nature scenes has on ostracized people in terms of psychological outcomes. Participants were randomly assigned to recall an experience of social exclusion and rejection or, on the contrary, an experience of social inclusion and acceptance. They then viewed either natural or urban scenes and reported positive and negative affect, basic emotional needs satisfaction, self-esteem, and social pain. Participants in the social exclusion condition reported higher affect balance, satisfaction of basic emotional needs, self-esteem and lower levels of social pain after viewing natural scenes compared to those who viewed urban scenes. These findings were replicated in two consecutive studies in which ostracism was manipulated in different ways and participants saw not only natural or urban scenes, but also neutral (i.e., geometrical figures) ones. No significant differences were found between exposure to urban and neutral scenes.

The results of these studies indicate that exposure to nature can psychologically support individuals experiencing ostracism or social exclusion, as compared to exposure to urban environments. As previously suggested (Hartig, 2021; Poon et al., 2016; Yang et al., 2021), it may be that nature helps restore ostracized participants' diminished resources, allowing them to better cope with the setbacks of being socially excluded. Unfortunately, previous studies did not examine whether participants' resources were depleted due to being socially excluded. Thus, it is not possible to know whether the positive effects found after nature exposure are indeed due to the restorative potential of contact with nature (Hartig & Jahncke, 2017; Stevenson et al., 2018). Given the scarcity of studies examining the positive effects of contact with nature for ostracized people, it is also difficult to generalize their results to other populations. Specifically, previous studies about the effects of exposure to nature on ostracized people focus on adult populations (Poon et al., 2016; Yang et al., 2021). Since adolescents are more affected by ostracism than older populations (Pharo et al, 2011) it is especially relevant to seek strategies that can help them deal with this painful experience. Our study represents a first step towards filling this gap in the literature by examining the potential restorative effect of exposure to nature for ostracized adolescents (aged 12–18 years) while considering an antecedent condition of resource depletion. Specifically, positive affect, perceived social competence, and directed attention will be investigated while controlling for and inducing conditions of prior emotional, social and cognitive fatigue.

1.2. The present study

Our primary aim is to take a closer look at the restorative effect that nature exposure may have on ostracized adolescents (12- to 18-year-olds) and compare this effect to exposure to non-natural scenes. Restoration is measured in terms of positive affect, perceived social competence, attention and reported restoration.

Positive affect refers to the degree to which a person feels positive emotions such as enthusiasm or happiness, while negative affect relates to aversive moods (Sanmartín et al., 2018). Having low levels of positive affect can reflect low mood and higher levels of depression (Vanderlind et al., 2020). This is especially relevant for adolescents as it is common during these ages to have lower levels of positive affect compared to adults and infants, which may lead to developing different types of problems in the future (Young et al., 2019). On the other hand, perceived social competence refers to an individual's self-assessment of their aptitude to effectively engage in social interactions with others (Anderson & Messick, 1974). It has been found that greater perceived social competence is negatively associated with being bullied (Gómez-Ortiz et al., 2019), and positively associated with academic achievement (Armstrong-Carter et al., 2021) and resilience (Bunce et al., 2019). Directed attention can be defined as the ability to consciously focus on relevant stimuli and inhibit irrelevant ones (Kaplan, 1995). A lack of attention is associated with different factors such as smoking during adolescence (Treur et al., 2015) or a low socioeconomic level (O'Neill et al., 2017). A low attention capacity can also lead to poorer adaptation to daily needs in the future (Küper et al., 2012), highlighting the need to seek strategies to improve attentional levels.

We expect a socially excluding situation (i.e., ostracism) to decrease adolescents' positive affect (Hales et al., 2016), perceived social competence (Sakız et al., 2021) and directed attentional capabilities (Buelow et al., 2015) (Hypothesis 1a). No resource depletion is expected for adolescents who are socially accepted (Hypothesis 1b). Positive affect, perceived social competence, and attention are expected to be restored after exposure to nature, and ostracized participants are expected to report being restored (Hypothesis 2a). No restoration is expected to occur after exposure to non-natural scenes (Hypothesis 2b). Exposure to either natural or non-natural scenes is expected to have no restorative effect on socially included participants (Hypothesis 2c). These three last hypotheses will be tested via interactions.

2. Method

2.1. Participants and design

Data were collected from two secondary schools in Spain. Both schools can be considered urban schools because of their absence or insignificant presence of nature in and surrounding the buildings. The city where the schools are located is also an urban environment with a low presence of nature. The study was approved by the Ethics Committee of the university to which two of the authors are affiliated (CEI 113–2234) and by the schools' boards. Adolescents were also asked for informed consent and told that they were not required to participate in the study if they did not want to. They were assured that they could stop their participation whenever they wanted. Three hundred and four adolescents (47.4 % males) aged 12–18 years old ($M_{age} = 14.66$, $SD = 1.39$) participated in this study.

The study was a 2 (Ostracism: exclusion, inclusion) by 2 (Stimuli: natural, non-natural) by 3 (Time: before ostracism, just after ostracism, and after restoration condition) repeated measures design (Fig. 1). Exposure to stimuli was offered via a slideshow. As indicated above, outcomes indicative of restoration were recorded by means of four different measures: positive affect, perceived social competence, performance on an attentional task, and reported restoration.

2.2. Experimental manipulations and procedure

Data collection took place in the adolescents' classrooms. A total of 14 classrooms were assessed, with an average of 22 students per classroom. Given that students were nested within 14 distinct classrooms, the data structure is inherently hierarchical. Classrooms may systematically differ in social dynamics, baseline affective states, and instructional environments, all of which could influence the outcomes of interest. Furthermore, since the environmental manipulation was assigned at the classroom level, the unit of randomization for this part of the experiment was the group rather than the individual. Ignoring this nested structure may lead to underestimated standard errors and biased parameter estimates. For this reason, efforts were made to quantify the impact of this hierarchical structure on the results (see Data Analysis section).

Following Yang et al.'s (2021) approach, participants were asked to write down on a piece of paper the names of five classmates that they would choose to work with in a group project. Participants handed each piece of paper to their teacher who was allied with the researcher. The teacher stepped outside the classroom for 10 min to simulate that s/he was reading the papers so that students would receive feedback about their classmates' choices. In reality, students would later on be randomly assigned to either social exclusion or social inclusion experimental conditions, and their real choices were not used in this experiment.

Data collection took place at three points in time. Data collection 0 (T0) took place while the teacher was outside the classroom "reading" the students' choices of classmates to work on a project with. Data at T0 served as a baseline, and positive affect, perceived social competence and attentional levels were registered. Once students had completed this part of the questionnaire, participants were randomly assigned to the experimental condition (i.e., social exclusion, social inclusion). To do this, the teacher reentered the classroom and gave each student a piece of paper describing the results of their classmate's choices. To avoid comments with their counterparts, students were asked to remain silent. There were two options for the text written on the piece of paper handed to the students: Social exclusion: "Almost no one in the class wants to group with you to work on the class project: your name has been written by less than three people", and Social inclusion: "Everybody wants to group with you for the class project: a lot of people have written down your name".

