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Optimizing forest-dominated campus environment: The impact of campus green and blue spaces on well-being and institutional per-formance

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Abstract The built environment of a campus is characterized by forest-dominated landscapes, which may determine the competitiveness of host university by influencing the emotional perceptions of experiencers. Relevant evidence has been derived from studies in parks and neighborhood landscapes but less is known about the emotions of experiencers in indoor and outdoor settings. In this study, 50 top universities were randomly chosen from a list of highly competitive rankings along a competition gradient, with campuses distributed over a wide geographical range from mainland China. Volunteers were recruited from indoor and outdoor locations (either number of 50 individuals per campus) to collect facial photos as a source of data used for analyzing expression scores for happy, sad, and neutral emotions (n = 4824). The positive response index (PRI) and emotional nonparametric relation index (ENRI) were calculated to comprehensively assess emotions. The neutral score decreased with an increase in university competition evaluated using the A+ discipline number. The blue space area benefited presentations of PRI and ENRI in the cohort mainly at outdoor places, and the green space area increased the exposure of happy scores for the indoor population. The campuses of top universities with more competitive disciplines were built with larger areas of blue and green spaces and larger cohorts with less calm facial emotions. It is recommended that top universities aiming to enhance competitiveness prioritize incorporating well-designed green and blue spaces with size and distribution tailored to campus usage patterns.

Keywords: built environment; sustainable university; higher education; campus construction; building and human emotion.

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Introduction

With a global background dominated by population growth and urbanization sprawl, higher education systems have become marketized (Hurt 2012; Natale & Doran 2012). The published ranking of universities is an important proxy for higher education competition because it is considered a determinant of student enrollment, faculty employment, and fiscal investment (Grewal et al. 2008). Worldwide, three major indicators are employed in university rankings to obtain the widest attention: THE World, ARWU, and QS World. These three indexes share a suite of criteria, including seven dimensions that cover quantified outcomes about teaching, research, education, industry income, etc. Variables that work to precisely rank universities according to their competi-tiveness include international collaboration networks, publicly disclosed research findings, ease of employment, and knowledge information archive (Dachyar & Dewi 2015; Krägeloh et al. 2019).

Teaching is one of the core tasks that a university provides for the public, and discipline is an important synthesis of facets determining competition. Competitive disciplines reflect the compre-hensive abilities of students' innovation (Pan et al. 2013; Lian 2019), research productivity (Abramo et al.; 2014), participation in science and technology transformation (Xie et al. 2015), and university-enterprise corporations (Shen & Zhai 2018). One may agree that multidisciplinary universities are more competitive than special discipline (Chen et al. 2014; IEEE 2015). However, this argument can be refuted from the viewpoint that the number of competitive disciplines is more determinative than the variety of general disciplines. To my knowledge, little evidence supports all these aspects, and it is still debated whether to use the competi-tive discipline number as a proxy to assess the competitiveness of host universities.

A highly ranked university with multiple competitive disciplines is competitive in funding acquisition (Harman 1998; Vittal et al. 2003). It is widely appealing to use funds to invest in a built environment in which water and energy are conserved with a high dose of accessible nature (Fachrudin 2019, Zhu et al. 2021). This is more apparent for top universities than for common or lowly ranked universities because highly competitive universities usually have strong abilities to attract funds and invest in build-ing campuses as needed. A university campus can also be considered a park where nature in the built environment has the function of providing ecosystem services. The built environment comprises not only natural spaces derived from vegetation and water bodies, but also built spaces such as impervious surfaces, concrete pavements, buildings, and sculptures. A competitive university campus should be built in a natural atmosphere that can motivate hints to induce positive sentiments (Zhang & Wang 2016).

