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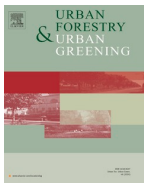

Original article

Visible greenery as my resource? The connection between passive green space exposure and relative deprivation from a self-determination perspective

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ABSTRACT

Relative deprivation can lead to aggression, riots, and revolutions. Previous research has frequently examined the social factors influencing relative deprivation, often neglecting the impact of the natural environment. To investigate whether daily exposure to the natural environment affects relative deprivation and the mechanisms underlying this effect, we propose a model grounded in self-determination theory. Specifically, passive exposure to green spaces can mitigate relative deprivation by fulfilling basic psychological needs such as autonomy, competence, and relatedness. To validate our hypotheses, we conducted two studies involving Chinese participants. Study 1 comprised two sub-studies, both utilizing survey methods to explore the association between passive green space exposure and relative deprivation. Study 1a ($N = 263$) assessed objective passive green space exposure using the normalized difference vegetation index (NDVI), whereas Study 1b ($N = 288$) measured subjective passive green space exposure through self-reports. Study 2 ($N = 214$) employed a laboratory experiment to examine the effects of passive green space exposure on relative deprivation. The findings indicated a negative correlation between passive green space exposure and relative deprivation, mediated by the satisfaction of three basic psychological needs. This effect was evident for greenspaces within the neighborhood and within a 100-meter radius, as well as for both perceived and experimentally induced levels of exposure. The results confirm the beneficial effect of passive greenspace exposure on reducing relative deprivation and offer valuable insights for urban greenspace planning aimed at alleviating such feelings. Furthermore, the study provides an explanation for the disparities observed in previous findings.

1. Introduction

Multidimensional inequality in the economic, educational, political, and other spheres is a global problem that has worsened in recent years (Chancel et al., 2022; Greig et al., 2007). People living in a social environment where resources are unevenly distributed are prone to relative deprivation (RD), a person's perception of being at a disadvantage compared to other individuals or groups and the resulting feelings of resentment and dissatisfaction (Smith et al., 2012). Multiple studies have indicated that relative deprivation is correlated with a heightened risk of aggression (Kassab et al., 2021), gambling (Mishra and Novakowski, 2016), and suicide (Zhao et al., 2023). More seriously, Kunst and Obaidi (2020) suggest that relative deprivation will likely be a significant driver behind the emergence of violent extremism across cultures and contexts in the 21st century.

Given the significant harm caused by relative deprivation, prior research has examined its influencing factors (Crosby, 1976; Smith et al., 2012). Research indicates that individual factors, including personality traits (Crosby, 1976) and income levels (Moore, 2003), as well as social and environmental factors, such as procedural justice (Folger et al., 1983) and social class (Callan et al., 2017), can affect relative deprivation. However, addressing relative deprivation through these factors presents several challenges. For instance, intervening in individual factors is difficult to implement on a large scale, whereas changing macro-level social environments requires significant time. Therefore, it is essential to explore relatively easy and effective ways to reduce relative deprivation.

Notably, previous research has ignored the physical environment as

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a key factor influencing relative deprivation, especially in the surrounding natural environment, including parks, greenways, street trees, and other green spaces. Even without actively utilizing green spaces, simply being passively and unconsciously exposed to them can offer benefits such as improving well-being (Sharifi et al., 2021), fostering prosocial behavior (Putra et al., 2021), and alleviating stress (Lin et al., 2019) and loneliness (Astell-Burt et al., 2022). Therefore, exploring the benefits of passive green space exposure may offer a simple and effective strategy for reducing relative deprivation.

Furthermore, the self-determination theory proposes that favorable environments satisfy basic psychological needs, leading to positive psychological outcomes and reducing negative consequences (Deci and Ryan, 2000; Deci and Ryan, 2012; Yang et al., 2022). This provides a solid theoretical foundation from a motivational perspective on how the environment (passive green space exposure) influences psychology (relative deprivation) and offers insights into the dynamics of this relationship. Therefore, this study extends the existing literature by examining the relationship between passive green space exposure and relative deprivation and exploring the mediating role of basic psychological needs. We conducted two correlational studies (Studies 1a and 1b) and one experimental study (Study 2) to investigate these effects systematically. In conclusion, this study examined the impact of the surrounding natural environment on relative deprivation. This will contribute to sustainable intervention in relative deprivation.

1.1. Passive green space exposure

People interact with these natural environments in various ways, including active and passive green space exposure (Norwood et al., 2019). Active green space exposure refers to individuals consciously engaging in activities in natural environments and using nature as a part of learning and therapy, such as horticultural and wilderness therapies. Conversely, people living in these natural environments often lack the awareness that they are already integrated into them or unconsciously engage in activities within these natural environments, which is referred to as passive green space exposure. This includes passing by nature, observing the surrounding natural environment, and engaging in activities such as walking or jogging. Although active and passive forms of green space exposure have demonstrated positive effects, a critical limitation of research on active green space exposure is the difficulty in disentangling the intrinsic benefits of nature from other potential confounding factors (Norwood et al., 2019). Therefore, exploring the effects of passive green space exposure is particularly important, as it offers a clearer understanding of the unique psychological and social benefits provided by natural environments.

Previous studies have used different methods to measure passive green space exposure, including the assessment of green views by the Normalized Difference Vegetation Index (NDVI) to obtain objective passive green space exposure data (Dadvand et al., 2015) and questionnaire surveys to understand people's subjectively perceived passive green space exposure (Liu et al., 2023a; Markevych et al., 2017; Shentova et al., 2022). Previous studies have shown that the NDVI sometimes diverges from individuals' subjective perceptions of green spaces (Teeuwen et al., 2024), and these two measures do not always produce consistent results when predicting mental health (Sun et al., 2022). Combining these two indicators can provide a more comprehensive understanding of passive green space exposure. Additionally, existing studies have often focused on correlations rather than examining the effects of passive green space exposure on psychological outcomes. To address this limitation, recent studies have employed experimental paradigms to manipulate passive green space exposure, revealing its effects on aggression (Liu et al., 2024). This study integrates the aforementioned methods to examine the effects of passive green space exposure comprehensively.

1.2. Passive green space exposure and relative deprivation

The natural environment is closely associated with relative deprivation. Research has found that the deterioration of the natural environment to which people are attached may be a potential cause of social dissatisfaction because a decline in the quality of the natural environment leads to an increase in people's relative deprivation (Walker et al., 2015). This result indicates that people can derive positive experiences from the natural environment, sensitively perceive how environmental changes affect them, and use these experiences as the basis for societal cognition.