Once students had read their piece of paper, data collection 1 (T1) took place. As in T0, students' positive affect, perceived social competence, and attentional capabilities were registered. In addition, we conducted a manipulation check by asking participants to write down whether they had been selected to group with someone in the class or not (i.e., the information provided by the teacher), and registering participants' social pain.

After this data collection, the second part of the experimental manipulation took place (i.e., environmental manipulation). Students' classes were randomly assigned to one of the three experimental conditions (nature, urban and neutral[1]). In each condition, adolescents were asked to pay attention to a PowerPoint presentation including different stimuli. The stimuli were projected onto a large screen that could be clearly seen throughout the classroom. Students were collectively exposed to the projected stimuli only after ensuring they were paying attention to the screen. Following Yang et al.'s (2021) approach, the presentations consisted of a series of 14 stimuli (10 s per stimulus; 140 s in total for each of the conditions) showing natural scenes (14 scenes; one scene per stimulus) in the natural condition, urban scenes in the urban condition, and symbols (e.g., plus mathematical symbol, a

[1] Note that, similar to Yang et al. (2021), no significant differences were found between exposure to urban and neutral stimuli. Thus, data from adolescents exposed to these stimuli were merged into one category named non-natural.

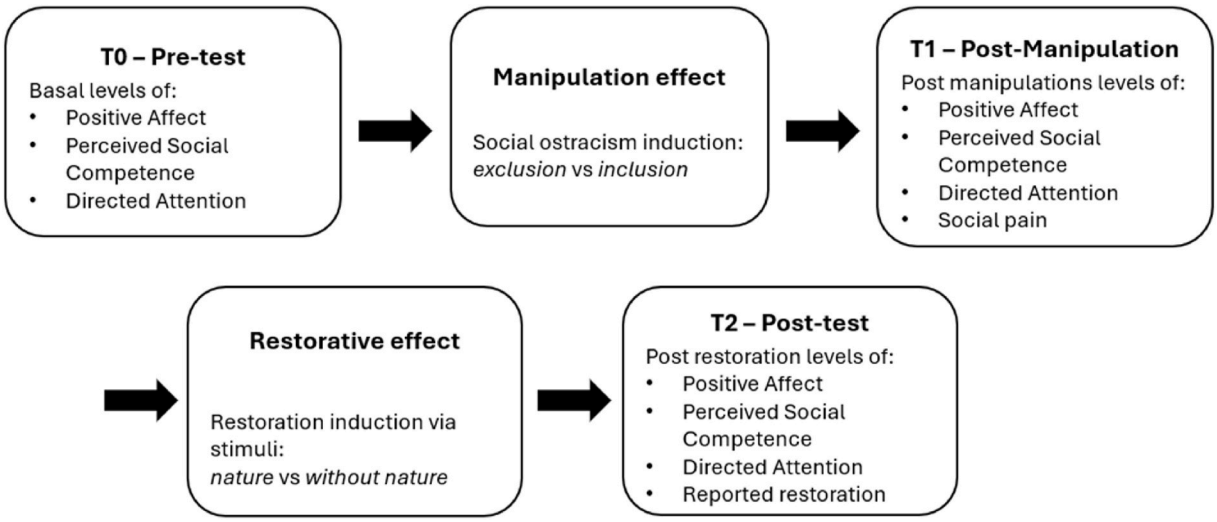

Fig. 1. Experimental procedure.

straight arrow, a pen, etc.) in the neutral condition. After viewing either the natural, urban or neutral scenes, the last data collection (T2) took place. Adolescents' positive affect, perceived social competence, and attentional levels were registered. In addition, participants who viewed nature or urban scenes reported how restored they felt after exposure to the stimuli (i.e., reported restoration). Participants were then debriefed about the experiment and assured that the social exclusion and inclusion was an experimental manipulation and did not reflect their actual choices.

2.3. Environmental stimuli

Our stimuli were selected based on Yang et al.'s (2021) study. These researchers examined the positive effects of exposure to nature scenes (as opposed to urban and neutral scenes) on ostracized people and made their stimuli available to other researchers. To enhance replicability, we used the same or similar stimuli in our study. Stimuli were modified in cases in which the ecological validity of the study could be hindered by possible confounding variables. These modifications mainly relate to the fact that some elements appearing in Yang et al.'s (2021) scenes were context specific. For instance, in some cases, the scenes contained Chinese characters, and, in others, natural environments were atypical for Spain. Nevertheless, for all scenes, we kept the same content as Yang et al. (2021) (e.g., grass and trees) in the scene, as well as the same distribution of elements within the scene. Fig. 2 shows an example of each kind of stimuli.

2.4. Measures

Positive affect. Adolescents' positive affect was measured with a short version of the PANAS scale, validated for the Spanish non-adult population (from 6 to 18 years old; Sanmartín et al., 2018). The scale includes five positive emotions (cheerful, lively, happy, joyful, proud) and asks how participants are feeling now. Each item is on a Likert-type scale ranging from one ("nothing or almost nothing") to five ("completely"). A single score referring to the presence of positive affect was formed by taking the mean of the five items. The resulting positive affect scale showed good reliability (Cronbach's α at T0 = .88; T1 = .92; and T2 = .93).

Perceived social competence. To measure perceived social competence in educational settings, we employed an item designed ad-hoc, using Anderson and Messick, (1974) framework as the main reference. This item ("I find it easy to make friends among my classmates") was presented on a Likert-type scale from one ("nothing or almost nothing") to five ("completely"). The item has high ecological validity as it is specifically designed for the school context and is a relevant question as adolescents greatly rely on their peers for social relationships (Selvam, 2017).

Directed attention. To measure attentional capabilities, we used a cancellation task. Cancellation tasks are a typical and well-studied type of task for assessing attentional capacity (Mahone & Schneider, 2012). In this study, a list of letters was presented. Specifically, only "R", "F", and "P" appeared in the list. These letters were selected as they share similarities in how they are written, so greater attention must be paid to avoid confusing them. The task consisted of students scanning each row and crossing out the "R" and "F" letters, while avoiding crossing out the letter "P". Participants had a maximum time of 10 s per row, and once that time was up they had to move on to the next row even if they had not finished scanning the previous row. The task was designed to make it challenging to cross out all the "R" and "F" letters in the same row within 10 s, so that greater variability in the students' results could be observed. There were 15 rows in total; completing the task took 150 s. The task was administered collectively, and time was controlled by one of the researchers. The final score was equal to the sum of correctly crossed-out

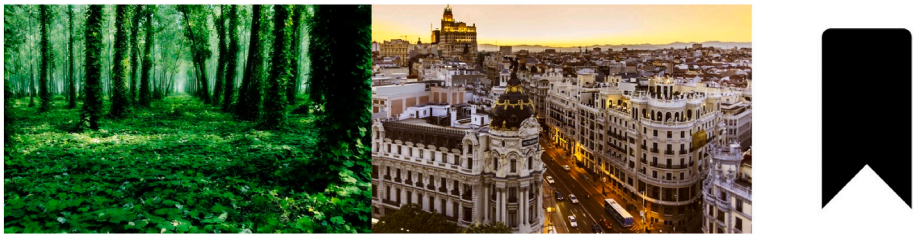

Fig. 2. From left to right:
nature, non-natural (urban) and non-natural (neutral) stimuli examples.

letters. In case a letter "P" was crossed out, a correct answer was subtracted from the final score. Omissions (i.e., not crossing out an "R" or a "F") were not penalized.