It is widely recognized that an experience with nature can trigger positive sentiments by reducing mental stressors (Kaplan & Kaplan 1989). This theory has been verified in urban lives that are close to neighboring green and blue spaces (GBS) in parks and communities (Chen & Guo 2022; Sun et al. 2023; Liu et al. 2024). A campus is also a type of park where the local environment is built by artificial planning and construction. People may perceive positive sentiments on campus, the built environment plays a key role in the campus landscape. This positive effect may be a key motivation trigger for the cohort, which further strengthens university competitiveness. Little is documented about this effect verified in the built environment of a campus, as most of the cur-rent studies were and rare work has been revealed to fill this gap.

Students, tutors, and management staff are the main users of a university campus and account for the major role of the force that determines the competitive ability of host universities and their ranking positions. Intrinsic motivation activates stu-dents to pursue the academic achievement of mastery goals (Bieg et al. 2017). The motivation of university teachers affects students, employers, incubators, and innovators in terms of their knowledge, skills,

and experiences (Blasková & Blasko 2013). Together, the motivation for innovation and intension for studying are both sources of forces that forward university competi-tiveness and potentially increase discipline ranking. People harness these forces; hence, they can be promoted in the activated atmosphere of a given campus. Hence, emotional state rules motivation by controlling anxiety about competition (Ponseti et al. 2019).

Empirical studies have documented detailed relationships between achievement motivation and emotional promotions on intelligence, learning (Turki et al. 2018), self-efficacy (Pedditzi & Spigno 2018), and desire for social reinforcement (Mercader-Rubio et al. 2022). As mentioned, if a highly ranked university assembles multiple competitive disciplines, people on its campus should theoretically show more positive sentiments with activated motivations. This speculation cannot be fully veri-fied using evidence from the current literature, because most findings were obtained from surveys using questionnaires (Blasková & Blasko 2013, Bieg et al. 2017, Latorre-Cosculluela et al. 2022). Subjective ratings are difficult to fully repeat in the same experimental design arrangement on a specific university campus. The lack of validation limits the reliability of the rates of invisible intrinsic emotions through self-reported scores (Aerts et al. 2018). Inevitable human errors result in an uncontrolled range of mo-tivation evaluations (Kaplan & Kaplan 1989). Therefore, a more reliable technique is needed for data collection that has a high reliability in emotional analysis

Facial expression is the direct delivery of information about the intrinsic emotions of a human being (Ekman 1993). Facial expressions consist of two posting types: spontaneous and intentional. Spontaneous facial expressions are associated with a lack of awareness of being photographed (Wei et al. 2021a, Wei et al. 2021b). By contrast, intentional facial expressions are posted with clear awareness that facial photos are being photographed (Wei et al. 2022a, Wei et al. 2022b). Social network services (SNS) rely closely on Internet platforms, which contain a large pool of intentional facial photos of users who share their emotions with the public. Using emotional scores recognized from intentional facial photos, it has been successful to monitor emotional re-sponses to experiences on regional (Wei et al. 2019) and national scales (Wei et al. 2022a, Wei et al. 2022b).

Facial expression scores have also been used to map the emotional states of people posting photos to SNS in campuses (Wei et al. 2020a). Using this instrument, it was easy to detect the driving factors of urban infrastructure and socioeconomic status that affected emotional perceptions. Although it was queried that intentional photos were fake to disclose full emotions, the large number of individual photos posted at various places can dilute the technical errors that were generated among individuals. High education institutions have a large number across the national scale, with millions of teachers and students dwelling in campuses (Ministry of Education of the People's Republic of China, 2023).

Facial expression scores are an available parameter that can reflect emotional scores in a large population of subjects (Yan & Sun 2024; Liu et al. 2025b). This instrument is flexible in supporting large-scale studies and contributes to drawing powerful conclusions because data can be sourced either from social networks (Wei et al. 2020a) or offline experiments (Wei et al. 2020a; Wei et al. 2021a). Hence, facial expressions can be rated as an updated replacement for self-reported scores with higher reliability. To my knowledge, facial expressions have rarely been used as a gauge of emotional states or the activation of teachers and students in universities with varied competitive disciplines. Hints in campus environments are at the top position for inducing positive sentiments and high motivations in the development of a competitive university (Yan & Sun 2024).

