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Green mind, healthy mind: investigating nature's role in students' health-related quality of life in China

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Abstract

Background Connectedness to nature is a psychological concept describing an individual's emotional and cognitive bond with the natural environment. The relationships between Big Five personality traits and environmental connectedness have emerged as a crucial area of study in understanding human well-being and behavior.

Aim This research seeks to understand the complex relationships between Extraversion and Neuroticism, connectedness to nature, and their subsequent impact on Health-related quality of life (HRQOL) among Chinese college students through flourishing.

Method The sample for this study was comprised of Chinese college students ($N = 1640$) between 18 and 25 years old who answered a self-report survey.

Results The findings showed that Extraversion has an impact on HRQOL, mediated through Connectedness to Nature and more so through Flourishing. Moreover, the analyses supported the hypothesis that the negative impact of neuroticism on HRQOL operates significantly through diminished flourishing and, to a lesser extent, reduced connectedness to nature.

Conclusion These results underline the importance of addressing Flourishing in interventions aimed at mitigating the detrimental effects of Neuroticism on quality of life, suggesting that enhancing Flourishing and Connectedness to Nature may serve as valuable targets for psychological interventions in individuals with high levels of Neuroticism.

Keywords Connectedness to nature, Extraversion, Neuroticism, Flourishing, Health-related Quality of Life, China

Introduction

The concept of connectedness to nature encompasses the psychological links—both emotional and cognitive—that individuals form with their natural environments. This connection fosters a sense of harmony and interdependence with nature, often promoting enhanced environmental awareness and fostering sustainable behaviors [1]. An emerging and significant area of research is the exploration of how individual personality traits interact with environmental connectedness to influence human well-being and behaviors [2]. The Big Five personality traits—Extraversion, Neuroticism, Agreeableness, Conscientiousness, and Openness to Experience—represent a widely accepted framework in psychology for describing individual differences in personality [3]. This study aims to dissect the intricate dynamics between the Big Five personality traits and connectedness to nature, particularly focusing on their collective influence on flourishing—a critical aspect of individual well-being.

Additionally, this research explores the impact of these personality and environmental interactions on

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Health-related Quality of Life (HRQOL) among college students. HRQOL is an inclusive metric that evaluates both the physical and mental dimensions of health and examines how health conditions affect an individual's overall life quality [4]. This broader perspective on health outcomes reveals more about the multifaceted influence of health on life experiences than traditional health metrics can provide. Recent studies, such as those reviewed by Chen [5], indicate that personality traits like Extraversion and Neuroticism can significantly affect the quality of life, with Extraversion showing positive correlations and Neuroticism showing negative ones in specific cultural contexts.

Central to our hypothesis is the idea that specific personality traits—particularly Extraversion and Neuroticism—significantly predict an individual's degree of connectedness to nature. This connectedness is hypothesized to bolster personal well-being, manifesting as flourishing, which in turn impacts HRQOL. Educational settings play a critical role in fostering connectedness to nature and promoting flourishing, as these environments offer opportunities to implement nature-based interventions that can influence both personal and collective well-being. By integrating nature-based educational programs, institutions can enhance students' resilience, emotional health, and overall quality of life, thereby contributing to improved HRQOL outcomes. By examining these associations, our study aims to enrich the understanding of how intrinsic personality factors and environmental attitudes interact to shape not only educational outcomes but also the overall psychological health of college students. The findings of this investigation could have profound implications for educational strategies, mental health interventions, and environmental policies, especially in promoting sustainable behaviors and holistic well-being within academic settings.

Connectedness to nature and individual well-being

The concept of connectedness to nature extends beyond the appreciation of the natural world. It includes an individual's awareness of their integral part within the ecological system, fostering a sense of belonging and psychological connection to the natural environment. This psychological construct is characterized by affective and cognitive components, which influence the individual's emotional and mental well-being, as a recent meta-analysis stated [6]. Regarding the theoretical framework that supports positive relationships between Connectedness to nature and people's well-being, one of the first proposals was the Stress Recovery Theory [7, 8], which suggests that humans have an innate affinity for natural settings, which significantly mitigates stress levels. Engaging with natural environments directly or integrating nature-like elements into workspaces effectively mitigates feelings of anger, enhances stress management, and diminishes emotional exhaustion, subsequently boosting overall health and happiness. Specifically, natural environments promote recovery by easing physical symptoms such as muscle tension and by lowering heart rate and blood pressure. Psychologically, these settings enhance mood and foster positive emotional states. Such benefits underline the importance of natural spaces for emotional rejuvenation and cognitive development, supporting the notion that regular interaction with nature is essential for maintaining overall health.

Evidence suggests that office workers who tend to plant in their workspace experience heightened personal satisfaction and a decrease in stress related to their jobs. Research from different studies [2, 9, 10] and systematic reviews [1] confirm these benefits, demonstrating how even minimal interactions with elements of nature can positively affect well-being and enhance the working environment, impacting health professionals, patients, and their families. These findings advocate for the regular inclusion of natural aspects in workplace settings as a crucial strategy for improving individuals' health and morale. The impact of nature connectedness on individual well-being has been suggested by empirical studies, highlighting a positive correlation [11]. A study by Capaldi, Dopko, and Zelenski [12] demonstrates that individuals with higher levels of nature connectedness tend to experience enhanced emotional well-being, reduced stress, and a heightened sense of life satisfaction. This correlation can be attributed to the biophilic tendency of humans, where exposure to natural environments promotes mental health benefits, as evidenced in the work of Kaplan and Kaplan [13] on attention restoration theory.

The relevance of this concept to college students in China is particularly significant, considering the rapid urbanization and environmental challenges faced in the country. A study by Zhang, Howell, and Iyer [14] found that Chinese college students with higher levels of connectedness to nature reported better well-being and more positive emotional outcomes. This is pivotal in an educational context, as fostering a connection with nature among students can promote individual flourishing and long-term mental health. Additionally, the integration of nature-based activities and environmental education in college curricula can further enhance students' connection to nature, promoting both personal well-being and a sustainable future [15]. An increasing amount of empirical studies conducted with Chinese adolescents and young students confirmed the influence of connectedness to pro-environmental behavior and personal well-being outcomes [16]. Considering that

Chinese college students, as their families and the whole of Chinese society, highly value students' well-being, the potential positive influence of Connectedness to nature on students' HRQOL deserves attention [17].