Social pain. Social pain was measured as a manipulation check. At T1, adolescents were asked about how they felt after learning the results of their classmates' choices in relation to their participation in a hypothetical group project (i.e., exclusion vs. inclusion conditions). Specifically, we asked participants, "How do you feel after knowing the result?". This was assessed using a Likert scale ranging from one ("bad") to five ("really good"). This item was later reversed for analysis so that a higher score indicated higher social pain.

Reported restoration. This was measured via four items taken to be indicative of restoration (Staats et al., 2003). These were: "I feel free and relaxed after spending free time in places like the one in the picture", "After spending free time in places like the one in the picture, I feel I can think more clearly", "I feel full of energy after spending free time in places like the one in the picture" and "I feel calm after spending free time in places like the one in the picture". Responses were recorded on a Likert-type scale from one ("nothing or almost nothing") to five ("completely"). The mean of the four indicators reflects the reported level of restoration for natural and urban environments. The scale showed a good level of reliability (Cronbach's $\alpha = .91$).

2.5. Data analyses

The data is available at https://osf.io/uktqr/?view_only=8bb0200f30f0490a9e4338bc3a5cc65a. Statistical analyses were performed using SPSS (v. 25). Multiple observations of the same individual and for the same variables were collected at three different times (T0, T1, T2). Thus, our analyses were conducted within a repeated measures framework. A repeated measures ANOVA can be understood as one, simple type of mixed-effects model. SPSS syntaxis was used to calculate post-hoc effects (applying Bonferroni corrections for multiple comparisons). They were also used to examine statistical differences in the slopes of some variables (i.e., to check whether the growth trend found in some variables differed across experimental conditions). Partial eta-square (η_p^2) was computed to assess the effect size. Effect sizes of .01, .06, and .14 were considered small, medium, and large effects for η_p^2 respectively (Cohen, 1988).

Before conducting the repeated measures analyses, we examined whether participants' classroom membership had an effect on the dependent variables (i.e., Positive Affect, Perceived Social Competence, and Attention) using the R packages `lme4` (Bates et al., 2015) and `lmerTest` (Kuznetsova et al., 2017). To determine whether including classroom as a random effect significantly improved model fit, we compared two nested models using a likelihood ratio test via the anova () function in R. The first model included only fixed effects, while the second added a random intercept for classroom. A significant result in this comparison would indicate that accounting for the hierarchical structure provides a better fit to the data. In addition, ICCs were calculated from the variance components extracted from the multilevel model using VarCorr (). We then computed the ICC by dividing the variance associated with the classroom level by the total variance (i.e., between-classroom variance plus residual variance). According to Hox (2010), ICC values of .10, .20, and .30 can be interpreted as small, medium, and large, respectively, in terms of the magnitude of between-group effects. However, the ICC should be viewed as a diagnostic indicator rather than a strict threshold. Even small ICCs can be meaningful when the study involves hierarchical design, group-level randomization, or when properly adjusting standard errors is necessary. All results related to the multilevel analysis are included in the Supplementary Material. This includes the estimated models, as well as summary tables comparing models with and without the classroom-level random effect and reporting the corresponding ICCs.

To keep the main text concise while acknowledging important methodological considerations, repeated measures ANOVAs are reported in the results section, but additional comments are included when multilevel models reveal relevant group-level variance. Specifically, we highlight cases where the ICC exceeds a conservative threshold of .05. While such cut-off points are essentially arbitrary, they serve as useful heuristics for guiding interpretation. Using this criterion, as can be seen in Supplementary Tables 2 and 4, the ICCs for the tested models ranged from 0 to .13. Values exceed the .05 threshold only in the case of Perceived Social Competence (change from T0 to T1) and Attention (changes from T0 to T1 and from T1 to T2). As will be noted in the Discussion, accumulating empirical evidence is essential for informing more context-sensitive interpretations of effect sizes in hierarchical designs.

An a priori power analysis using the G*Power program (Erdfelder et al., 1996) shows that to detect a small effect size with this design, 216 participants would be needed for a power of .90, and 258 for a power of .95, with an assumed correlation of .5 between measures. Considering this, the sample size of our experiment (304 participants) is expected to be adequate.

3. Results

Descriptive statistics for Positive Affect, Perceived Social Competence, and Attention at T0, T1 and T2 are provided in Tables 1 and 2. Urban and neutral stimuli have been combined for all the analyses (non-natural condition) as no statistical differences were found in any experimental condition. These results resemble those of Yang et al. (2021), where no differences were found when participants were exposed to urban or neutral conditions.

3.1. Effects of ostracism on positive affect, perceived social competence, and attention (from T0 to T1) – hypothesis 1a, 1b

As a manipulation check, we first examined whether adolescents assigned to the social exclusion condition actually felt the social pain of being ostracized (as compared to being socially included). Mean for Social Pain in the exclusion and inclusion conditions were 3.19 ($SD = 1.09$) and 1.97 ($SD = .97$), respectively. Our results show that participants assigned to the social exclusion condition felt worse than those who were on the social inclusion condition, with a large effect size associated to these differences (F (1, 304) = 106.89, $p < .00$, $\eta_p^2 = .26$). Hence, our manipulation had the expected effect.