Although limited research has specifically investigated the impact of passive green space exposure on relative deprivation, evidence indicates a notable association between such exposure and the core dimensions of relative deprivation in terms of cognition and emotion. At the cognitive level, social comparison serves as the central psychological mechanism of relative deprivation, involving horizontal comparisons with in-group or out-group members and vertical comparisons with past or future circumstances (Smith et al., 2012). Passive green space exposure promotes self-acceptance and shifts the focus away from self-evaluation, reducing the likelihood of social comparison (Pritchard et al., 2020; Ruan et al., 2023; Wang et al., 2022a). Furthermore, emotions such as anger and dissatisfaction, resulting from discrepancies between reality and expectations after social comparison, are important components of relative deprivation (Smith et al., 2012). Correspondingly, higher levels of green space predict lower levels of negative emotions (Wang et al., 2022b). Therefore, passive green space exposure could also alleviate negative emotions such as disappointment and resentment that arise after social comparison. Based on these findings, we hypothesized that passive green space exposure would be negatively related to relative deprivation.

1.3. The mediating role of basic psychological needs

The fundamental principles of self-determination theory revolve around basic psychological needs—autonomy, competence, and relatedness—the three essential elements for an individual's healthy development (Deci and Ryan, 2000). Autonomy is defined as the need to be in control of one's behavior and feel psychologically free; competence is the requirement to exert control over one's surroundings and possess the capability to achieve objectives, and relatedness refers to the desire for close relationships with others and to receive care and support. A positive environment is key to satisfying all three basic psychological needs (Deci and Ryan, 2012; Peters et al., 2020). People can achieve beneficial outcomes such as well-being and meaning (Martela et al., 2023) and reduce negative outcomes such as depression and problematic behavior (Tian et al., 2018) only when these three needs are satisfied. In other words, basic psychological needs are key variables in explaining the impact of the environment on psychological and behavioral outcomes.

Basic psychological needs may be effectively satisfied through passive green space exposure. First, it provides individuals with free space and opportunities for autonomous choice, creating favorable conditions for the satisfaction of autonomy (Yang et al., 2022). Interviews with residents revealed that being surrounded by nature made them feel free, unjudged, and able to be themselves, which is difficult to achieve in socially constrained and judgmental environments (Birch et al., 2020). Conversely, manufactured environments typically have explicit rules and behavioral norms that restrict individual choices. Passive green space exposure allows for a wider range of behaviors, promoting the development of autonomy (Araújo, 2019). For example, Fjortoft and Sageie (2000) found that green spaces better meet children's diverse play needs compared to manufactured environments.

Second, passive green space exposure significantly reduces the stress individuals experience in their environment while enhancing vitality and self-efficacy, significantly satisfying the need for competence (Lin

et al., 2019; Tesler et al., 2022; van den Berg et al., 2016). Researchers have found that in high-stress situations, passive green space exposure effectively alleviates stress (Maury-Mora et al., 2022). This allows individuals to focus more on exploring and mastering their surroundings, better utilizing their abilities and potential. Furthermore, passive green space exposure enhances multisensory experiences, promotes cognitive expansion, stimulates exploration and learning processes, and ultimately boosts confidence and a sense of control in completing tasks (Tang et al., 2023). McCormick (2017) found that passive green space exposure helps children escape stress and has a significantly positive impact on their competence development.

Additionally, passive green space exposure reduces feelings of loneliness and enhances a sense of belonging, which are prerequisites for satisfying the need for relatedness (Rugel et al., 2019). Through a series of experiments, Poon et al. (2015) discovered that individuals subjected to social exclusion have a greater desire to engage with nature and demonstrate more pro-environmental behaviors. This may be because natural environments can replace social connections, offering a sense of belonging that excluded individuals lack. Research indicates that residents experience a greater sense of belonging in neighborhoods featuring periodic markets situated in green spaces than in those without green spaces (Aram et al., 2019). Individuals living within 1600 m of green spaces, especially those living alone, have a lower cumulative incidence of loneliness (Astell-Burt et al., 2022). Therefore, passive green space exposure may have a significant positive correlation with the three basic psychological needs.

Basic psychological needs are important antecedents of relative deprivation (Xie et al., 2018). When individuals' three basic psychological needs are unmet or frustrated, their attention tends to internalize and focus on satisfying them, leading to decreased attention to their surrounding environment (Deci and Ryan, 2000). In such cases, individuals may become more inclined to adhere to external rules or norms, which can result in feelings or behaviors misaligned with their needs. Specifically, when individuals feel a lack of control and freedom, experience incompetence and frustration, or feel isolated and excluded, they will likely compensate for these frustrated needs by increasing their pursuit of external goals such as money or social status. This tendency increases the likelihood of engaging in social comparisons and experiencing relative deprivation (Zhang and Zhang, 2016).

Conversely, when basic psychological needs are adequately satisfied, individuals become less reliant on external rewards and experience enhanced intrinsic motivation and fulfillment (Deci and Ryan, 2000). Whether it is the satisfaction of feeling control over internal and external environments or experiencing acceptance and care from others, such satisfaction makes individuals more likely to perceive what they deserve, reducing the need for social comparison and significantly lowering the likelihood of experiencing relative deprivation (Zhang et al., 2015). Additionally, findings from a meta-analysis showed a significant correlation between the satisfaction of three basic psychological needs and an increase in positive emotions alongside a decrease in negative emotions (Stanley et al., 2021). This also suggests that satisfaction with basic psychological needs may help reduce the resentment and dissatisfaction resulting from social comparisons. Therefore, satisfaction with basic psychological needs may negatively correlate with relative deprivation.

1.4. The present study

Considering these research gaps, this study addresses several key issues. First, although an independent examination of passive green space exposure can provide valuable insight into the unique benefits of natural environments, few studies have exclusively examined its impact (Liu et al., 2023b; Norwood et al., 2019). Second, current research on passive green space exposure often relies on single-source indicators or correlational methods, which restricts a thorough understanding of its psychological impacts. Third, although previous studies have suggested a potential connection between passive green space exposure and the core dimensions of relative deprivation (Wang et al., 2022a; Wang et al., 2022b), research directly examining this relationship is lacking. Finally, simply exploring this relationship without further examining the underlying mechanisms may limit the understanding of such phenomena and restrict theoretical precision and practical applications. To address this gap, this study explored the relationship between passive green space exposure and relative deprivation. Specifically, our hypotheses were as follows: (1) passive green space exposure is negatively correlated with relative deprivation; (2) the three basic psychological needs (autonomy, competence, and relatedness) mediate the relationship between passive green space exposure and relative deprivation.