As of May 31, 2022, China has built a total of 3013 high education institutions containing 1270 universities (Ministry of Education of the People's Republic of China, 2023). In the

fifth discipline evaluation of these universities, the Ministry of Educa-tion of the People's Republic of China announced the establishment of competitive disciplines to be in a higher position than before in November 2020 (Ministry of Education of the People's Republic of China, 2020). About 1/10 of them can be catego-rized as top universities, all of which are highly competitive in maintenance and increase in the number of highly evaluated disci-plines. Many competitiveness-evaluation parameters fail to obtain sufficient public (Dachyar & Dewi 2015, Olcay & Bulu 2017; Krägeloh et al. 2019). In contrast, the number of A+ (top premium) disciplines was frequently disclosed and easily obtained; hence, it was taken as a key proxy of competitiveness for ranking Chinese universities (Ministry of Education of the People's Republic of China, 2020).

The competitiveness of a discipline can be evaluated in descending order as follows: A+, A-, A, B+, B-, and B. Hence, the more A+ disciplines a university has, the more competitive it is. The number of competitive disciplines (e.g., A+ and A-) varied among universities, as did their specific names of them among universities. According to the fifth evaluation of competitive disciplines, top universities have varied numbers and terms of competitive disciplines. For example, Tsinghua Univer-sity was evaluated as having over 21 A+ disciplines, including software engineering, environmental science and technology, and optical engineering. Peking University has about 15 A+ disciplines, including but not limited to philosophy, world history, mathe-matics, and chemistry. Maintaining or increasing the number of highly competitive disciplines is a common objective contention among top universities in China.

In this study, 50 top universities were randomly chosen from mainland China, and their A+ discipline numbers were clearly disclosed. My objective was to detect the relationship between human sentiments and nature in built environments on the cam-puses of host universities with varied levels of competitiveness. Facial expression scores were rated from campuses and detected for their relationships with the A+ discipline numbers of host universities. The campus landscape was evaluated remotely to ex-tract metrics and explore relationships with emotional motivations. I hypothesized that (i) competitive universities can attract people with more positive sentiments than sad sentiments (perhaps in either indifferent or negative emotions), which results from (ii) larger areas of GBS in their campuses. My methodology can be referred to as a novel model and its use for unraveling the mechanism by which human emotions increase competitive discipline numbers in top universities to increase their competitive-ness. My findings can be useful as evidence for constructing or planning campuses to improve host universities' competitiveness.

Materials and Methods

Study area and sampling

A total of 1270 universities in China were numbered and classified according to their locations in host provincial or municipal regions (Ministry of Education of the People's Republic of China, 2023). University locations were targeted from online maps using a commonly used methodology as described in a previous study (Sun et al. 2023; Liu et al. 2024b). Each locational unit referred to the local of a campus, which was used once for a random selection of campus numbers using '=rand( )' function in the Excel.xlsx file (Microsoft Inc. Great China Region, Beijing Branch, Beijing, China). This was employed to ensure that at least one university could be chosen from a local unit. Generally, highly competitive universities can be categorized into two types that are labelled by '985' and '211.' The '985' label abbreviates a full term of 'Project 985,' which was named for a sponsorship scheme by Chinese central government for building 39 universities to the world-class which was initiated in May 1998. The '211' label abbreviates a program released in November 1995 when it aimed to build about 100 universities that had competitiveness in

varied fields in the 21st century. It is generally recognized that universities categorized to '985' or '211' labels might probably belong to the queue of high competitiveness with probably more competitive disciplines than other types of universities.

Finally, a total of 50 universities in '985' or '211' categories were chosen, and their coordinates and rating categories are listed in Table 1. The spatial distributions of these species are shown in Figure 1. The spatial distributions were mapped using ArcGIS Pro version 10.5 software (ESRI 2025). The number of A+ disciplines was obtained from the official webpages of each chosen university. As we only studied the number of competitive disciplines, the detailed names and quality of each discipline were not considered.