Personality traits and connectedness to nature

Searching for the personality bases of connectedness to nature, some studies explored the relationships between the Big Five traits and the individual's affinity towards the natural environment [18]. Agreeableness and Openness, in particular, have been consistently linked to a stronger connectedness to nature. Agreeableness, characterized by traits such as empathy, altruism, and kindness, naturally aligns with a pro-environmental stance. A study by Nisbet, Zelenski, and Murphy [19] highlighted that individuals scoring high in agreeableness are more likely to exhibit concern and caring attitudes toward the environment, underpinning their connectedness to nature. This is attributed to the empathetic disposition of agreeable individuals, extending their compassion towards non-human entities and the natural world.

Similarly, Openness, which encompasses traits like creativity, intellectual curiosity, and appreciation for art and beauty, has been found to correlate with a heightened sense of connectedness to nature. Open individuals, with their propensity for novel experiences and deep appreciation for aesthetics, are more likely to seek and value their interactions with the natural world. Tam [20] illustrated that openness significantly predicts environmental concern and engagement, linking it to a greater understanding and appreciation of the complexity and beauty of nature.

Extraversion and Neuroticism, while not as directly linked to nature connectedness as Agreeableness and Openness, play substantial roles in predicting individual well-being in relation to environmental engagement [21]. Extraversion, with its emphasis on sociability and assertiveness, can influence the way individuals interact with the environment, often leading to more active and social forms of nature engagement [22, 23]. On the other hand, Neuroticism, which often correlates with tendencies toward anxiety and emotional instability, can impact how individuals perceive and react to environmental challenges [24]. While a higher level of neuroticism might lead to increased anxiety about environmental issues, it could also motivate proactive behavior toward environmental conservation.

Chain mediation of connectedness to nature and flourishing between personality and HRQOL.

Despite the fact that some studies have provided empirical evidence of the relationships between personality traits and attitudes towards nature, the debate continues to open [25]. Recently, the dark side of personality has also been proposed as an antecedent of environmental activism, showing that the subtle processes surrounding connectedness to nature remain still unclear [26]. The exploration of the link between connectedness to nature and Chinese college students' well-being, considering extraversion and neuroticism as antecedents, should not be supposed to be direct. Instead of this, the role of flourishing, as an indicator of individual wellbeing, could mediate the influence of connectedness to nature and HRQOL, viewed as an indicator of both physical and mental health dimensions, as well as evaluating how health conditions influence one's quality of life [27]. This chain mediation model posits that personality traits not only directly affect an individual's sense of connectedness to nature but also have, first, an indirect impact on their flourishing and, later, on students' HRQOL through this connectedness [28].

Flourishing, a concept encapsulating a state of optimal mental health and self-realization, is significantly impacted by one's relationship with the natural environment. Research by Capaldi et al. [12] demonstrates that individuals with a stronger connection to nature experience higher levels of positive emotions, life satisfaction, and a sense of purpose, all of which are components of flourishing. The third link in this mediating chain model is the relationship between flourishing and HRQOL among college students. Flourishing students are more likely to exhibit higher levels of health-protective behaviors, characterized by active participation in healthy activities, a strong sense of caring for their well-being, and positive attitudes towards their healthcare. In this vein, a study by Bullock and Collins [29] found that high levels of mental components of HRQOL were significantly related to Flourishing among cricket players, showing that integration between HRQOL research and positive psychology constructs continues offering a fruitful avenue as predicted [30].

Finally, the model suggests that HRQOL, as a useful indicator of overall health, is not only directly influenced by flourishing but also indirectly affected by personality traits through the mediating roles of connectedness to nature and flourishing. This comprehensive model highlights the interconnectedness of personality, environmental attitudes, well-being, and HRQOL. Understanding these relationships is crucial for educators and policymakers in designing interventions and curricula that not only enhance students' academic performance but also promote their overall well-being and environmental stewardship.

Based on the revised literature, the present study proposed that:

Hypothesis 1: Extraversion and Neuroticism are significant predictors of an individual's connectedness to nature.
Hypothesis 2: Connectedness to nature acts as a mediating factor, enhancing personal well-being, particularly in terms of flourishing.
Hypothesis 3: Flourishing then positively influences HRQOL among college students.
Hypothesis 4: The relationship between personality traits (Extraversion and Neuroticism) and HRQOL is mediated as a chain, first by the individual's connectedness to nature and second by Flourishing. Figure 1 displays the Research model for the present study.

Method

Participants and procedures

The sample for this study was comprised of Chinese college students ($N=1640$) between 18 and 25 years of age (Mean = 20.64; SD = 2.14), with 54.6% females. Specialties of such students include Engineering (34%), Computer Science (19%), Business Administration (17%), Medicine and Health-related studies (16%), and Social Sciences and Humanities (14%). 31,1% of the participants were in their first year of College, 30,5% in the second, 13,7% in the third, and 14,8% in their last year. Regarding geographical distribution, most of the respondents studied in major cities such as Beijing, Shanghai, and Guangzhou. At the same time, fewer participants belonged to the central and western parts of the country, such as Chengdu and Chongqing in the southwest and Xi'an in the northwest. Participants were recruited through advertisements posted on bulletin boards and the college campus network. The advertisements briefly described the study's main aim and included information that participation was voluntary, participants could withdraw at any moment without consequences, and there was no financial compensation for participation. The WeChat contact number of the principal researcher was provided for further inquiries. Participants who contacted this number received detailed instructions on how to fill out the survey. The Ethical Committee of the Shanghai University of Finance and Economics Zhejiang College approved the research (Number of approval: PSYCH-2024–734, date of approval, January 18th, 2024). The study was designed and conducted following the recommendations of the Declaration of Helsinki and local legislation. All the participants provided informed consent electronically. The first part of the questionnaire included three informed consent questions. Only those participants who answered 'yes' to all were allowed to proceed to the next step, which involved completing the survey scales. All participants provided informed consent to publish their aggregated data. The initial contact sample size was $N=1889$; however, 249 participants still needed to complete 100% of the survey and were therefore excluded from the study.