Two studies were conducted to test the hypotheses. Study 1 comprised two sub-studies that measured passive green space exposure using the NDVI and a questionnaire. The goal was to examine the relationship between subjective and objective passive green space exposure and relative deprivation while exploring the mediating roles of autonomy, competence, and relatedness. Study 2 used a one-factor experimental design to examine the effects of passive green space exposure on relative deprivation. This design provided stronger evidence for causality by enabling direct manipulation of exposure. Approval for all the studies was obtained from the ethics committee of the first author's university. The theoretical framework of this research is depicted in Fig. 1.

2. Study1

2.1. Study 1a

2.1.1. Participants and procedure

In July 2023, we recruited a total of 300 participants through Credamo (https://www.credamo.com). Credamo is a paid online research participation platform that is a member of ESOMAR (the European Society for Opinion and Marketing Research), gaining professional recognition from both the academic community and international peers. With its unique sampling methodology and extensive user database, Credamo covers all provinces, cities, and regions of China, as well as a wide range of occupational groups, ensuring the representativeness of the data (Wu et al., 2022). First, participants completed informed consent. Then, participants completed questionnaire measures that included demographic information, neighborhood information, relative deprivation, as well as basic psychological needs. Finally, all participants were reimbursed with 5 RMB for their participation.

To ensure the survey validity, answer settings were configured on Credamo before the study began, including intelligent human-machine verification, restrictions on duplicate responses, limiting one submission per IP, and ensuring participants were located at least 1 km apart. In addition, two indicators were selected to filter the questionnaire in order to exclude incomplete data and participants who responded carelessly: (1) Participants did not pass the attention check item, meaning that participants did not select "strongly disagree" on the item "I never eat anything."; (2) The monthly average NDVI of the participants' neighborhoods over the past 12 months could not be obtained. This left a final sample of 263 participants (51.7 % female, $M_{age} = 32.80$, $SD = 6.78$). Additional demographic information is provided in Supplementary Table 1.

2.1.2. Measures

Objective passive green space exposure. The NDVI was used to assess objective passive green space exposure. NDVI, which ranges from $-1 \sim 1$, is derived from the visible and near-infrared light reflected by photosynthetic plants, with values nearing 1 signifying greater vegetation coverage. Previous research has already demonstrated that NDVI is capable of effectively measuring the long-term exposure to residential greenness (Xue et al., 2019). Based on the geographic location information of the participants' neighborhood, we obtained the monthly

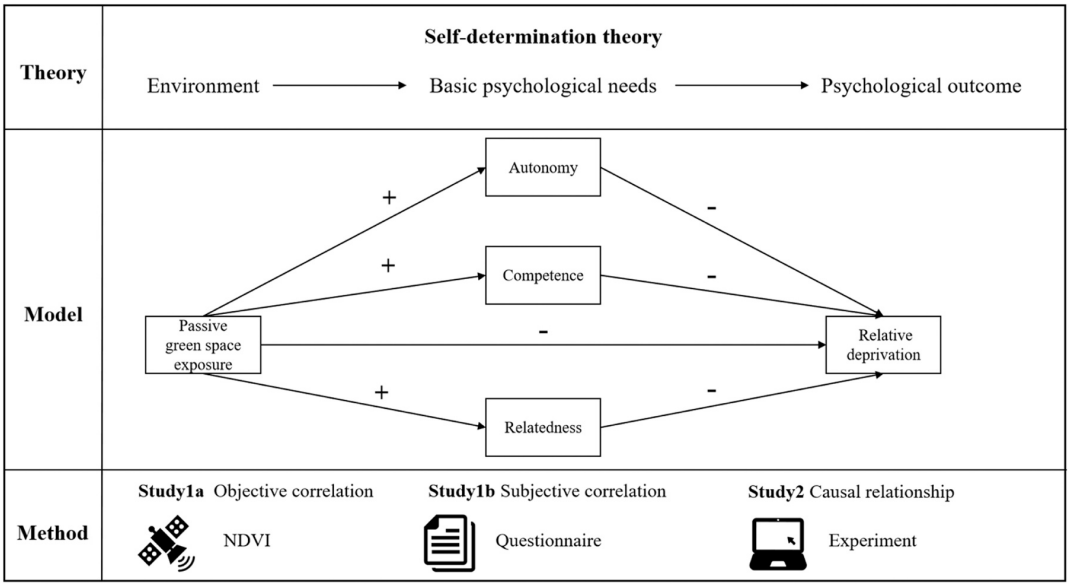

Fig. 1. The theoretical framework.

average NDVI for each neighborhood over the past 12 months (from July 2022 to June 2023) and calculated the annual average (Sentinel-2 data from Google Earth Engine, with a spatial resolution of 10 m × 10 m). Specifically, we calculated the annual mean NDVI within each neighborhood, and in the 100 m, 500 m and 1000 m buffers around the neighborhood, abbreviated as $NDVI_{inside}$, $NDVI_{100}$, $NDVI_{500}$, and $NDVI_{1000}$, respectively.

Relative deprivation. The assessment of relative deprivation was conducted with the Personal Relative Deprivation Scale (Callan et al., 2011). The scale contains 5 items, such as "I feel deprived when I think about what I have compared to what other people like me have." Participants rated their feelings on a scale of 1–6, where higher scores reflected stronger agreement with the statements. Following the reverse coding of negative terms, higher average scores indicated higher levels of relative deprivation. Cronbach's α for this scale was 0.71 in the present study.

Basic psychological needs. The assessment of basic psychological needs was conducted with the Need-Satisfaction Scale (La Guardia et al., 2000). The measure consists of three dimensions: autonomy, competence, and relatedness. Each dimension contains 3 items, resulting in a total of 9 items on the scale, such as "I feel free to be myself," "I feel that I am a capable person," and "I feel loved and cared for." The Likert five-point scale was used for scoring. Following the reverse coding of items that were negatively worded, higher average scores reflected a greater level of satisfaction with basic psychological needs. In the present study, Cronbach's α was 0.84 for the overall scale, 0.67 for autonomy, 0.73 for competence, and 0.64 for relatedness.