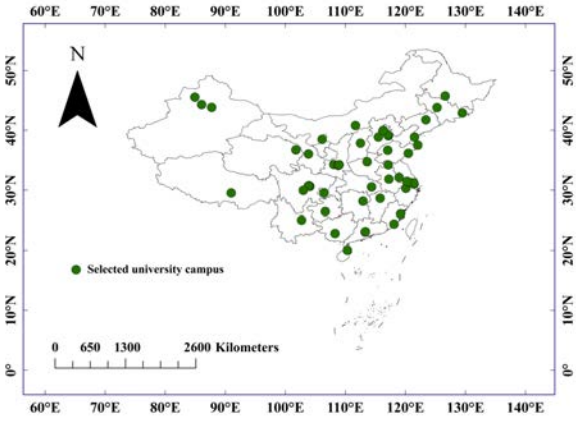

Figure 1 Spatial distribution of selected university campuses in mainland China. The figure were generated using ArcGIS Pro version 15.0 (ESRI, 2025).

Table 1 List of university campuses with number of subjects taking photos in indoor or outdoor places.

Province / Municipality	City	Campus name	Rating category	Number of photos at places photographed	
				Indoor	Outdoor
Anhui	Hefei	Anhui Univ.[1]	211	49	43
Beijing		Tsinghua Univ.	985	50	49
		Peking Univ.	985	50	50
Fujian	Xiamen	Xiamen Univ.	985	48	50
	Fuzhou	Fuzhou Univ.	211	48	50
Gansu	Lanzhou	Lanzhou Univ.	985	50	50
Guangdong	Guangzhou	Sun Yat-Sen Univ.	985	49	49
		South China Univ. Tech.[2]	985	46	46
Guangxi	Nanning	Guangxi Univ.	211	49	50
Guizhou	Guiyang	Guizhou Univ.	211	48	50
Hainan	Haikou	Hainan Univ.	211	49	47
Hebei	Tianjin	Hebei Univ. Tech.	211	49	48
	Baoding	North China Elec.[3] Power Univ.	211	47	47
Henan	Zhengzhou	Zhengzhou Univ.	211	49	48
Heilongjiang	Harbin	Harbin Inst.[4] Tech.	985	49	54
Hubei	Wuhan	Wuhan Univ.	985	49	46
Hunan	Changsha	Hunan Univ.	985	48	52
Jilin	Changchun	Jilin Univ.	985	48	58
	Yanji	Yanbian Univ.	211	49	49
Jiangsu	Nanjing	Nanjing Univ.	985	47	44
	Suzhou	Suzhou Univ.	211	49	47
	Wuxi	Jiangnan Univ.	211	48	47
	Xuzhou	China Univ. Mining Tech.	211	47	47
Jiangxi	Nanchang	Nanchang Univ.	211	49	50
Liaoning	Shenyang	Northeast Univ.	985	48	49
	Dalian	Dalian Univ. Tech.	985	48	49
Inner Mongolia	Hohhot	Inner Mongolia Univ.	211	47	47
Ningxia	Yinchuan	Ningxia Univ.	211	47	44
Qinghai	Xining	Qinghai Univ.	211	50	49
Shandong	Weihai	Shandong Univ., Weihai	985	45	49
	Jinan	Shandong Univ.	985	47	47
	Tsingdao	Ocean Univ. China	211	42	48
Shanxi	Taiyuan	Taiyuan Univ. Tech.	211	46	49
Shannxi	Yangling	Northwest A&F[5] Univ.	985	48	48
	Xi'an	Xidian Univ.	211	46	48
		Xi'an Jiaotong Univ.	985	50	50