We hypothesized that being socially excluded would decrease participants' emotional and attentional resources, as well as their sense of Perceived Social Competence (Hypothesis 1a). We also expected that being socially included would not lead to resource depletion (Hypothesis 1b). Thus, Positive Affect, Perceived Social Competence and Attention are expected to decrease from T0 to T1 for ostracized participants, while no differences are expected for participants in the inclusion condition. The interaction of Time*Ostracism was significant for both Positive Affect (F (1, 304) = 39.05, $p < .00$) and Perceived Social Competence ($F(1, 304) = 10.78$, $p < .00$), see Table 3. The effect size was larger for Positive Affect (.12 vs.04). This interaction is also shown in Fig. 3. Represented means show that, from T0 to T1, socially excluded adolescents reported a decrease in Positive Affect and Perceived Social Competence compared to those who were socially included. At T1, Positive Affect and Perceived Social Competence significantly differed between socially excluded and socially excluded participants ($p < .00$), while no significant differences were found before the manipulation at T0 ($p = .06$ and $p = .21$ respectively). Considering Attention, the interaction Time*Ostracism was not significant ($F(1, 296) = .08$, $p = .78$). As Fig. 3 shows, adolescents improved their score on the Attention task from T0 to T1, independently of whether they were ostracized or not, ($p < .00$), suggesting a learning effect had occurred in both experimental conditions. The interpretations derived from the models that

Table 1
Descriptive Statistics [Mean (Standard Deviation)] of Positive Affect, Perceived Social Competence and Attention before (T0) and after (T1) ostracism condition (Exclusion, Inclusion).

	Positive Affect		Social Competence		Attention	
	T0	T1	T0	T1	T0	T1
Exclusion	3.08 (.99)	2.77 (1.06)	3.21 (1.24)	2.91 (1.18)	153.66 (28.89)	166.21 (32.25)
Inclusion	3.29 (.94)	3.43 (1.01)	3.40 (1.39)	3.39 (1.30)	153.11 (27.42)	166.11 (30.51)

Note. Sample size in each cell ranges from 146 to 155.

Table 2
Descriptive Statistics [Mean (Standard Deviation)] of Positive Affect, Perceived Social Competence and Attention before (T1) and after (T2) exposure to stimuli (Nature, Non-natural).

	Natural Stimuli						Non-natural Stimuli					
	Positive Affect		Social Competence		Attention		Positive Affect		Social Competence		Attention	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
Exclusion	2.89 (1.02)	3.03 (1.08)	2.90 (1.20)	3.06 (1.10)	180.78 (28.65)	193.35 (34.86)	2.71 (1.09)	2.74 (1.13)	2.92 (1.18)	2.87 (1.15)	158.39 (31.48)	164.66 (35.49)
Inclusion	3.57 (1.03)	3.52 (1.03)	3.70 (1.21)	3.72 (1.28)	174.98 (33.45)	187.76 (38.17)	3.35 (1.00)	3.19 (1.14)	3.23 (1.31)	3.07 (1.29)	161.55 (27.96)	169.72 (32.26)

Note. Sample size in each cell ranges from 51 to 102.

Table 3
Repeated Measures model results for the analyses of Positive Affect, Perceived Social Competence and Attention after Ostracism (Exclusion, Inclusion) condition controlled by age.

	Positive Affect			Social Competence			Attention		
Within subjects effects	*F*	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
Time	1.10	<.29	<.00	2.07	.15	.01	.08	.78	<.00
Time:Age	.69	<.41	<.00	3.18	.08	.01	1.47	.23	<.00
Time:Ostracism	**39.05**	**< .00**	**.12**	**10.78**	**< .00**	**.04**	.08	.78	<.00
Between subjects effects	*F*	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
(Intercept)	**26.56**	**< .00**	**< .08**	**23.48**	**< .00**	**.07**	2.25	.13	.01
Age	.08	.78	<.00	.27	.60	<.00	**74.53**	**< .00**	**.20**
Ostracism	**15.61**	**< .00**	**.05**	**5.61**	**.02**	**.02**	.01	.93	<.00

Note. Ostracism: Exclusion/Inclusion condition. Significant effects appear in bold.

include the classroom-level effect were consistent across all cases (see Supplementary Table 1).

3.2. Recovery and improvement effects of nature exposure on positive affect, perceived social competence and attention (from T1 to T2) – hypothesis 2a, 2b, 2c

We expected that exposure to nature scenes would help restore depleted resources (i.e., Positive Affect, Perceived Social Competence and Attention levels) for ostracized adolescents (Hypothesis 2a). Exposure to non-natural scenes was not expected to have a restorative effect (Hypothesis 2b). As no resource depletion was expected for participants in the socially included condition, we hypothesized that there would not be a restorative effect due to exposure to nature (or non-natural) scenes for socially included participants (Hypothesis 2c). Fig. 4 shows participants' Positive Affect, Perceived Social Competence and Attention before (T1) and after (T2) exposure to the different stimuli in each of the experimental condition (social exclusion; inclusion). The three-way interaction Time*Ostracism*Stimulus was not significant for any of the dependent variables (Table 4). Thus, we checked the two-way interactions. We found a significant Time*Stimulus interaction for all dependent variables, suggesting an improvement in Positive Affect, Perceived Social Competence and Attention for participants exposed to nature scenes, as compared to those exposed to non-natural images. Effects sizes were small (.02 for Positive Affect and Attention, and .03 for Perceived Social Competence). Regarding the interaction of Time*Ostracism, we found it to be significant for Positive Affect (η_p^2 = .03), but not for Perceived Social Competence or Attention. Socially excluded adolescents showed higher Positive Affect at T2 than at T1, but socially included ones did not show differences.

Although three-way interaction effects were non-significant, post-hoc effects reflected significant differences between certain groups. To the extent that theory supports these differences, there is evidence in favor of those effects, and for this reason these interactions are described below. After applying Bonferroni correction, we found that ostracized adolescents who viewed nature scenes reported a significant increase in Positive Affect from T1 to T2 ($p = .04$; $\eta_p^2 = .02$; see Fig. 4) while those who viewed non-natural scenes did not show an increase in Positive Affect ($p = .70$). Socially included participants exposed to nature did not show a significant change in Positive Affect from T1 to T2 ($p = .68$), while exposure to non-natural stimuli resulted in a decrease in Positive Affect from T1 to T2 ($p < .00$; $\eta_p^2 = .03$).

Interestingly, the same pattern of effects was found for Perceived Social Competence. In other words, ostracized participants reported finding it easier to make friends after exposure to nature (T2) as compared to before exposure (T1) ($p = .04$; $\eta_p^2 = .01$). However, ostracized participants exposed to non-natural stimuli did not show any significant change from T1 to T2 ($p = .35$). Considering socially included participants, exposure to nature did not increase their Perceived Social Competence ($p = .77$), while exposure to non-natural stimuli significantly decreased their perception of how easy it is to make friends (i.e.,