Control variables. Based on previous research, demographic variables such as gender, age, educational level, and monthly income may influence relative deprivation (Xiong and Ye, 2016). Therefore, we measured these variables as control variables. The specific items include: "What is your gender?" (0 = male, 1 = female); "What is your age?"; "What is your educational level?" (1 = no formal education, 2 = primary school, 3 = junior high school, 4 = high school/vocational school/technical school, 5 = junior college, 6 = bachelor's degree, 7 = master's degree, 8 = Ph.D. degree); "What is your monthly income?" (1 = no income, 2 = 1999 RMB and below, 3 = 2000–4999 RMB, 4 = 5000–9999 RMB, 5 = 10000–19999 RMB, 6 = 20000–29999 RMB, 7 = 30000 RMB and above).

Furthermore, subjective socioeconomic status (SES) is an important social environmental variable that influences relative deprivation (Xiong and Ye, 2016). Therefore, we assessed SES with the MacArthur Scale of Subjective Social Status (Adler et al., 2000). Each participant was requested to identify their position on a 10-step ladder, where 1 represents the lowest social status and poorest people and 10 represents the highest social status and richest people. Higher scores indicated higher SES.

2.1.3. Statistical analysis

SPSS 23.0 was used for statistical analysis. First, descriptive statistics for the variables were calculated. Next, Cronbach's alpha was used to evaluate the internal consistency of the scale. Then, Spearman's correlation analysis was used to assess the relationships between all variables. Following this, variance inflation factors (VIF) were used to diagnose collinearity issues. A VIF value below 5 is generally considered acceptable (Shrestha, 2020).

Building on these preliminary analyses, a parallel mediation model (Model 4 of the PROCESS Macro in SPSS; Hayes, 2013) was used to examine the mediating roles of autonomy, competence, and relatedness in the relationship between objective passive green space exposure and relative deprivation. This method estimates the unique contributions of each need, highlighting their distinct psychological functions. The analysis controlled for gender, age, educational level, monthly income, and SES. Objective passive green space exposure ($NDVI_{inside}$ and $NDVI_{100}$) was treated as the independent variable, autonomy, competence, and relatedness needs as the mediator variables, and relative deprivation as the dependent variable. The mediation effect was assessed using 95 % bootstrapped confidence intervals with 5000 resamples (Hayes and Scharkow, 2013). A significant mediating effect was indicated if the 95 % bias-corrected confidence interval did not include zero, suggesting that the mediating path was statistically robust.

2.1.4. Results

Correlation analyses were conducted for key variables and control variables (as shown in Table 1). The results showed that among the indicators of objective passive green space exposure, only $NDVI_{inside}$ and $NDVI_{100}$ showed significant correlations with other key variables, while $NDVI_{500}$ and $NDVI_{1000}$ were not. Relative deprivation was negatively correlated with both the total score of basic psychological needs and its dimensions. Multicollinearity diagnostics showed that VIFs for all

Table 1
Descriptive statistics and correlations between variables in Study 1a.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Objective passive green space exposure	–													
1.$NDVI_{inside}$	–													
2.$NDVI_{100}$	.765***	–												
3.$NDVI_{500}$	.444***	.742***	–											
4.$NDVI_{1000}$	.331***	.577***	.888***	–										
5. Relative deprivation	−.174**	−.142*	−.119	−.065	–									
6. Basic psychological needs	.263***	.192**	.136*	.080	−.565***	–								
7.Autonomy	.211**	.160**	.117	.071	−.538***	.870***	–							
8.Competence	.211**	.164**	.116	.055	−.519***	.831***	.572***	–						
9.Relatedness	.248***	.165**	.113	.077	−.371***	.841***	.612***	.547***	–					
Covariates														
10. Gender	.062	.004	−.043	−.039	−.167**	.122*	.103	.163**	.043	–				
11. Age	−.028	.010	.020	.059	−.074	.043	.089	.021	−.008	−.110	–			
12. Educational level	.106	.022	.030	−.019	−.245***	.137*	.102	.190**	.055	.115	−.234***	–		
13. Monthly income	.140*	.075	.091	.019	−.297***	.262***	.241***	.240***	.184**	.039	.093	.468***	–	
14. Subjective socioeconomic status	−.009	−.052	−.066	−.109	−.225***	.260***	.225***	.277***	.158*	.089	.098	.298***	.510***	–
M	0.21	0.22	0.22	0.23	2.83	4.14	4.04	4.18	4.21	0.52	32.80	6.08	4.52	5.80
SD	0.08	0.07	0.07	0.07	0.78	0.52	0.66	0.60	0.58	0.50	6.78	0.67	0.91	1.44

Notes. M: mean. *SD*: standard deviation. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

predictors ranged from 1.06 to 2.58, indicating no serious multicollinearity.

The regression results of all key variables in the mediation model were shown in Fig. 2 and Table 2. The results showed that basic psychological needs fully mediated the relationship between $NDVI_{inside}$ and relative deprivation. In the mediation model, the total effect was significant, while the direct effect was not significant. The indirect effect of $NDVI_{inside}$ on relative deprivation through basic psychological needs was significant. Notably, $NDVI_{inside}$ had significant indirect effects on relative deprivation through autonomy and competence, while the indirect effect through relatedness was not significant.

In a similar manner, basic psychological needs fully mediated the relationship between $NDVI_{100}$ and relative deprivation. In the mediation model, the total effect was significant, while the direct effect was not significant. The indirect effect of $NDVI_{100}$ on relative deprivation through basic psychological needs was significant, with significant indirect effects through autonomy and competence; however, the effect through relatedness was not significant.

2.2. Study 1b

2.2.1. Participants and procedure

In December 2023, we recruited a total of 300 participants through Credamo. First, participants completed informed consent. Then, participants completed questionnaire measures that included demographic information, subjective passive green space exposure, relative deprivation, as well as basic psychological needs, Finally, all participants were reimbursed with 5 RMB for their participation.

Study 1b used the same answer settings as Study 1a. After data collection, 12 participants were excluded for failing to pass the attention check item, as they did not select "strongly disagree" in response to the statement, "I never drink water." This left a final sample of 288 participants (64.6 % female, M_{age} = 32.91, *SD* = 7.23). Additional demographic information is provided in Supplementary Table 2.