Instruments

Extraversion and Neuroticism were assessed using the Chinese version of the Ten-Item Personality Inventory (TIPI-C) [27, 28], a concise tool for assessing the Big Five personality traits, by quick self-administration. It consists of ten items, with each pair of items aimed at assessing one of the Big-Five personality traits, Extraversion (E), Agreeableness (A), Conscientiousness (C), Emotional Stability (ES), and Openness (O)—with two questions per dimension. The TIPI has been translated into numerous

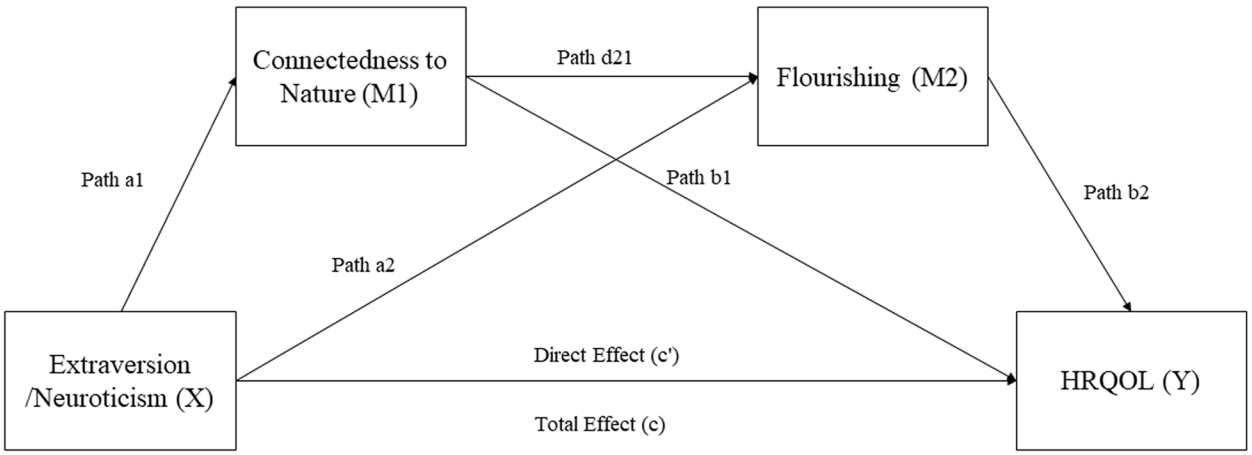

Fig. 1 Research Model with paths. Note: Path a1: Extraversion or Neuroticism (X) on Connectedness to Nature (M1); Path a2: Extraversion or Neuroticism (X) on Flourishing (M2); Path d21: Connectedness to Nature (M1) on Flourishing (M2); Path b1: Connectedness to Nature (M1) on HRQOL (Y); Path b2: Flourishing (M2) on HRQOL (Y); Direct Effect (c'): direct effect of Extraversion or Neuroticism (X) on HRQOL (Y); Total Effect (c): total effect of Extraversion or Neuroticism (X) on HRQOL (Y), which includes both direct and indirect effects

languages, and its psychometric properties have been validated in various countries. Higher scores reflect a greater presence of the respective personality trait.

Connection with Nature Scale (CNS) was utilized [31], using the Chinese version [32]. The Connection with Nature Scale comprises 14 items that gauge an individual's emotional and cognitive connection to nature. Higher scores on the Connection with Nature Scale indicate a stronger bond with nature, for instance, feeling a sense of unity with the natural environment. The scoring scaled from 1 (Strongly Disagree) to 5 (Strongly Agree). The internal consistency of the scale was demonstrated by a Cronbach's alpha of 0.87, suggesting it is a reliable measure.

Flourishing

The assessment of individual well-being was conducted using the Flourishing Scale, created by Diener et al. [33], in the adapted version for the Chinese population [34]. This self-assessment tool is comprised of eight items designed to measure an individual's sense of achievement in key life domains, including interpersonal connections, self-regard, life purpose, and outlook on life. Participants responded using a 5-point Likert scale, which spans from 1 (Strongly Disagree) to 5 (Strongly Agree). Sample statements from the scale include "I receive support and satisfaction from my relationships," "I feel skilled and effective in the activities that matter to me," and "My daily activities are interesting and engage my attention." The scale showed high reliability with a Cronbach's alpha of 0.85, indicating its efficacy in measuring aspects of human flourishing.

Health-related quality of life (HRQOL)

This variable has been assessed using the four core questions developed for the Centers for Disease Control and Prevention, named CDC HRQOL-4. The four questions have been used in national-level surveys in the United States since 1993, showing their reliability and validity. The four questions have also been used as a single indicator of overall health status as recommended [4].

A full list of items is provided as supplemental material.

Data analyses

Descriptive and correlational analyses were conducted with SPSS. At the same time, Model 6 of the PROCESS Procedure for SPSS Version 4.2, Macros [35] was used to test the chain mediating effect of Connectedness to nature and Flourishing into the relationships between Personality traits and HRQOL. This model allows for the examination of the indirect effect of an independent variable (X) on a dependent variable (Y) through two mediators (M1 and M2) in a specific order. In this case, the independent variables are both Extraversion and Neuroticism, the dependent variable is HRQOL (Health-Related Quality of Life), and the two mediators are Connectedness to Nature (M1) and Flourishing (M2). Given that Model 6 admits only one independent variable, analysis was carried out first with extraversion and then with neuroticism.

Results

Descriptive analyses

Table 1 reveals several significant correlations: Extraversion is positively correlated with Flourishing and HRQOL. Conversely, Neuroticism shows a negative correlation with Flourishing and HRQOL. Connectedness to Nature shows positive correlations with both Flourishing and HRQOL. Flourishing itself is strongly correlated with HRQOL, reinforcing the idea that higher levels of personal growth and well-being are linked with better health outcomes.

Mediational analyses

Extraversion as the predictor variable.