Province / Municipality	City	Campus name	Rating category	Number of photos at places photographed	
				Indoor	Outdoor
Shanghai		Shanghai Jiaotong Univ.	985	47	58
		East China Normal Univ.	985	49	49
Sichuan	Chengdu	Sichuan Univ.	985	47	50
		Univ. Elec. Sci.[6] Tech. China	985	50	50
		Southwestern Univ. Finan.[7] Econ.[8]	211	49	50
	Ya'an	Sichuan Agr. Univ.	211	47	41
Tianjin	Tianjin	Nankai Univ.	985	45	50
Tibet	Lhasa	Tibet Univ.	211	42	45
Xinjiang	Urumchi	Xinjiang Univ.	211	49	48
	Shihezi	Shihezi Univ.	211	49	45
	Karamay	China Univ. Petr.[9] Beijing Karamay	211	46	47
Yunan	Kunming	Yunnan Univ.	211	50	50
Zhejiang	Hangzhou	Zhejiang Univ.	985	50	49
Chongqing		Chongqing Univ.	985	49	49

[1]University, University; [2]Tech., technology; [3]Elec., electricity; [4]Inst., institute; [5]A&F, agriculture and forest; [6]Sci., science; [7]Finan., finance; [8]Econ., economy; [9]Petr., petroleum.

Facial photo collection and emotion assessment

The locations of objective campuses were taken as check-in plots, which were used to recruit volunteers by posting repeated ad-vertisements on the SNS platforms Little Red Book (Xingyin Information S&T Inc., Shanghai, China) (Little Red Book 2024) and Sina Weibo (Micro-Dream Internet Tech. Inc., Beijing, China) (Sina Weibo 2024). The promotion slogan was to 'Let your confidence disclose on your face in a beautiful campus with enriched elements of nature from a host university.' Volunteers were asked to send at least one of their facial photos to a specified email address, with a digitally signed agreement to transfer rights to the authorship of this study to use their facial photos.

Real-time participation was required for the moment when photos were taken on the campus to ensure that facial emotions were responsive to the environment in the photo background. Volunteers clearly indicated that their photos had to be taken on campus and explicitly inside the administrative range of host university. Photos were derived from blogs in their social network records, with pieces of information about real-time location and time dis-closed. These were asked to ensure that photos were taken on the chosen campuses at the required times because social network records can show not only photos but also the places where photos were taken, which can also be checked according to the open-access records.

The photos were requested to be delivered with a certificate in any form that could prove that the photo was taken on one of the objective campuses, either indoors or outdoors. Age and gender were also provided through photos, which could not be seen through SNS records, but were necessary for statistical analysis. The demographic attributes were recorded to provide data for statistical analysis. Every campus was designed to capture 100 photos, 50 indoors, and 50 outdoors. All photos and their location certificates were reviewed by a technician, and the host could obtain an award of 1 CNY if his/her photo was chosen.

The recruitment for a campus was closed as soon as the number of chosen individuals reached the required line, and any further photos sent were no longer rewarded. The time for photo collection was limited to the calendar period of 2023. Since this year, global people have started to be free from lockdown caused by large-scale COVID infections, and campuses were open for students and mentors to get back and enroll in ordinary educational lives. Recruitment started on February 1, 2023, and ended on January 13, 2024, when the last photo passed the review.

Photos that were excluded by rejection in the review had typical attributes:

(i) A face was over-decorated by digital

manipulations, either heavily made up or over a warped cheek.
(ii) Sensing organs were covered with sunglasses, hats, hair, or a large neckerchief.
(iii) The reported location could not be verified to be at any of the objective campuses.

Photos were cropped to leave the face, accounting for over 60% of that in host image, and rotated to the corrected slant cheek back to a frontal position with the nose naturally vertical to eyes' horizon. The photographs were recognized using FireFACE software (version 1.0) to rate the scores of happy, sad, and neutral emotions (Wei et al. 2019; Wei et al. 2020; Wei et al. 2022b). The numbers of photos recognized for the facial expression scores for indoor and outdoor volunteers are listed in Table 1. A total of 4824 photos were successfully recognized by the software and rated as emotional scores. Subsequently, the emotional indices can be calculated as follows:

$$\mathrm{PRI} = \mathrm{S_{Happy}} - \mathrm{S_{Sad}} \quad (1)$$

$$\mathrm{ENRI} = \log\left(\frac{\mathrm{S_{Happy}}}{\mathrm{S_{Sad}} + \mathrm{S_{Neutral}}}\right) \quad (2)$$

where PRI is the abbreviation of the positive response index, which is computed as net positive performance in a face with combined happy and sad scores (Wei et al. 2019a); ENRI is abbreviated from the emotional nonparametric relation index, which was used to gauge relative emotional performance between positive and negative/indifferent sentiments without units (Garau et al. 2024); and S_{Happy}, S_{Sad}, and $S_{Neutral}$ refer to happy, sad, and neutral scores in a photo, respectively. The dual employment of the PRI and ENRI can be used to fully evaluate the emotional motivation of positive sentiments against indifferent or negative emotions.

Given that emotions recognized by the machine may suffer technical errors because the model used in the pre-training had the ability to accumulate mismatched errors and recognized facial expression scores, it is necessary to validate the use of typical facial expression scores as dependent variables. Approximately 10% of the photos were randomly chosen from the total data pool, and 480 photos were targeted and arranged into a sub-sample for validation. They were then randomly divided into ten groups, each containing 48 photos. The photos in one group were divided into three columns, and each column contained 16 photos. One participant was invited to distribute 16 photos to one of the three boxes: happy, sad, and neutral. The recognition ratio of an emotion was calculated as the number of photos distributed in the box divided by the total number of 48. Ten participants were recruited for repeat distributions, and their recognition ratios were averaged to mean values, which were compared with those calculated by the machine. Matching accuracy was calculated as the quotient of the human-distributed number for an emotion divided by the machine-distributed number. The matching accuracies for happy, sad, and neutral scores were 73.8%, 79.9%, and 75.4%, respectively. According to a previous study, only when the matching accuracy is higher than 70% can the emotion be accepted for the analysis (Wei et al. 2021b).

Landscape metrics: evaluation and calculation

The campus landscape was evaluated remotely using Landsat 8 OLI satellite imageries (30m resolution) (Chen & Guo 2022, Sun et al. 2023). Green space area (GreenA) and blue space area (BlueA) were commonly evaluated using the normalized difference vegetation index (NDVI) (Markevych et al. 2017) and normalized difference water index (NDWI) (Sekertekin et al. 2018), re-spectively (Chen & Guo 2022):

$$\mathrm{NDVI} = \frac{\mathrm{Band_5} - \mathrm{Band_4}}{\mathrm{Band_5} + \mathrm{Band_4}} \quad (3)$$

$$\mathrm{NDWI} = \frac{\mathrm{Band_3} - \mathrm{Band_6}}{\mathrm{Band_3} + \mathrm{Band_6}} \quad (4)$$

where, $Band_5$ and $Band_4$ are reflections of near

infrared ray and red-light bands, respectively; $Band_3$ and $Band_6$ are reflections of green light and short-wave infrared 1 (1.57–1.65 μm) bands, respectively. The vegetation height in green spaces was evaluated using a digital surface model (DSM) (Japan Aerospace Exploration Agency, 2021) by subtracting the digital elevation model (DEM) (NASA EarthData, 2021). In addition, the DEM was used to calculate the average elevation of a campus.

Statistical analysis

All data were analyzed using SAS software (9.4 version 64-bit for Windows) (SAS Stat. Ins. Inc., Cary, NC, China). The data followed normal distributions with homogeneous variances, except for the sad scores. Hence, sad scores were transformed into statistical analysis to enable free abnormal distribution and transformed back when exposing the results. Emotional scores were analyzed using one-way analysis of variance (ANOVA) in response to grouping by rating category (211 vs. 985), seasonal varia-tion (spring, summer, autumn, winter), gender (female vs. male), age (adolescent, youth, middle age, senior), and photographed (indoor vs. outdoor). Thereafter, emotional scores were also analyzed using two-way ANOVA to detect the combined effects of A+ discipline number category (0, 1-10, 10-20, >20) and places on emotional scores. Pearson's correlation was used to detect relationships between A+ discipline number and every emotional score and between pairs of emotional scores (Liu et al. 2025a). Based on these analyses, multivariate linear regression was used to detect multiple landscape factors that contributed to emotional scores.