2.2.2. Measures

Subjective passive green space exposure. Subjective passive green

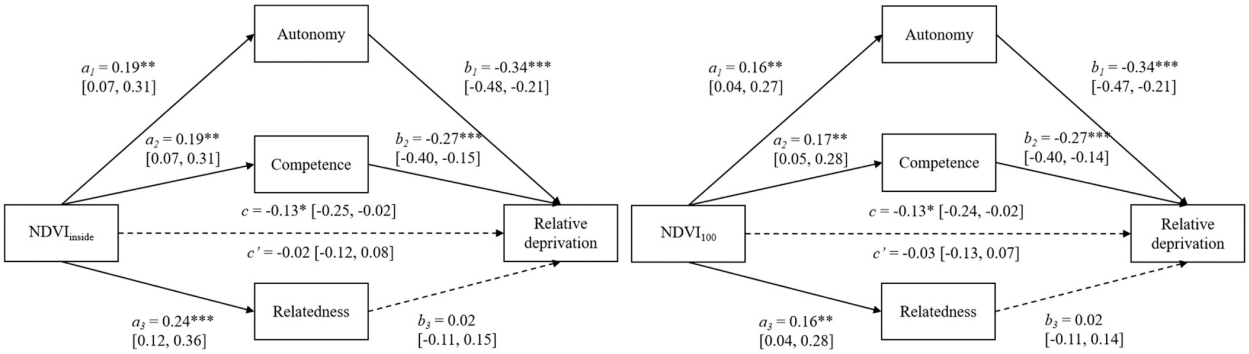

Fig. 2. The mediating role of basic psychological needs between objective passive green space exposure (i.e., NDV_{inside} and $NDVI_{100}$) and relative deprivation (Study 1a).

Notes: The path coefficients above are all standardized. The number of bootstrap samples = 5000. Control variables are gender, age, educational level, monthly income and subjective socioeconomic status. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 2
Standardized coefficients of the mediation model in Study 1a.

Independent variable	Model	β	*SE*	95 % CI	Ratio (%)
$NDVI_{inside}$	Total effect	−0.13	0.06	[−0.25, −0.02]	
	Direct effect	−0.02	0.05	[−0.12, 0.08]	
	Total indirect effect	−0.11	0.04	[−0.18, −0.05]	
	$NDVI_{inside}$→Autonomy→RD	−0.06	0.03	[−0.12, −0.02]	55.55 %
	$NDVI_{inside}$→Competence→RD	−0.05	0.02	[−0.10, −0.01]	44.45 %
	$NDVI_{inside}$→Relatedness→RD	0.00	0.02	[−0.03, 0.04]	
$NDVI_{100}$	Total effect	−0.13	0.06	[−0.24, −0.02]	
	Direct effect	−0.03	0.05	[−0.13, 0.07]	
	Total indirect effect	−0.10	0.04	[−0.17, −0.03]	
	$NDVI_{100}$→Autonomy→RD	−0.05	0.03	[−0.11, −0.01]	50.00 %
	$NDVI_{100}$→Competence→RD	−0.05	0.02	[−0.10, −0.01]	50.00 %
	$NDVI_{100}$→Relatedness→RD	0.00	0.01	[−0.02, 0.03]	

Note. RD = Relative Deprivation; Ratio = Specific indirect effect/Total indirect effect.

space exposure was assessed using a two-item Likert scale (Liu et al., 2023a). The two items are: "How green is your community and surrounding environment, including gardens, trees, parks, and other natural areas?" and "How much greenery is visible from the room where you spend most of your time at home, including parks, gardens, and trees?" Responses were rated on a 10-point scale from 1 (little) to 10 (a lot), with higher average scores indicating greater subjective passive green space exposure. Cronbach's α for this scale was 0.86 in the present study.

Other scales were the same as in Study 1a, including relative deprivation (Cronbach's α = 0.79), basic psychological needs (Cronbach's α = 0.87 for the overall scale; 0.69 for autonomy, 0.76 for competence, and 0.70 for relatedness), gender, age, educational level, monthly income, and SES.

2.2.3. Statistical analysis

The statistical analysis methods and procedures employed in Study 1b were consistent with those utilized in Study 1a.

2.2.4. Results

Correlation analyses were conducted for key variables and control variables (as shown in Table 3). The results indicated significant correlations among subjective passive green space exposure, the total score and dimensions of basic psychological needs, and relative deprivation. Multicollinearity diagnostics showed that VIFs for all predictors ranged from 1.07 to 2.61, indicating no serious multicollinearity.

The regression results of all key variables in the mediation model were shown in Fig. 3 and Table 4. The results showed that basic psychological needs played a partial mediating role in the relationship between subjective passive green space exposure and relative deprivation. The total effect, direct effect, and indirect effect in the mediation model were all significant. Notably, subjective passive green space exposure had significant indirect effects on relative deprivation through autonomy and competence, while the indirect effect through relatedness was not significant.

3. Study2

3.1. Methods

3.1.1. Participants

To determine an optimal sample size for this study, an a priori power analysis was conducted using G*Power 3.1.9.2 (Faul et al., 2007). With a medium effect size (d = 0.5), a significance level of 0.05, and a statistical power of 95 %, the required sample size was calculated to be 210 participants.

In February 2024, we recruited a total of 230 participants through Credamo. Similar to Studies 1a and 1b, this study applied the same answer settings before starting. After the experiment, 16 participants were removed from the sample because they did not select "strongly disagree" for the item "I never sleep." This left a final sample of 214 participants (58.9 % female, M_{age} = 31.30, *SD* = 9.06). Additional demographic information is provided in Supplementary Table 3.

3.1.2. Procedure and measures

For this experiment, participants first completed informed consent. After providing demographic information, they were randomly assigned to a high passive green space exposure scene (109 participants) or a low passive green space exposure scene (105 participants). Participants completed the passive green space exposure manipulation task. Based on previous research (Liu et al., 2024), different images and accompanying texts depicted hypothetical communities with varying levels of passive green space exposure (for images, see Fig. 4). In the high exposure condition, participants were shown an image of a community with high

Table 3
Descriptive statistics and correlations between variables in Study 1b.