As Table 2 shows, the chain mediating model was analyzed to investigate the association between Extraversion on HRQOL through the mediators Connectedness

Table 1 Descriptive statistics and Pearson's correlation matrix (*N*=1640)

Variables	Mean	S.D	1	2	3	4	5
1. Extraversion	3,15	,89	1				
2. Neuroticism	2,88	,85	-,058*	1			
3. Connectedness to nature	3,60	,65	,156**	-,140**	1		
4. Flourishing	3,93	,58	,384**	-,327**	,280**	1	
5. HRQOL	3,60	1,26	,272**	-,197**	,162**	,426**	1

HRQOL Health-related Quality of Life

* $p < .05$

** $p < .001$

Table 2 Model Summary and Coefficients for Extraversion as predictor variable on Connectedness to Nature (M1), Flourishing (M2) and HRQOL (Y)

Variable	Coefficient	SE	t	p	LLCI	ULCI
Variable: *Connectedness to Nature (M1)*						
Constant	3.2481	.0585	55.5618	.0000	3.1335	3.3628
Extraversion (X)	.1141	.0178	6.3970	.0000	.0791	.1490
Variable: *Flourishing (M2)*						
Constant	2.4879	.0806	30.8535	.0000	2.3297	2.6460
Extraversion (X)	.2277	.0147	15.5321	.0000	.1990	.2565
Connectedness to Nature (M1)	.2018	.0201	10.0563	.0000	.1624	.2411
Variable: *HRQOL (Y)*						
Constant	-.3396	.2182	−1.5567	.1197	-.7675	.0883
Extraversion (X)	.1765	.0338	5.2230	.0000	.1102	.2428
Connectedness to Nature (M1)	.0767	.0445	1.7240	.0849	-.0106	.1639
Flourishing (M2)	.7897	.0532	14.8507	.0000	.6854	.8940
Total Effect Model						
Variable *HRQOL (Y)*						
Constant	2.3918	.1096	21.8192	.0000	2.1767	2.6068
Extraversion (X)	.3832	.0334	11.4616	.0000	.3177	.4488

to Nature and Flourishing. The results are summarized in Table 2.

The initial regression analysis examined the association between of Extraversion (X) on Connectedness to Nature (M1). The model was statistically significant, indicating that Extraversion significantly predicted Connectedness to Nature ($\beta = 0.1141$, SE = 0.0178, t = 6.3970, $p < 0.001$). The confidence interval for the coefficient ranged from 0.0791 to 0.1490, suggesting a positive relationship between Extraversion and Connectedness to Nature.

Next, the model assessed the association between of both Extraversion (X) and Connectedness to Nature (M1) on Flourishing (M2). Both predictors were statistically significant. Extraversion (X) was associated with Flourishing ($\beta = 0.2277$, SE = 0.0147, t = 15.5321, $p < 0.001$), with a confidence interval of 0.1990 to 0.2565. Additionally, Connectedness to Nature (M1) was associated with Flourishing ($\beta = 0.2018$, SE = 0.0201, t = 10.0563, $p < 0.001$), with the confidence interval ranging from 0.1624 to 0.2411. These results suggest that both Extraversion and Connectedness to Nature are positively related to Flourishing.

The final stage of the model evaluated the associations between of Extraversion (X), Connectedness to Nature (M1), and Flourishing (M2) on HRQOL (Y). Extraversion remained a significant predictor ($\beta = 0.1765$, SE = 0.0338, t = 5.2230, $p < 0.001$), with a confidence interval between 0.1102 and 0.2428. Flourishing (M2) showed a strong positive association with HRQOL ($\beta = 0.7897$, SE = 0.0532, t = 14.8507, $p < 0.001$), with the confidence interval ranging from 0.6854 to 0.8940. Although Connectedness to Nature (M1) had a positive coefficient ($\beta = 0.0767$, SE = 0.0445), it was not statistically significant (t = 1.7240, $p = 0.0849$), with a confidence interval from −0.0106 to 0.1639.

The total effect model, which examines the relationship between Extraversion (X) on HRQOL (Y) without mediators, showed that Extraversion was a significant predictor ($\beta = 0.3832$, SE = 0.0334, t = 11.4616, $p < 0.001$), with the confidence interval ranging from 0.3177 to 0.4488.

Overall, the chain mediating model reveals that Extraversion is positively associated with HRQOL both directly and indirectly through the mediator's Connectedness to Nature and Flourishing. While Connectedness to Nature is significantly related to Flourishing, its direct effect on HRQOL is not significant. Flourishing, on the other hand, plays a critical role in linking Extraversion to HRQOL, emphasizing its importance as a mediator in this relationship.

The analysis revealed that Extraversion is directly associated with HRQOL ($\beta = 0.1255$). Beyond this direct effect, the indirect effects through the mediators were significant. The total indirect effect of Extraversion on HRQOL through the mediators was 0.2068 ($\beta = 0.1470$; 95% CI [0.1695, 0.2477]), indicating a substantial mediation. Breaking down the total indirect effect, the specific indirect effect through Connectedness to Nature alone (Indirect 1) was smaller ($\beta = 0.0062$, 95% CI [−0.0024, 0.0215]) compared to the effect through Flourishing alone (Indirect 2) which was more substantial ($\beta = 0.1279$, 95% CI [0.1439, 0.2182]).

Table 3 Total, and Direct Effects of Extraversion (X) on HRQOL (Y)

Effect Type	Effect	SE	t	p	LLCI	ULCI
Total effect of X on Y	.3832	.0334	11.4616	.0000	.3177	.4488
Direct effect of X on Y	.1765	.0338	5.2230	.0000	.1102	.2428

Table 4 Indirect Effects of Extraversion (X) on HRQOL (Y)

Effect	BootSE	BootLLCI	BootULCI
TOTAL	.2068	.0198	.1695
Indirect 1	.0087	.0060	-.0024
Indirect 2	.1798	.0186	.1439
Indirect 3	.0182	.0041	.0109
(C1)	-.1711	.0206	-.2133
(C2)	-.0094	.0070	-.0238
(C3)	.1617	.0180	.1268

Note: Indirect 1: Extraversion—> Connectedness to Nature—> HRQOL; Indirect 2: Extraversion—> Flourishing—> HRQOL; Indirect 3Extraversion—> Connectedness to Nature—> Flourishing—> HRQOL. (C1): Indirect 1 minus Indirect 2; (C2): Indirect 1 minus Indirect 3; (C3): Indirect 2 minus Indirect 3

Tables 3 and 4 showed, that the indirect effect through both Connectedness to Nature and Flourishing in sequence (Indirect 3) was also notable (β=0.0129, 95% CI [0.0109, 0.0267]). These findings indicate that Flourishing acts as a more potent mediator in the association between Extraversion and HRQOL compared to Connectedness to Nature.