Results

Records and distributions of campuses with A+ discipline numbers

Universities with a large number of A+ disciplines had campuses that were mainly distributed in the northern and eastern parts of mainland China (Figure 2A). Beijing and Heilongjiang harbored universities that had the largest number of A+ disciplines due to the high numbers at Peijing University, Tsinghua University, and Harbin Institute of Technology (Figure 2B). Regions around downstream of the Yangtze River also harbored university campuses that had large A+ discipline numbers. This was mainly at-tributed to the high number of A+ disciplines at Zhejiang University, Shanghai Jiaotong University, Nanjing University, and Wu-han University.

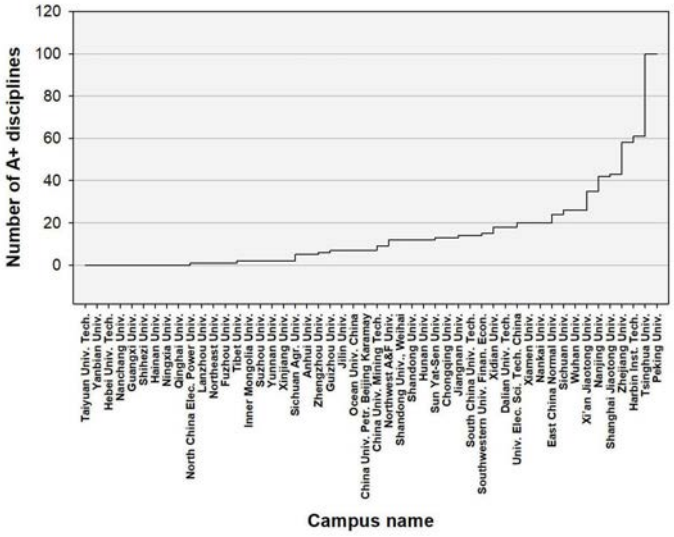

Figure 2 Ranking of A+ discipline numbers among universities.

Attributes of emotional scores

The matching accuracies for happy, sad, and neutral emotions were 91.62%, 87.86%, and 84.23%, respectively, and no signifi-cant

differences were found between machine and human recognition (P = 0.0864, 0.0792, and 0.0748, respectively). Happy scores ranged between 0.01% and 99.99% with an average of 55.54±49.67 (mean ± standard deviation) (Figure 3A, B). Sad scores ranged between 0.00% and 97.06%, with an average of 15.48±18.95 (Figure 3C, D). Neutral scores ranged between 0.00% and 99.77% with an average of 43.28±33.75 (Figure 3E, F). PRI score ranged between -96.65% and 99.99% with an average of 25.75±53.05 (Figure 3G, H). ENRI score ranged between -4.00% and 4.00%, with an average of 1.69±4.00 (Figure 3I, J).