	1	2	3	4	5	6	7	8	9	10	11
1.Subjective passive green space exposure	–										
2.Relative deprivation	−.409***	–									
3.Basic psychological needs	.420***	−.611***	–								
4.Autonomy	.404***	−.610***	.900***	–							
5.Competence	.326***	−.538***	.880***	.687***	–						
6.Relatedness	.386***	−.467***	.873***	.691***	.642***	–					
Covariates											
7.Gender	−.103	.124*	−.129*	−.088	−.186**	−.066	–				
8.Age	−.079	−.062	−.034	.024	−.055	−.061	−.036	–			
9.Educational level	.032	.024	.024	−.042	.079	.027	.100	−.175**	–		
10.Monthly income	.179**	−.282***	.320***	.284***	.284***	.282***	.036	.048	.350***	–	
11.Subjective socioeconomic status	.275***	−.433***	.355***	.358***	.312***	.267***	−.039	.074	.101	.371***	–
M	7.35	2.88	4.07	3.97	4.09	4.16	0.65	32.91	6.02	4.41	5.77
SD	1.60	0.89	0.60	0.70	0.69	0.64	0.48	7.23	0.74	0.83	1.37

Note. M: mean. *SD*: standard deviation. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

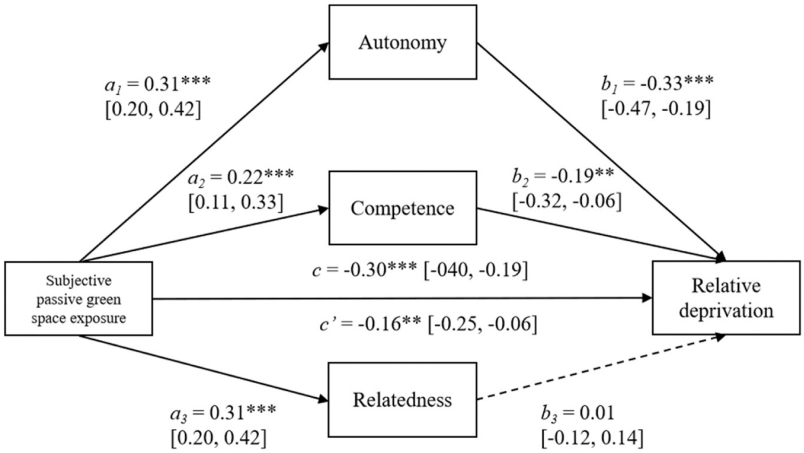

Fig. 3. The mediating role of basic psychological needs between subjective passive green space exposure and relative deprivation (Study 1b).
Notes: The path coefficients above are all standardized. The number of bootstrap samples = 5000. Control variables are gender, age, educational level, monthly income and subjective socioeconomic status. $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 4
Standardized coefficients of the mediation model in Study 1b.

Model	*β*	*SE*	95 % CI	Ratio(%)
Total effect	−0.30	0.05	[−0.40, −0.19]	
Direct effect	−0.16	0.05	[−0.25, −0.06]	53.33 %
Total indirect effect	−0.14	0.04	[−0.22, −0.08]	46.67 %
SPGSE→Autonomy→RD	−0.10	0.03	[−0.18, −0.04]	33.34 %
SPGSE→Competence→RD	−0.04	0.02	[−0.09, −0.01]	13.33 %
SPGSE→Relatedness→RD	0.00	0.02	[−0.05, 0.05]	

Note. SPGSE = Subjective Passive Green Space Exposure; RD = Relative Deprivation; Ratio = Specific effect/Total effect.

green space exposure. The text encouraged them to imagine living in a lush, evergreen community, where they could always look out their windows and see vibrant, green landscapes. However, under the low exposure condition, participants viewed images of a community with low green space exposure. The text guided them to imagine scenarios that were also the opposite of those in the high exposure condition. Participants were asked to imagine living in the community depicted in the image and text for five years. They were then required to describe their feelings about living in the imagined community in 30–50 words.

Following that, participants were required to complete the questionnaire as if they were residents of the illustrated neighborhood, which consisted of subjective passive green space exposure (Cronbach's α = 0.96), relative deprivation (Cronbach's α = 0.76), basic psychological needs (Cronbach's α = 0.90 for the overall scale; 0.74 for autonomy, 0.78 for competence, and 0.77 for relatedness), as well as perceived socioeconomic status. Finally, all participants were reimbursed with 5 RMB for their participation.

3.2. Statistical analysis

SPSS 23.0 was used for statistical analysis. First, descriptive statistics for the variables were calculated. Next, Cronbach's alpha was used to evaluate the internal consistency of the scale. Then, VIFs were used to diagnose collinearity issues. Following this, an independent samples *t*-test was used to evaluate whether the manipulation of passive green space exposure was successful and whether there were significant differences in relative deprivation between the two groups.

To examine the mediating effects, a parallel mediation analysis was conducted using PROCESS Model 4 in SPSS (Hayes, 2013). Since PROCESS allows both continuous and categorical independent variables, this study, consistent with Study 1, treated the experimental condition as the independent variable (1 = high passive green space exposure, 0 = low passive green space exposure). Basic psychological needs (autonomy, competence, and relatedness) were included as mediator variables, relative deprivation as the dependent variable, and gender, age, educational level, monthly income, and perceived socioeconomic status as control variables.

3.3. Results

3.3.1. Collinearity diagnosis

Descriptive statistics for the variables are provided in Supplementary Table 4. The calculation of VIFs showed that all predictors had VIFs ranging from 1.05 to 3.17 in the present study.

Fig. 4. Example image of high passive green space exposure scene vs. low passive green space exposure scene (Study 2).

3.3.2. Perceived passive green space exposure manipulation test

The results showed that participants in the high passive green space exposure group reported a higher perceived level of passive green space exposure ($M = 8.37$, $SD = 1.06$) compared to those in the low passive green space exposure group ($M = 2.87$, $SD = 2.00$), $t = 25.30$, $p < 0.001$, 95 %CI = [5.07, 5.93]. Thus, the manipulation check was effective.

3.3.3. Effect of perceived passive green space exposure on relative deprivation

The results showed that participants in the high passive green space exposure group reported a lower perceived level of relative deprivation ($M = 2.49$, $SD = 0.75$) compared to those in the low passive green space exposure group ($M = 3.56$, $SD = 0.94$), $t = -9.22$, $p < 0.001$, 95 %CI = [-1.30, -0.84].