The analysis further indicated significant contrasts among the specific indirect effects, particularly highlighting the dominant role of Flourishing as a pathway associated with Extraversion and HRQOL. The total effect model demonstrated that Extraversion is significantly associated with HRQOL (β=0.2725, $p<0.000$), indicting a substantial influence of Extraversion on HRQOL, mediated through Connectedness to Nature and more so through Flourishing. Figure 2 displays the model with the standardized estimation for the paths, illustrating the relationships among the variables.

Neuroticism as predictor variable

As Table 5 shown, the chain mediating model was analyzed to investigate the associations between Neuroticism on Health-Related Quality of Life (HRQOL) through the mediators Connectedness to Nature and Flourishing. The results are summarized in Table 5.

The initial regression analysis examined the associations between of Neuroticism (X) on Connectedness to Nature (M1). The model was statistically significant, indicating that Neuroticism significantly predicted Connectedness to Nature (β=−0.1070>, SE=0.0187, t=−5.7127, $p<0.001$). The confidence interval for the coefficient ranged from −0.1438 to −0.0703, suggesting a negative relationship between Neuroticism and Connectedness to Nature.

Next, the model assessed the associations between both Neuroticism (X) and Connectedness to Nature (M1) on Flourishing (M2). Both predictors were statistically significant. Neuroticism (X) was negatively associated

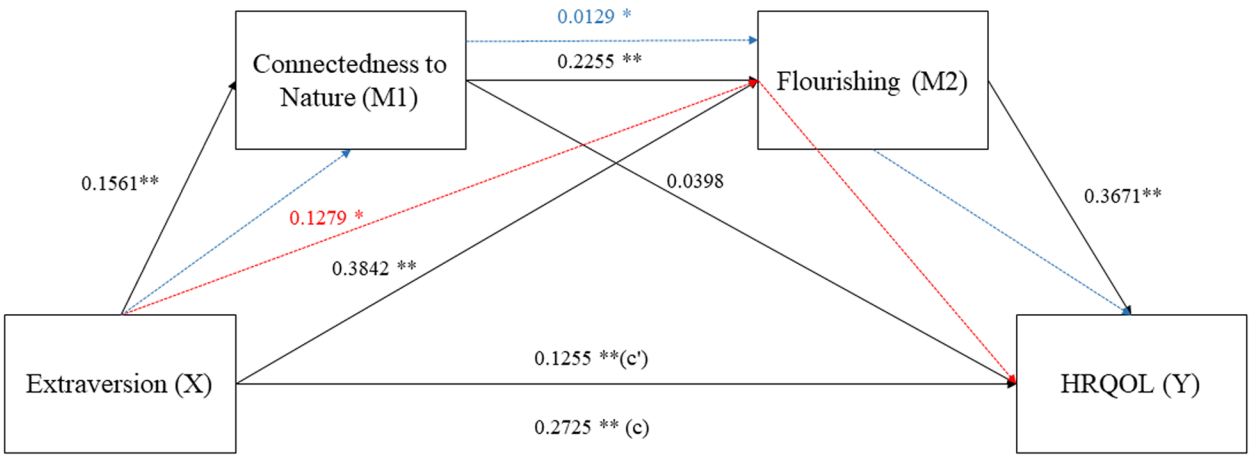

Fig. 2 Standardized estimates for the model with Extraversion as predictor variable. Note: Indirect 2: Extraversion—> Flourishing—> HRQOL (red dot line); Indirect 3: Extraversion—> Connectedness to Nature—> Flourishing—> HRQOL. (blue dot line)

Table 5 Model Summary and Coefficients for Neuroticism as predictor variable on Connectedness to Nature (M1), Flourishing (M2) and HRQOL (Y)

Variable	Coefficient	SE	t	p	LLCI	ULCI
Variable: *Connectedness to Nature (M1)*						
Constant	3.9167	.0564	69.4451	.0000	3.8061	4.0274
Neuroticism (X)	-.1070	.0187	−5.7127	.0000	-.1438	-.0703
Variable: *Flourishing (M2)*						
Constant	3.7427	.0926	40.3985	.0000	3.5610	3.9244
Neuroticism (X)	-.2009	.0156	−12.8405	.0000	-.2316	-.1702
Connectedness to Nature (M1)	.2138	.0204	10.4604	.0000	.1737	.2539
Variable: *HRQOL (Y)*						
Constant	.2345	.2776	.8449	.3983	-.3099	.7790
Neuroticism (X)	-.0925	.0348	−2.6562	.0080	-.1607	-.0242
Connectedness to Nature (M1)	.0831	.0448	1.8577	.0634	-.0046	.1709
Flourishing (M2)	.8471	.0524	16.1657	.0000	.7443	.9499
Total Effect Model						
Variable: *HRQOL (Y)*						
Constant	4.4400	.1075	41.3079	.0000	4.2292	4.6508
Neuroticism (X)	-.2909	.0357	−8.1494	.0000	-.3610	-.2209

with Flourishing (β = −0.2009, SE = 0.0156, t = −12.8405, $p < 0.001$), with a confidence interval of −0.2316 to −0.1702. Additionally, Connectedness to Nature (M1) was positively associated with Flourishing (β = 0.2138, SE = 0.0204, t = 10.4604, $p < 0.001$), with the confidence interval ranging from 0.1737 to 0.2539. These results suggest that while Neuroticism is negatively related to Flourishing, Connectedness to Nature is positively related to it.

The final stage of the model evaluated the associations between Neuroticism (X), Connectedness to Nature (M1), and Flourishing (M2) on HRQOL (Y). Neuroticism remained a significant negative predictor (β = −0.0925, SE = 0.0348, t = −2.6562, $p = 0.008$), with a confidence interval between −0.1607 and −0.0242. Flourishing (M2) was positively associated with HRQOL (β = 0.8471, SE = 0.0524, t = 16.1657, $p < 0.001$), with the confidence interval ranging from 0.7443 to 0.9499. Although Connectedness to Nature (M1) had a positive coefficient (β = 0.0831, SE = 0.0448), it was not statistically significant (t = 1.8577, $p = 0.0634$), with a confidence interval from −0.0046 to 0.1709.