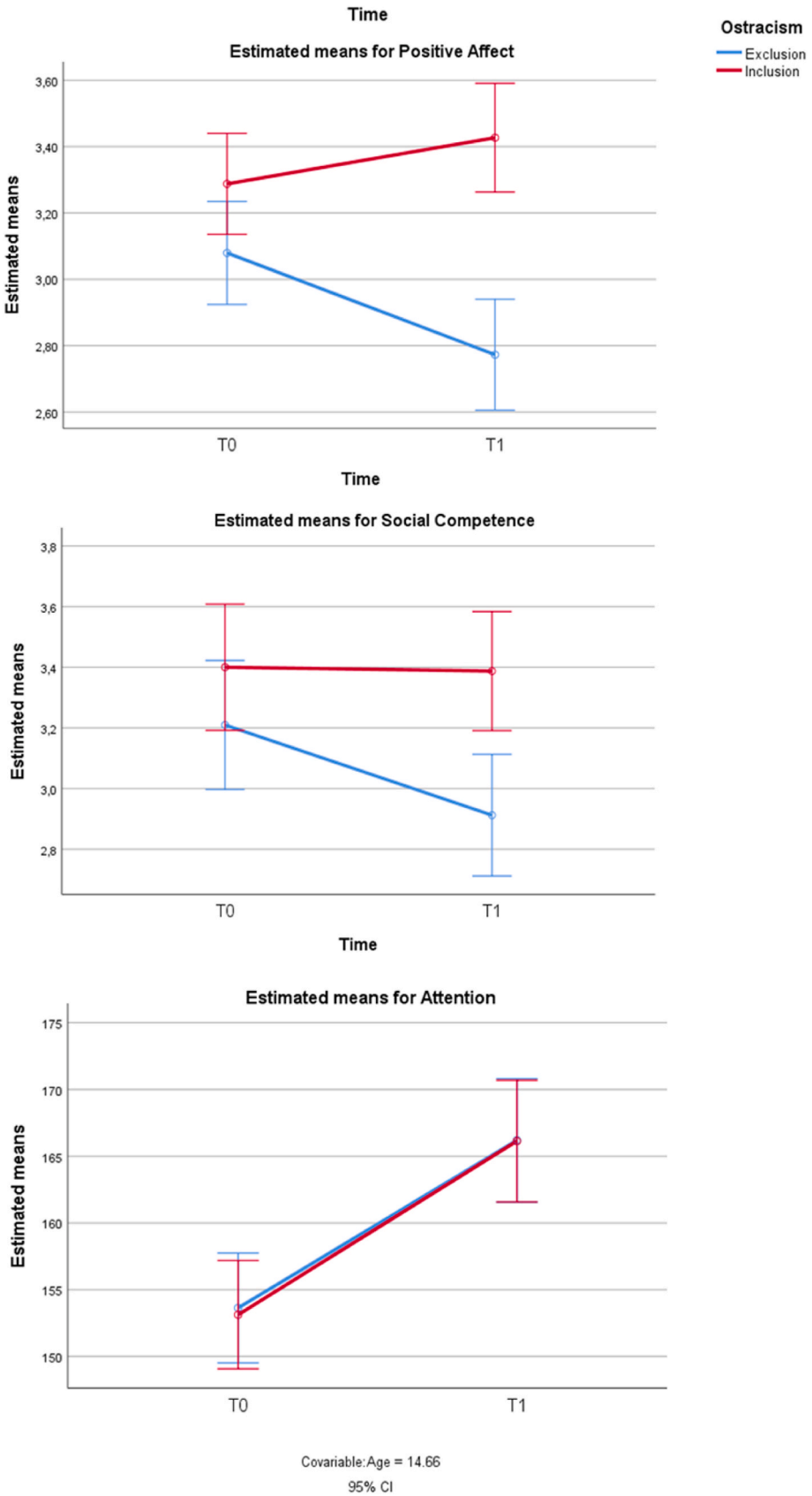

Fig. 3. Estimated means for Time (T0, T1) × Ostracism (Exclusion, Inclusion) for Positive Affect, Perceived Social Competence and Attention scores with 95 % confidence interval and age as a covariate.

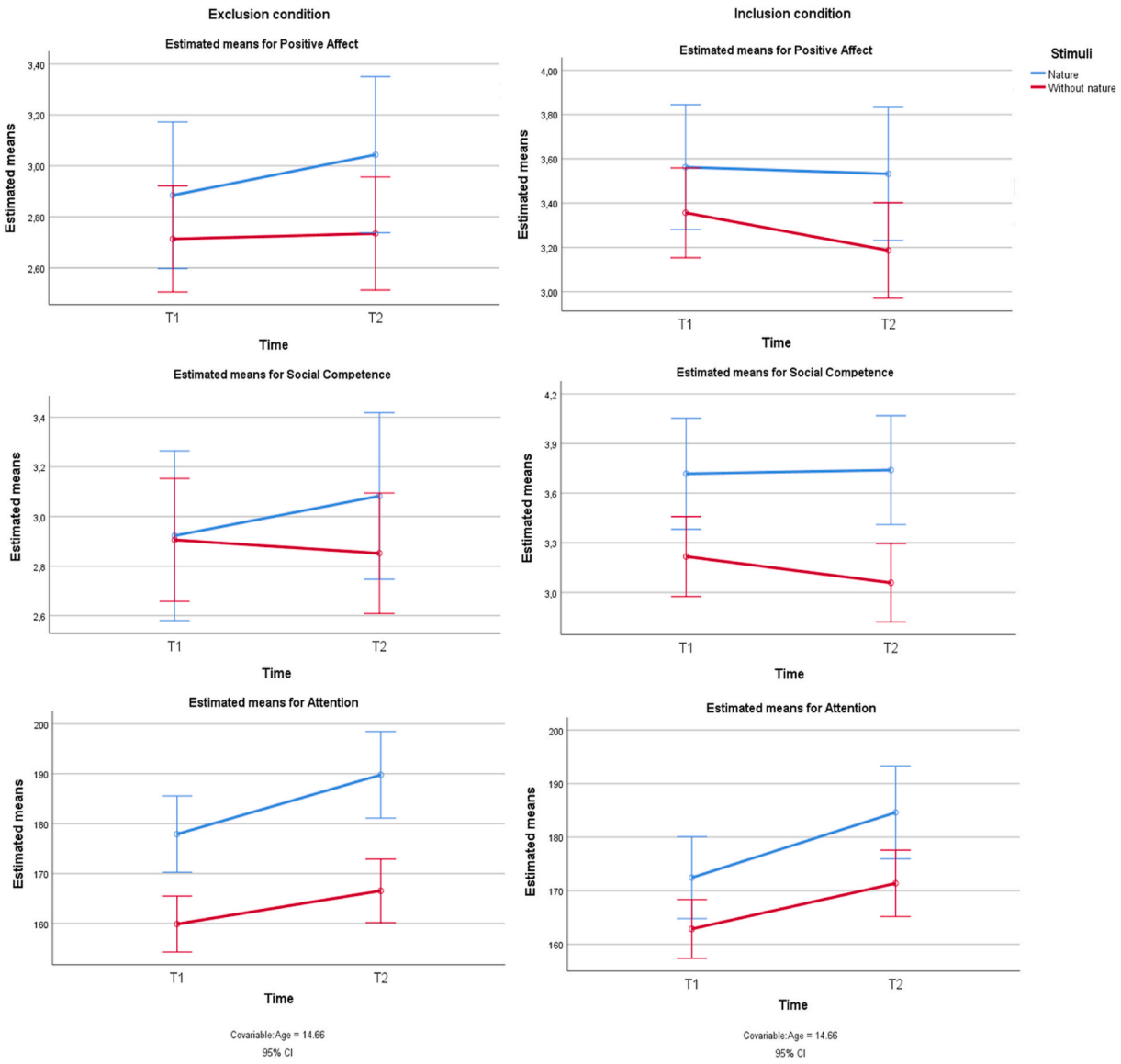

Fig. 4. Estimated means for Time (T1, T2) × Ostracism (Exclusion, Inclusion) × Stimuli (Nature, Non-nature) for Positive Affect, Perceived Social Competence and Attention scores with 95 % confidence interval and age as a covariate.