3.3.4. Testing for the mediating effect

The regression results of all key variables in the mediation model were shown in Fig. 5 and Table 5. The results indicated that basic psychological needs fully mediated the relationship between perceived passive green space exposure and relative deprivation. In the mediation model, the total effect was significant, while the direct effect was not significant. More crucially, perceived passive green space exposure had significant indirect effects on relative deprivation through basic psychological needs, which include autonomy, competence, and relatedness.

Table 5
Standardized coefficients of the mediation model in Study 2.

Model	*β*	*SE*	95 % CI	Ratio(%)
Total effect	−0.80	0.12	[−1.04, −0.57]	
Direct effect	0.17	0.13	[−0.09, 0.43]	
Total indirect effect	−0.97	0.13	[−1.23, −0.72]	
PGSE→Autonomy→RD	−0.33	0.10	[−0.52, −0.13]	34.02 %
PGSE→Competence→RD	−0.33	0.10	[−0.54, −0.16]	34.02 %
PGSE→Relatedness→RD	−0.31	0.12	[−0.55, −0.08]	31.96 %

Note. PGSE = Passive Green Space Exposure; RD = Relative Deprivation; Ratio = Specific indirect effect/Total indirect effect.

4. Discussion

Based on self-determination theory, this study examined the relationship between passive green space exposure and relative deprivation. All studies found consistent results that passive green space exposure was negatively related to relative deprivation. Moreover, passive green space exposure reduced relative deprivation by satisfying three basic psychological needs. In particular, the roles of autonomy and competence were more stable, with mediating effects found in all studies.

4.1. Key findings

This study preliminarily confirms that passive green space exposure can reduce relative deprivation. In Study 1, the objective and subjective measures of passive green space exposure were consistently negatively correlated with relative deprivation, confirming our first hypothesis. Study 2 provided further causal evidence: participants with high passive green space exposure reported greater satisfaction with their basic psychological needs and lower perceived relative deprivation. These findings are consistent with previous research demonstrating a strong association between the natural environment and relative deprivation (Walker et al., 2015).

Notably, greenery within 500 m and 1000 m of the neighborhood showed no significant association with relative deprivation. Conversely, a higher degree of greenery within 100 m of the neighborhood (including the inside) was associated with lower levels of relative deprivation, probably because relative deprivation is the result of people comparing "own" with "other people's" (Smith et al., 2012). The green spaces within the neighborhood and the surrounding 100 m area may represent environments that individuals frequently encounter in their daily lives. Therefore, greenery within this range may be perceived as their "own." Thus, people may intentionally or unintentionally include this aspect of greenery in their comparisons. The more "own" greenery there is, the more the relative deprivation in people's minds will be reduced. Contrarily, greenery outside the 100 m perimeter of the neighborhood may be perceived as other people's or the public's and excluded from the comparison.

Additionally, the correlational and experimental studies consistently found that basic psychological needs mediated the relationship between passive green space exposure and relative deprivation, supporting Hypothesis 2. Consistent with self-determination theory, passive green space exposure satisfied basic psychological needs and provided people with the sense that they were getting what they deserved, such as feelings of control over their lives, accomplishment, efficacy, and intimate connections with others (Deci and Ryan, 2000). This reduced the likelihood of relative feelings of deprivation. Basic psychological needs partially mediated the relationship for subjective passive green space exposure and fully mediated it for objective and experimental measures.

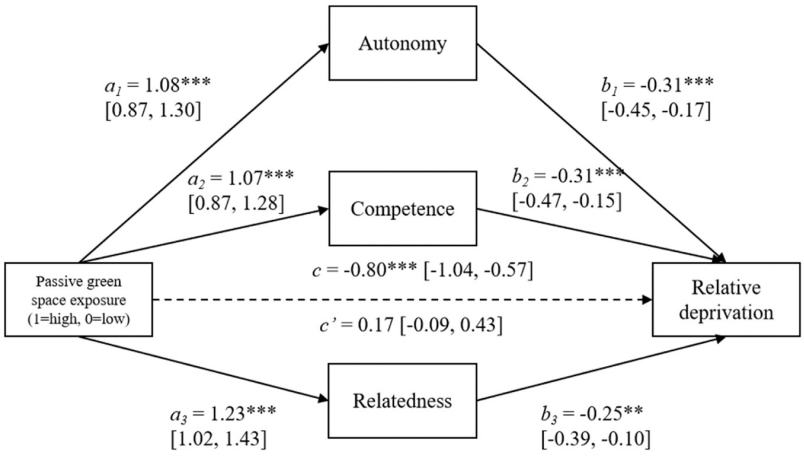

Fig. 5. The mediating role of basic psychological needs between passive green space exposure and relative deprivation (Study 2).
Notes: The path coefficients above are all standardized. The number of bootstrap samples = 5000. Control variables are gender, age, educational level, monthly income and perceived socioeconomic status. $^{**}p < 0.01$, $^{***}p < 0.001$.

This suggests that subjective passive green space exposure may have a direct impact on relative deprivation. This aligns with previous research (Sun et al., 2022) indicating that subjective and objective measures may predict psychological outcomes inconsistently, emphasizing the importance of using both for a complete understanding.

However, none of these three basic psychological needs exhibited equally strong mediating effects. The mediating effects of autonomy and competence were significant across all studies, whereas the mediating effect of relatedness was only observed in Study 2. Consistent with previous research, the findings showed that satisfaction with autonomy and competence serves as a protective factor against relative deprivation more than satisfaction with relatedness (Crosby, 1976; Xie et al., 2018). This discrepancy in the results may be attributed to the unique design of Study 2, which required participants to imagine a spatial scenario of passive green space exposure. In this experimental context, "green space" was not merely a visual representation of the natural environment but also a potential setting for social interactions. This might have heightened the participants' sensitivity to relatedness needs, prompting them to imagine community life and social interactions within this context. Furthermore, this imaginative process may have led the participants to an unconscious comparison of their social relationships and sense of belonging with those of others, influencing their sense of relative deprivation. This suggests that while passive green space exposure can satisfy the need for relatedness, the effectiveness of this need in reducing relative deprivation may depend closely on the participants' sensitivity to it. Additionally, the self-determination theory posits that the impact of relatedness needs is generally more distal than that of autonomy and competence needs (Ryan and Deci, 2000). Even when the mediating effect of relatedness needs reached statistical significance in Study 2, its effect size was notably lower than that of autonomy and competence needs, further supporting this theoretical perspective.