The total effect model, which examines the association between Neuroticism (X) on HRQOL (Y) without mediators, showed that Neuroticism was a significant negative predictor (β = −0.2909, SE = 0.0357, t = −8.1494, $p < 0.001$), with the confidence interval ranging from −0.3610 to −0.2209.

Overall, the chain mediating model reveals that Neuroticism is negatively associated with HRQOL both directly and indirectly through the mediators Connectedness to Nature and Flourishing. While Connectedness to Nature is significantly related to Flourishing, its direct effect on HRQOL is not significant. Flourishing, on the other hand, plays a critical role in linking Neuroticism to HRQOL, emphasizing its importance as a mediator in this relationship. These findings suggest that individuals with higher levels of Neuroticism tend to report lower HRQOL, partially due to their lower levels of Connectedness to Nature and Flourishing.

Neuroticism was negatively associated with Connectedness to Nature (coefficient = −0.1070, $p < 0.000$), indicating that higher levels of Neuroticism are linked to lower feelings of connectedness to nature. Similarly, a significant negative association was observed between Neuroticism and Flourishing (coefficient = −0.2009, $p < 0.000$), suggesting that higher Neuroticism is linked to lower levels of flourishing. The overall model examining the relationship between Neuroticism on HRQOL, considering the mediators, demonstrated a significant negative association (β = −0.1974, $p < 0.000$).

This total effect was partitioned into a direct association of Neuroticism on HRQOL (coefficient = −0.0925, $p = 0.0080$, β = −0.0627) and a significant total indirect association (coefficient = −0.1985, 95% CI [−0.2426, −0.1578], β = −0.1347), as Table 6 shows.

Turning into specific indirect association, the path through Connectedness to Nature alone (Indirect 1) showed a minimal effect (coefficient = −0.0089), while the path through Flourishing alone (Indirect 2) showed a more substantial negative indirect association (coefficient = −0.1702), as Table 7 shown. The sequential

Table 6 Total, and Direct Effects of Neuroticism (X) on HRQOL (Y)

Effect Type	Effect	SE	t	p	LLCI	ULCI
Total effect of X on Y	-.2909	.0357	−8.1494	.0000	-.3610	-.2209
Direct effect of X on Y	-.0925	.0348	−2.6562	.0080	-.1607	-.0242

Table 7 Indirect Effects of Neuroticism (X) on HRQOL (Y)

	Effect	BootSE	BootLLCI	BootULCI
TOTAL	-.1985	.0216	-.2426	-.1578
Indirect 1	-.0089	.0060	-.0213	.0020
Indirect 2	-.1702	.0206	-.2125	-.1315
Indirect 3	-.0194	.0045	-.0289	-.0113
(C1)	.1613	.0229	.1179	.2072
(C2)	.0105	.0068	-.0020	.0252
(C3)	-.1508	.0202	-.1922	-.1122

Note: Indirect 1: Neuroticism—> Connectedness to Nature—> HRQOL; Indirect 2: Neuroticism—> Flourishing—> HRQOL; Indirect 3Neuroticism—> Connectedness to Nature—> Flourishing—> HRQOL. (C1): Indirect 1 minus Indirect 2; (C2): Indirect 1 minus Indirect 3; (C3): Indirect 2 minus Indirect 3

mediation path involving both Connectedness to Nature and Flourishing (Indirect 3) also yielded a negative effect (coefficient = −0.0194).

The contrast between specific indirect effects highlighted the predominant role of Flourishing as a mediator. The relationship between Neuroticism on HRQOL was significantly associated with Flourishing, either directly or as part of a sequential path including Connectedness to Nature. The analyses support the hypothesis that the negative association between Neuroticism on HRQOL operates significantly through diminished Flourishing and, to a lesser extent, through reduced Connectedness to Nature. Figure 3 shows the standardized estimates for the Model.

Discussion

The present study was aimed to test the psychological pathways through which personality traits like Extraversion are associated with well-being and quality of life. The findings supported the first hypothesis, highlighting the contrasting associations of both Extraversion and Neuroticism at enhancing personal growth and connectedness to nature to improve health outcomes.

Comparing the results of the mediational analyses with Extraversion and Neuroticism as predictors of HRQOL, we observe distinct pathways through which these personality traits are related to HRQOL, mediated by Connectedness to Nature and Flourishing. The direct and indirect effects of Extraversion on HRQOL were both positive, indicating that more extraverted individuals tend to have a higher quality of life, partly due to their greater Flourishing and, to a lesser extent, their Connectedness to Nature, supporting hypotheses 2 and 3. In the analysis with Extraversion as the predictor, Flourishing emerged as a potent mediator, suggesting that positive personality traits significantly are linked to HRQOL through increased levels of Flourishing, supporting hypothesis 4.

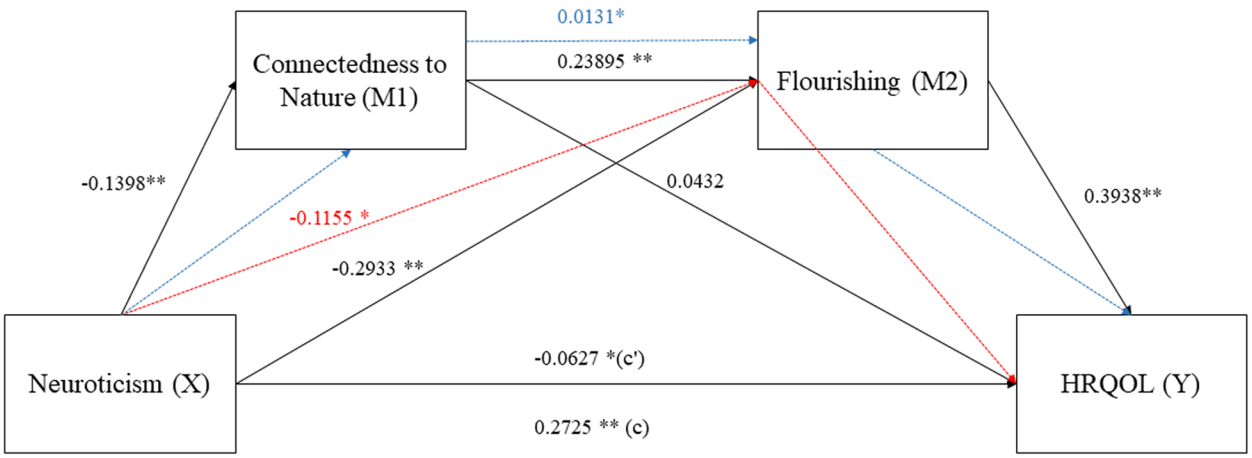

Fig. 3 Standardized estimates for the model with Neuroticism as predictor variable. Note: Indirect 2: Neuroticism—> Flourishing—> HRQOL (red dot line); Indirect 3: Neuroticism—> Connectedness to Nature—> Flourishing—> HRQOL. (blue dot line)