Table 4
Repeated Measures model results for the analyses of Positive Affect, Perceived Social Competence and Attention after exposure to Stimuli (Nature, Non-natural) controlled by age.

	Positive Affect			Social Competence			Attention		
Within subjects effects	*F*	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
Time	**7.29**	**.01**	**.02**	.19	.67	.00	**5.54**	**.02**	**.02**
Time:Age	**7.52**	**.01**	**.03**	.21	.65	.00	**11.96**	**< .00**	**.04**
Time:Ostracism	**8.65**	**< .00**	**.03**	3.13	.08	.01	.36	.55	<.00
Time:Stimuli	**4.48**	**.04**	**.02**	**8.04**	**.01**	**.03**	**5.99**	**.02**	**.02**
Time:Ostracism:Stimuli	<.00	.99	<.00	.06	.81	<.00	.19	.67	<.00
Between subjects effects	*F*	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
(Intercept)	**28.02**	**< .00**	**.09**	**32.18**	**< .00**	**.10**	2.37	.13	.01
Age	.20	.65	<.00	1.89	.17	.01	**68.56**	**< .00**	**.19**
Ostracism	**20.21**	**< .00**	**.06**	**11.68**	**< .00**	**.04**	.04	.84	<.00
Stimuli	**4.10**	**.04**	**.01**	**5.99**	**.02**	**.02**	**20.41**	**< .00**	**.07**
Ostracism:Stimuli	.02	.89	<.00	2.62	.11	.01	1.73	.19	.01

Note. Ostracism: Exclusion/Inclusion condition. Stimuli: Nature/Without nature condition. Significant effects appear in bold.

Perceived Social Competence; $p = .04$; $\eta_p^2 = .03$).

Moving on to Attention, our results show that both socially excluded and socially included participants performed better on the Attention task from T1 to T2 ($p < .00$), independent of the stimuli they were exposed to. When exposed to nature, the effect sizes were .10 and .11 for adolescents in the social exclusion and social inclusion conditions respectively. When participants were exposed to non-natural stimuli, the effect sizes ranged from .06 to .10 for participants in the social exclusion and social inclusion conditions respectively. These effect sizes can be considered moderate. These findings suggest that there has been a learning effect that influences performance on the attentional task. When comparing the difference in the growth of the slopes from T1 to T2 for each experimental condition, socially excluded participants exposed to nature showed significantly greater growth in Attention ($p = .04$; $\eta_p^2 = .01$) than socially included participants exposed to nature ($p = .15$). This result suggests that the positive effect of nature exposure on Attention is stronger for ostracized participants.

Although the results were generally consistent with those obtained when accounting for classroom-level effects (see Supplementary Table 3), in the case of Positive Affect and Social Competence, the effect of Stimuli Condition was not statistically significant ($p = .07$ and .09, respectively). However, the associated effect sizes were relatively large ($\eta_p^2 = .24$ and .25, respectively).

3.3. Reported restoration after exposure to natural and urban stimuli (T2)

Table 5 presents adolescents' Reported Restoration after exposure to nature or urban scenes (T2). The interaction between Ostracism*Stimuli was not significant ($F(1, 226) = .12$, $p = .73$). However, there were significant differences ($F(1, 226) = 67.92$, $p < .00$, $\eta_p^2 = .24$) for Reported Restoration in favor of the group exposed to natural scenes, with a large associated effect size. This positive effect was independent of being ostracized or socially included ($F = .10$, $p = .76$).

4. Discussion

Given that exposure to nature can help restore diminished psychological resources (Cleary et al., 2017; Hartig et al., 2014; Martin et al., 2020), the current study seeks to enrich the existing body of knowledge in the realm of restoration by exploring the potential restorative effects of nature exposure for ostracized people. Specifically, we aimed to ascertain if exposure to natural stimuli could serve as a buffer, mitigating the adverse effects of ostracism on Positive Affect, Perceived Social Competence, and Attention in adolescents.

This study contributes to the state of the art in two main ways. First, while there have been some studies analysing the relationship between exposure to nature and ostracism, their extent is limited, and they primarily focus on adults (Poon et al., 2016; Yang et al., 2021). Expanding knowledge about the benefits of nature exposure for ostracized people, we target adolescents, a population group especially sensitive to the effects of social exclusion (Pharo et al, 2011). Second, in our experimental design, we controlled the initial fatigue or resource depletion level. This allowed us to ensure that a restoration process has occurred, and not just an improvement which should be considered as an instorative effect (Hartig, 2007).

Table 5
Reported restoration for each Ostracism condition after exposure to Stimuli (Natural; Urban).

	Natural	Urban
Exclusion	3.75 (.97)	2.65 (1.14)
Inclusion	3.84 (.95)	2.65 (1.00)

Note. Sample size in each cell ranges from 51 to 61.

To check if exposure to natural stimuli can help deal with ostracism in terms of Positive Affect, Perceived Social Competence and Attention restoration, we created different experimental conditions: ostracism condition (exclusion vs. inclusion) and stimuli exposure (natural vs. non-natural). As expected in Hypothesis 1a, overall, the exclusion condition lowered the levels of the assessed variables (except for Attention). Moreover, in line with Hypothesis 1b, no depletion or fatigue level was observed when adolescents were socially included. After exposing adolescents to the different stimuli, our findings show that exposure to natural stimuli was more restorative than exposure to non-natural stimuli under the social exclusion (fatigue) condition. These results are in line with Hypotheses 2a and 2b. In the social inclusion condition, exposure to nature did not improve affective nor perceived social competence resources, in line with Hypothesis 2c. As previously indicated, participants' assignment to classroom did not have an effect on Positive Affect, Perceived Social Competence or Attention. Contrary to our hypotheses, Attention improved regardless of the experimental condition.