4.2. Research significance

These findings enrich theoretical understanding. First, this study focused on the impact of passive green space exposure, revealing the unique psychological effects of unconscious and inactive exposure to natural environments. These findings enhance our understanding of the therapeutic effects of nature from the perspective of passive perception.

Second, this study expanded on the antecedents of relative deprivation. Previous research has focused primarily on the influence of social and environmental factors on relative deprivation (Smith et al., 2012). We extended this exploration to the natural environments that people encounter in their daily lives and found that nature can reduce negative feelings of relative deprivation even when it is not intentionally utilized. Moreover, this research identified specific conditions under which passive green space exposure alleviates relative deprivation. The natural environment within a limited range, particularly within 100 m of residential neighborhoods, is critical in influencing relative deprivation. However, subjective perceptions of abundant green vegetation around the community also played a crucial role in reducing relative deprivation. This finding is significant for densely populated areas. Even with limited objective green spaces, the subjective perception of green-rich surroundings can significantly reduce relative deprivation, highlighting the potential to maximize the psychological benefits of natural environments in space-constrained urban settings.

Third, this study provides empirical support for the self-determination theory. Previous research has shown that the natural environment enhances well-being and life satisfaction by fulfilling basic psychological needs. Our findings further demonstrated that natural environments could also reduce negative psychological outcomes, such as relative deprivation, by satisfying these needs. Further, our findings revealed that the influence of the three basic psychological needs on the relationship between passive green space exposure and relative deprivation varied, with autonomy and competence showing stronger effects than relatedness.

Moreover, these findings provide practical insights for policymakers, communities, and individuals to leverage natural environments to reduce relative deprivation. Urban planners could design environments and green spaces to meet basic psychological needs, reducing social comparison and deprivation. Governments should optimize the distribution of green spaces, ensuring sufficient greenery within 100 m of residences, with a focus on areas with limited resources or vulnerable populations. When space is constrained, it may be beneficial to prioritize visible greenery such as outside windows and along greenways. Additionally, governments could enhance residents' perceptions by improving landscape quality, removing visual obstructions, increasing visibility, and adding artistic elements to public messaging to maximize the benefits of nature.

For communities with limited resources, enhancing existing green space coverage can cost-effectively boost residents' sense of "owned" green space and reduce social comparison. Moreover, integrating green spaces into neighborhood gatherings, parent-child activities, or outdoor exercises can meet residents' relatedness needs, alleviating relative deprivation.

Although passive green space exposure is an "unconscious" process, individuals can consciously enhance their psychological benefits by selecting their living environment or adjusting their cognitive approaches. For example, individuals can choose to live in communities with abundant green resources or increase their exposure to natural environments in daily life by walking or appreciating greenery through windows.

4.3. Limitations and future directions

This study has several limitations that require resolution in future studies. First, the passive green spaces explored in this study were primarily exposed to green spaces. For example, the NDVI in Study 1a measured vegetation cover, the questionnaire in Study 1b measured participants' perceptions of green vegetation in the neighborhood, and the main difference between the experimental scenes in Study 2 was the abundance of vegetation in the neighborhood. The natural environment encompasses green and blue spaces, which can include individual bodies of water or larger freshwater ecosystems, such as oceans, watersheds, rivers, lakes, and coastlines (White et al., 2016). Blue spaces can directly or indirectly affect health and well-being (Braubach et al., 2021). For example, research has demonstrated that the increased visibility of blue space correlates with reduced psychological distress (Nutsford et al., 2016). Coss and Keller (2022) found that observing water surfaces, rather than land, can improve physiological (leading to lower blood pressure and heart rate) and psychological (resulting in a greater sense of relaxation) indicators. Consequently, subsequent investigations could investigate the influence of blue space on relative deprivation.

Second, although NDVI is an effective indicator for assessing passive green space exposure, it fails to provide specific information about green spaces. The NDVI cannot assess the quality of green spaces, such as plant type and diversity (Markevych et al., 2017). High-quality green spaces with diverse plant species have a significant positive impact on mental health (Adjei and Agyei., 2015). Moreover, the NDVI does not capture indicators such as accessibility and usability, which may limit an individual's exposure to green spaces and affect their relative deprivation and other feelings. Future studies should integrate other methods to address these limitations.

Third, Study 2 manipulated passive green space exposure by guiding the participants to imagine a green space scenario through a single image. Although detailed instructions and descriptions were provided to stimulate the participants' imagination, this approach may have limited the ecological validity of the findings. A single image could not fully replicate the complexity and immersive experience of real green space exposure, and the participants' imagined scenarios might have varied. This limitation implies that subsequent research could incorporate more immersive technologies, such as virtual reality, to simulate realistic

three-dimensional neighborhood environments (Liu et al., 2023b). Incorporating both indoor and outdoor perspectives may improve the participants' sense of immersion.

In addition, this study collected data through the Credamo platform. However, the sample may have been biased toward specific age groups and higher education levels, potentially limiting the generalizability of the findings. Future research should incorporate offline data collection or adopt stratified sampling methods to enhance sample diversity and representativeness. Considering that all studies involved Chinese participants, the findings may not apply to other cultures or regions. Future research should include diverse samples to verify these results' universality.

Finally, this study did not examine the potential moderators of the proposed model. Previous research has indicated that the psychological effects of environmental exposure may be influenced by individual differences such as preferences for nature, connectedness to nature, and perceived restorativeness (Hartig et al., 2014). Future research should investigate these psychological characteristics as potential moderators to better understand the conditions under which passive green space exposure influences relative deprivation.

5. Conclusions

In conclusion, this study identified the significant positive impact of passive green space exposure on reducing relative deprivation and preliminarily clarified the extent to which this effect can occur. Grounded in the framework of the self-determination theory, this study confirmed the mediating role of basic psychological needs between passive green space exposure and relative deprivation. These findings expand our understanding of protective factors against relative deprivation and provide direction for future research.

Ethics approval

The Ethical Committee of the Department of Psychology, Beijing Forestry University, China, approved this research.

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CRediT authorship contribution statement

Rui Gao: Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Jia Liu:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Wenwu Dai:** Writing – review & editing, Methodology. **Jingyuan Yang:** Writing – review & editing, Investigation. **Hui Chen:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Zhihui Yang:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Consent to participate

The informed consent was obtained from the participants.

Declaration of Competing Interest

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

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Not applicable.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2025.128932.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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