Research generally supports the notion that Extraversion is positively associated with HRQOL. Extraverts, with their tendency towards sociability, optimism, and activity, often report higher levels of subjective well-being and life satisfaction. These individuals are more likely to engage in social activities that promote a sense of connectedness and belonging, which are critical components of Flourishing and Connectedness to Nature. Recent studies found that extraversion is positively related to well-being, even during times of reduced social contact such as the COVID-19 pandemic. This suggests that more extraverted individuals maintain higher well-being levels despite decreased social interactions, aligning with the idea that extraversion is linked to HRQOL through increased engagement and positive emotional experiences [18].

In a similar vein, Ready, Boileau [36] discovered that positive affect, a component of extraversion, is associated with better HRQOL in persons with Huntington's disease, especially when individuals have better functional status. This indicates that the positive emotional aspect of extraversion is connected to higher quality of life across different health conditions. Furthermore, Wacker [37] explored the cognitive aspects of extraversion, finding that it is positively related to cognitive stability-flexibility and frontal EEG asymmetry. Although this study focuses on cognitive processes rather than HRQOL directly, it underscores the broader beneficial associations of extraversion on mental health and by extension, quality of life.

In the context of non-specific health conditions, the metasynthesis conducted by Strickhouser and Zell [38] reported that personality–health relations were larger for Neuroticism than for Extraversion and that the relationships were also stronger when examining mental health outcomes than physical health outcomes or health-related behaviors. These findings align with our study, which reinforces the link between extraversion and improved HRQOL, illustrating how extraverted personality traits are related to greater well-being through positive emotional experiences, resilience, and a meaningful life perspective, as well as positive work-related outcomes, as compliance with safety standards at workplace [39].

Conversely, the analysis with Neuroticism as the predictor revealed a negative influence on HRQOL, with Flourishing again playing a crucial mediating role but in the opposite direction. Higher levels of Neuroticism were linked to lower HRQOL, significantly mediated by reduced Flourishing and, to a lesser extent, lower Connectedness to Nature, providing support for hypotheses 2, 3 and 4. This suggests that negative personality traits like Neuroticism are associated with diminished quality of life by diminishing an individual's sense of Flourishing and connection with nature.

Several recent studies further support the role of Connectedness to Nature as a mediator between personality traits and HRQOL. For example, Gong et al. [40] demonstrated that connectedness to nature enhances psychological well-being through positive experiences with biodiversity and green spaces. Similarly, Chen and Yang [41] highlighted the mediating effect of nature connectedness on the relationship between natural sensory experiences and emotional outcomes, suggesting its significant role in promoting overall health and positive emotions. Lopes et al. [42] and Løvoll et al. [43] further confirm that even brief contact with nature improves mood and reduces rumination, key components of HRQOL.

In the context of educational and environmental interventions, nature-based recreational and educational programs have been shown to enhance students' well-being, connectedness to nature, and life satisfaction [44, 45]. These findings provide further evidence that fostering a stronger sense of connection to nature in structured settings can mediate positive well-being outcomes, supporting our results regarding the importance of nature-based interventions for improving HRQOL.

Related to previous research, Neuroticism is consistently linked with poorer HRQOL outcomes. The higher propensity for experiencing negative emotions, such as anxiety and depression, characteristic of neurotic individuals, directly undermines their sense of well-being and quality of life. Martyn and Brymer [46] found that connectedness to nature can reduce anxiety, a key factor in neurotic individuals' diminished well-being. Similarly, Wu [6] conducted a meta-analysis confirming that nature connectedness plays a significant role in reducing negative affect, further mitigating the impact of Neuroticism on quality of life. Luciano and Hagenaars [47] provided evidence that Neuroticism is negatively associated with both mental and physical health, suggesting a detrimental impact on HRQOL. This study underscores the broad negative implications of Neuroticism on poorer mental and physical health, as well as its relationships with depressive symptoms. In a related vein, Slavish and Sliwinski [48] found that Neuroticism is negatively associated with HRQOL, further corroborating the notion that individuals with higher levels of Neuroticism experience lower quality of life. Specifically, with Chinese university students, Lu andYang [49] demonstrated that Neuroticism is negatively associated with HRQOL, providing additional support for the negative correlation between Neuroticism and well-being. This empirical research aligns with our findings, where Neuroticism negatively

influences HRQOL, significantly mediated by reduced levels of Flourishing and lower Connectedness to Nature.

Suggestions for the design of educational interventions

Educational interventions aimed at enhancing health-related quality of life (HRQOL) among college students should be rooted in empirical findings on personality, well-being, and nature connectedness. The evidence suggests that interventions focusing on promoting extraverted behaviors, mitigating the effects of neuroticism, and explicitly fostering flourishing as a key mechanism could be particularly beneficial.

First, drawing from the positive correlation between extraversion and HRQOL, interventions could include structured social engagement activities. These might involve group-based projects, peer mentorship programs, and extracurricular clubs that encourage active participation and foster a sense of belonging. Such initiatives can capitalize on extroverts' natural propensity for sociability and optimism, enhancing their well-being and, by extension, their quality of life. To further promote flourishing, these activities can incorporate reflective exercises that help students identify and appreciate positive social experiences, thereby creating more lasting effects on their well-being.

Second, given the mediating role of connectedness to nature in enhancing HRQOL for both extraverted and neurotic individuals, programs designed to increase students' engagement with natural environments could be effective. This could take the form of outdoor learning experiences, mindfulness walks, or the integration of biophilic design on campus, encouraging time spent in nature as a way to boost mental health and flourishing at the University and, later, at the workplace [50]. Incorporating nature-based mindfulness programs that encourage reflection on personal growth within nature settings could further boost flourishing by enhancing emotional rejuvenation and a sense of meaning.