The results were analyzed considering both the hierarchical structure of the data (students nested within classrooms) and the longitudinal structure (students assessed over time). If there is variability between classrooms, part of the variance attributed to the independent variables may actually reflect unmodeled group-level differences. Moreover, omitting this structure can lead to underestimated standard errors and, consequently, an increased risk of Type I errors (false positives). For this reason, we compared models with and without the classroom-level effect to assess whether the overall pattern of significant and non-significant effects remained consistent across model specifications. In general, the results were consistent across models, with similar conclusions regarding which effects reached statistical significance. The only exception was the effect of Stimuli Condition on Positive Affect and Social Competence from T1 to T2. Although this effect was not statistically significant, the associated effect size was large. This discrepancy may be due to limited statistical power or a small number of classrooms, highlighting the importance of considering both statistical significance and effect size when interpreting multilevel results. Even so, in many cases the effect sizes found were small, which should be taken into account when interpreting the results. The following subsections present a summary of the main conclusions.

4.1. Experimental manipulation - ostracism

According to our results, socially excluded adolescents decreased their Positive Affect and Perceived Social Competence resources in comparison to the baseline, but Attention significantly improved, partially supporting hypothesis 1a.

In accordance with Hypothesis 1b, adolescents in the social inclusion condition did not experience any difference in Positive Affect and Perceived Social Competence between the baseline and after our manipulation. They did, however, increase their attentional resources. These findings suggest that it was indeed our social exclusion manipulation task, and no other external variables, that led to diminished Positive Affect and Perceived Social Competence in the ostracized group. Our findings are in line with previous studies showing that being ostracized is detrimental to positive affect (Williams and Nida, 2011) and perceived social competence (Gómez-Ortiz et al., 2019). As for Attention, we found that the final score was similar for participants in both the social exclusion and inclusion conditions. One explanation for this effect might be that adolescents learnt how to optimize the cancelling task, being faster and more accurate each time they repeated the task, probably reflecting a learning effect. In line with this idea, Verbruggen and Logan (2008) observed that participants learned to associate certain stimuli with go/no go attentional tasks and that when the type of action they had to perform with these same stimuli was changed, their response time increased, reinforcing this idea of association and learning. Another possible explanation for our results is that

our ostracism manipulation might not have been as attentionally demanding as expected due to its relatively short length (Arseneault, 2018). However, prolonging this demanding situation would have had severe ethical considerations.

4.2. Restorative effects of environmental exposure

When analysing the two-way interactions of Time*Stimulus, all conditions pointed to an improvement in favor of restoration by exposure to nature, with these effects being small. We believe these effects would have been larger if participants had been exposed to the stimuli longer (Barton & Pretty, 2010; Cox et al., 2017). This could be explored in future studies. After analysing post-hoc effects, some significant differences were found. More specifically, only participants who were assigned to the social exclusion condition and were exposed to natural stimuli increased their Positive Affect, while no significant effects were found in the other conditions. In other words, those who saw natural stimuli after having been in a condition of social exclusion stated they felt better and had higher positive emotions after being exposed to nature. This suggests a restorative effect of exposure to nature for this group. Similarly, for Perceived Social Competence, those participants who were in a condition of social exclusion and observed natural stimuli reported that it was easier for them to make friends than before seeing the natural stimuli, which also suggests a restorative effect. These results are in line with hypotheses 2a, 2b, and 2c.

In addition, a significant negative effect was observed for those participants who were socially included and saw non-natural stimuli, as they reported lower Perceived Social Competence levels. This effect, although small, was not contemplated in the hypotheses, and we can only speculate the reasons behind it. Living in cities activates neural areas related to social stress (Lederbogen et al., 2011). It may be that, when observing urban stimuli, these neural mechanisms are activated by association. This, however, should be more deeply investigated in future research.

Considering Attention, as in our ostracism manipulation, it improved independently of the experimental condition, so a learning effect probably took place. Nevertheless, the slope from T1 to T2 for the condition of social exclusion and after having seen natural stimuli was statistically larger and more pronounced than the rest of the slopes, suggesting that socially excluded participants who saw natural stimuli improved their Attention more than the other groups. Still, this effect was very small and should be further investigated in future experiments.

Reported restoration at T2 was also measured to verify if the experience of restoration had also been perceived as such by the participants. Regardless of the type of ostracism condition participants were assigned to (inclusion vs exclusion condition), those who observed natural stimuli reported a significantly larger effect on reported restoration than those who observed urban stimuli. In other words, contrary to the findings described above (i.e., that participants in the social inclusion condition did not experience restoration), both ostracized and socially included participants still report that they benefit from exposure to nature. It may be that people understand the concept of restoration differently from what the theory proposes, and therefore objective restoration (measured here by increases in Positive Affect and Perceived Social Competence after a condition of fatigue or depletion) and reported restoration would not reflect similar psychological processes. Retrospective reports could be biased by participants' current psychological state as well as by researchers' communication with them, as researchers may be interested in specific types of changes (Hartig, 2011).

The increase in reported restoration might also be partially explained because participants felt that their Attention had improved, since it increased in every experimental condition. However, this would not explain why those exposed to urban stimuli reported a significantly smaller positive effect. Another plausible reason is that some participants might have guessed the study's objective. It cannot be ruled out that participants might have expressed their opinions about the positive effects of exposure to natural environments rather than experiencing real changes. Last, the fact that participants in the social inclusion condition, and therefore without a previous condition of fatigue or depletion, indicated an increase in their reported restoration scores could be explained by an instorative effect. This effect refers to positive changes due to exposure to (natural) environments when there is no antecedent condition of resource depletion (Hartig, 2007). Given our findings, future studies should not assume that if a reported restoration effect is found, an actual restorative effect has taken place.

4.3. Limitations and future directions

This study contributes valuable insights into the restorative effects of nature exposure on adolescents who have experienced social exclusion. However, it is important to note that there is still room for improvement that should be addressed in future research to expand our understanding of this complex and multifaceted relationship.

First, the sample used in this study was big enough to detect small effects. However, more research is needed to generalize the results to the entire population. For instance, contextual differences might influence the results; e.g., people living in urban settings may consider natural settings as recreational, and restorative experiences via exposure to nature could differ for people living in rural contexts (Hartig, 2021). Additionally, examining the role of individual differences in future studies, such as personality traits and coping strategies, in moderating the impact of social exclusion and nature exposure on adolescents' wellbeing could provide further insights. To the extent of our knowledge, there is not yet any study that specifically examines personality traits and restoration in social exclusion contexts, while there are some studies that have found a significant association between personality and restoration (Jeon et al., 2021).

Second, as we introduced earlier, ostracism-related psychological reactions are also associated with other social conditions of adversity (e.g., being bullied; Reinhard et al., 2020). In this study, participants' previous experiences of adversity were not recorded to simplify the interpretability of the experiment, but we acknowledge that this could be a relevant moderator to be considered in the future. Also, since the experiment was conducted with entire classes, it is possible that students perceived social cues during the experiment (e.g., reactions from other students due to their assigned ostracism condition), which could have influenced the results. However, as both the researcher and the teacher were present in the classroom to prevent any interference, this effect should be minimal. The implications of assigning at the class level instead of the individual level (i.e., nested structure) have already been discussed. In our case, this approach was chosen to avoid disrupting the functioning of the center, although there is an associated risk that variations between classes may account for differences in other relevant variables. Another relevant variation in the data analysis would be to estimate a model that accounts for the three time points, thus capturing the sequential nature of the design. In the present study, the effects of ostracism and nature exposure were tested separately, without evaluating the full interaction or the complete pattern of change over time. This decision was made to simplify the model estimation, given that certain time points were expected to reflect equivalence across groups. Nonetheless, this is an aspect that could be explored further. Tentatively, Supplementary Tables 2 and 4 suggest that the clustering effects within classrooms were greater for the change from T0 to T1 (ostracism manipulation) than from T1 to T2 (nature exposure manipulation). This could be interpreted as evidence that clustering effects may differ depending on the type of manipulation. With a larger number of individuals and groups, it would be possible to explore within a multilevel model whether the experimental effect varies from class to class by modeling random slopes. To tentatively explore this, Supplementary Figs. 1 and 2 show the results disaggregated by classroom, where it can be seen that the pattern for classrooms belonging to the same experimental condition were similar. In this and other areas, multilevel

modeling enables the investigation of research questions that are highly relevant to our field (McNeish, 2023).

Third, as a manipulation check, participants were asked how they felt after our experimental manipulation. As this is a self-reported variable, some students could have guessed the purpose of the experiment and answered congruently.

Fourth, justifying both significant and non-significant effects might introduce a statistical fallacy (Makin & Orban de Xivry, 2019). For instance, we hypothesized (Hypothesis 2a) that Positive affect, Perceived Social Competence, and Attention would be restored after exposure to nature, and ostracized participants were expected to report being restored, whereas (Hypothesis 2b) no restorative effect was expected after exposure to non-natural scenes. Overall, our results were in line with our predictions and theoretical background, suggesting that the positive effects found are due to the restorative potential of nature. To avoid this statistical fallacy, our results should be replicated in future studies. Partly related to this, the use of cut-off points in the interpretation of effect sizes remains questionable. While we encourage more experimental approaches in this area due to the valuable insights they can offer, the accumulation of such studies will also allow for a more contextualized and less arbitrary interpretation of effect sizes.

Fifth, we could not find any Perceived Social Competence scale that would fit the purposes of this study, so we created an ad-hoc measure based on previous studies. This measure was assessed with only one item. While it is normally recommended to use more than one item to measure a construct, when using a very specific, homogeneous and well-defined construct, it is generally preferable to use one item to avoid redundancy and to shorten the length of the questionnaire (Diamantopoulus et al., 2012). In this case Perceived Social Competence is considered very specific and suitable to be captured by our item ("I find it easy to make friends among my classmates"). Nevertheless, this measure needs further testing in upcoming studies.

Last, future studies could also extend the stimuli participants are exposed to. Our stimuli represent only a small part of the broad spectrum of natural and non-natural environments people can be exposed to. Thus, despite being representative, the observed results should not be generalized to all types of natural and non-natural environments. For instance, Gatersleben and Andrews (2023) found that participants reported lower levels of restorative experiences when imagining dense woodland environments, which also contained animal threats or danger of tripping and falling, than when imagining open woodland environments. Additionally, it remains to be studied whether the results observed in this study would be equivalent when exposed to real natural and non-natural environments.

4.4. Implications

The study's findings have different practical and conceptual implications. Regarding the practical implications, the study highlights the potential benefits of exposure to natural environments in restoring depleted psychological resources, especially for those who have experienced social exclusion. Given the societal prevalence of social exclusion and related outcomes such as loneliness (Surkalim et al., 2022; Williams and Nida, 2011), our study adds to the urgent need of finding new ways to cope with these unpleasant social situations. We do not know whether the benefits of visual contact with nature (as shown in our study) will also appear when individuals are in direct contact with nature. However, direct contact with nature enhances a sense of belonging (Peters et al., 2016), and provides relief from daily worries and demands (von Lindern, 2017), which are both useful for dealing with social exclusion (Timeo et al., 2019; Tobia et al., 2017). As a result, we would expect that the current findings could be amplified and generalized when in direct contact with nature. Understanding this relationship can help educators and counsellors develop strategies to support adolescents who have experienced social exclusion. For example, designing proper outdoor group nature-related activities could help young people to cope with, and even prevent, socially excluding experiences by building stronger bonds. Designing spaces with natural elements at schools could also enhance potentially protective or coping-related factors regarding social exclusion. Moreover, incorporating environmental education and experiences of contact with nature into the school curriculum might have dual benefits – enhancing learning and serving as a buffer against the adverse effects of social ostracism. We consider it particularly relevant to introduce the (natural) environment as a key variable for developing resilience in future educational programs. When designing these interventions one should consider, however, how the person-environment transactions might constrain or foster restoration. For instance, for some people, nature might be linked to personal obligations, hindering its restorative potential (Collado et al., 2016; von Lindern et al., 2013). Some others might become used to the natural stimuli, constraining the 'being away' process. Given the constant changes nature has due to seasonality, this becomes less relevant in real-nature interventions.

Moving on to the conceptual implications, we consider this study as an extra step supporting RRT theory (Hartig, 2021). RRT provides a conceptual framework for studying the effects of restoration on social resources, but it does not precisely define how these should be examined. The methodology used in this study could serve as a reference for investigating other psychological (e.g., memory or perceived stress) and social (e.g., social support or social functioning) resources in future research. To our knowledge, there are not many studies that control depletion and fatigue states in non-adult populations. In this experiment, these conditions have been controlled for, which helps establish causality within the effects found, supporting RRT. Considering the discrepancy between reported and actual restoration, we highlight the need for a deeper understanding of what constitutes actual restoration and how to study it. This could influence how psychological interventions are designed, ensuring they align more closely with the actual restorative needs of individuals.

5. Conclusion

Our findings provide empirical support for the restorative effects of nature exposure on ostracized adolescents. These findings highlight the potential of nature-based interventions as a cost-effective and accessible strategy to help adolescents cope with the negative consequences of social exclusion. They also contribute to a growing body of literature underscoring the importance of nature for human wellbeing, creating new avenues for research.

CRediT authorship contribution statement

Adrián Moll: Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Silvia Collado:** Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition, Conceptualization. **Eleanor Ratcliffe:** Writing – review & editing, Validation, Supervision. **Miguel Ángel Sorrel:** Methodology, Writing – review & editing. **José Antonio Corraliza:** Writing – review & editing, Visualization, Validation, Supervision, Project administration, Funding acquisition, Conceptualization.

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Declaration of competing interest

The authors declare they have no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2025.102790.

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