Third, to address the negative impacts of neuroticism on HRQOL, workshops focused on resilience building and positive psychology principles could be beneficial. These workshops can teach coping strategies for managing negative emotions, stress reduction techniques, and ways to foster positive emotional experiences. Incorporating evidence-based practices, such as cognitive-behavioral techniques and gratitude exercises, can help students with higher levels of neuroticism improve their sense of flourishing and overall well-being. These workshops should explicitly include activities that emphasize the development of personal strengths, self-efficacy, and optimism, key components of flourishing.

Fourth, educational interventions can also include sessions aimed at personal growth and self-reflection, with a focus on understanding one's personality traits and their influence on life satisfaction and quality of life. Activities could involve guided journaling, personality assessment debriefs, and goal-setting workshops that encourage students to reflect on their strengths and how they can be leveraged to enhance their HRQOL. Flourishing-focused interventions within these sessions could involve helping students identify "small wins" in their daily activities, fostering a sense of mastery and purpose, which is crucial for well-being.

Fifth, recognizing the specific challenges associated with neuroticism and offering tailored mental health support services can be crucial [51]. This might include counseling services, support groups, and online resources that specifically address the concerns of students with higher levels of neuroticism, such as anxiety and depression management strategies. Integrating mindfulness-based stress reduction and positive goal-setting in mental health interventions can further enhance flourishing, helping students shift their focus from managing symptoms to achieving growth and fulfillment.

Scaling Up the Interventions: To implement these interventions at a larger scale, educational institutions could adopt a tiered, multi-level approach. Large-scale programs could involve:

- Campus-wide initiatives, such as nature-based campaigns (e.g., "Nature and Well-being Week") and regular mindfulness walks open to all students.
- Online modules and mobile apps offering self-paced, evidence-based training in resilience, flourishing, and personality growth.
- Integrating flourishing-promoting activities into core curricula through life-crafting workshops, nature-based experiential learning, and reflective assignments that target both academic and personal development.

By combining in-person, group-based interventions with digital tools for flexibility and accessibility, large-scale implementation could maximize student participation and engagement. Partnerships with local environmental organizations and mental health professionals could also ensure that interventions are diverse and widely accessible.

In conclusion, designing educational interventions that leverage the positive aspects of extraversion and address the challenges of neuroticism requires a multi-faceted approach. By promoting social engagement, fostering connections with nature, building resilience, encouraging personal growth, and providing targeted mental health support, educational institutions can enhance the well-being and quality of life of their students.

Placing flourishing at the center of these interventions—as the strongest indirect pathway to improving HRQOL—ensures that students gain long-lasting benefits that extend beyond academic settings. These interventions should be grounded in scientific evidence and tailored to meet the unique needs of the student population, ensuring they are both effective and accessible.

Limitations of the present research

The present study has limitations that preclude generalizability of the findings.

First, the study's findings are derived from a specific demographic, Chinese college students aged 18 to 25, limiting the generalizability to other populations. The recruitment method through campus advertisements may have introduced selection bias, attracting participants with a pre-existing interest in the study's themes. The reliance on self-report measures for assessing personality traits, connection with nature, and well-being could lead to social desirability bias, where participants may answer in ways they perceive as favorable. Second, related to the instruments used, including the Ten-Item Personality Inventory Chinese version and the Connection with Nature Scale, though validated, rely on brief self-assessment, which might not capture the full complexity of the constructs being measured.

Moreover, the cross-sectional design of this study limits its ability to establish causality. The findings reflect associations between variables, but the directionality of these relationships cannot be determined. For example, while more Extraversion is associated with higher Flourishing, it is equally possible that higher Flourishing may promote greater Extraversion. Similarly, the mediational analyses should be interpreted with caution, as cross-sectional mediation only provides evidence of potential pathways without confirming causation. Future studies using longitudinal designs could address this limitation by examining how personality traits and connectedness to nature interact over time to influence well-being.

The exclusion of participants who did not complete the entire survey could also introduce non-response bias, possibly affecting the study's representativeness. These limitations suggest the need for future research to utilize more diverse samples, explore variables in more depth, and consider alternative analytical approaches to provide a more comprehensive understanding of the factors contributing to well-being.

Overall, these analyses underscore the contrasting associations between positive and negative personality traits and HRQOL. Extraversion is associated with a higher quality of life through its positive relationships with mediating factors, while Neuroticism is linked to lower HRQOL through its negative associations with these same factors. The promotion of Flourishing and Connectedness to Nature as potential interventions should be considered within the context of these limitations, emphasizing that the observed associations provide initial insights, but longitudinal research is necessary to validate these relationships.

Conclusion

In more detail, the mediational analysis underscores the importance of Flourishing as a critical mediator in the association between Extraversion and Health-Related Quality of Life, with Connectedness to Nature playing a lesser yet significant role. The findings also show that Neuroticism is associated with lower HRQOL, primarily due to its negative relationship with Flourishing. These results highlight the importance of addressing Flourishing in interventions aimed at mitigating the associations between Neuroticism and lower quality of life. Enhancing Flourishing and Connectedness to Nature may serve as valuable targets for psychological interventions in individuals with high levels of Neuroticism, although further longitudinal research is needed to confirm the direction of these relationships.

Abbreviation

HRQOL Health-related quality of life

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Authors' contributions

Dr. Wu fully contributed to the study's design, dissemination, data collection and analyses, manuscript original writing, and final editing.

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Data availability

The data supporting this study and apos;s findings are available from Shanghai University of Finance and Economics Zhejiang College, but restrictions apply. These data were used under license for the current study and are not publicly available. The data are, however, available from the authors upon reasonable request and with the permission of Shanghai University of Finance and Economics Zhejiang College.

Declarations

Ethics approval and consent to participate

The Ethical Committee of the Shanghai University of Finance and Economics Zhejiang College approved the research (Number of approval: PSYCH-2024–734, date of approval, January 18th, 2024). The study was designed and conducted following the recommendations of the Declaration of Helsinki and local legislation. All the participants provided informed consent electronically. The first part of the questionnaire included three informed consent questions. Only those participants who answered 'yes' to all were allowed to proceed to the next step, which involved completing the survey scales.

Consent for publication

Not applicable.

Competing interest
The authors declare no competing interests.

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