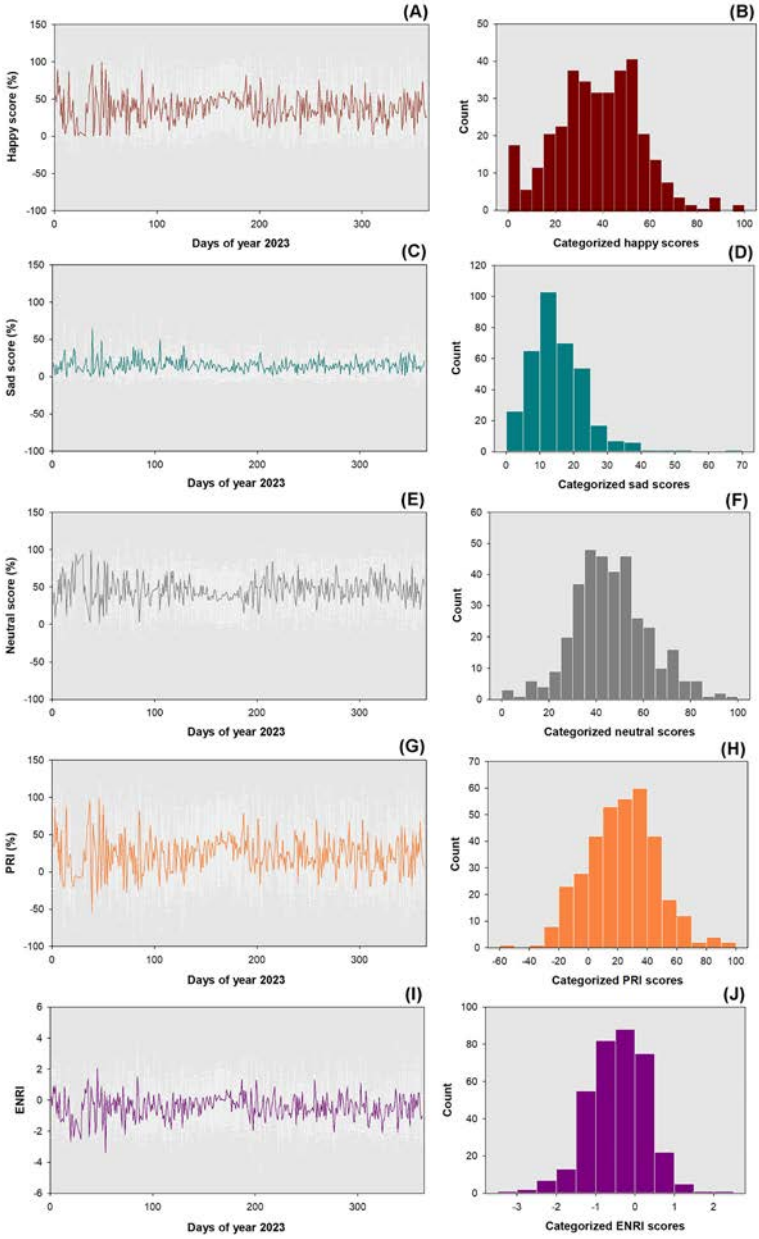

Figure 3 Raw data dynamics among days of the year 2023 (A, C, E, G, I) and histograms for happy (B), sad (D), neutral (F), PRI (H), and ENRI (J) scores. Standard errors in dynamic data are presented as white bars.

According to Table 2, 985-rated universities attracted people with higher positive emotions (happiness score, PRI, and ENRI) than 211-rated universities. The summer season had higher positive emotions and lower sad and neutral emotions than the other three seasons did. Compared to male volunteers, female volunteers had higher positive emotional scores and lower sad or neutral scores. Senior volunteers showed lower happy scores and ENRI but higher sad scores than did youth and middle-aged volunteers. Volunteers in outdoor places showed higher positive emotional scores, but lower sad and neutral scores than those in indoor places.

Table 2 Differences in emotional scores for people exposed to campuses in response to the rating category of university, seasonal variation, gender and age of subjects, and the place photographed were the main effects in comparisons using one-way ANOVAs.

Independent variables	*n*	Happy (%)	Sad (%)	Neutral (%)	PRI [1] (%)	ENRI [2]
Rating category						
211	2473	39.88±26.85b [3]	16.73±13.32a	43.39±22.41a	23.14±35.98b	–0.40±1.12b
985	2351	42.67±27.63a	14.16±12.25b	43.17±23.33a	28.50±35.82a	–0.26±1.17a
F value [4]		6.33	23.58	0.05	13.43	9.29
P value		0.0119	<0.0001	0.8168	0.0003	0.0023
Seasonal variation						
Spring	1118	36.43±26.93c	18.01±14.16a	45.56±22.78b	18.42±36.49b	–0.55±1.12c
Summer	1875	47.86±28.34a	13.41±12.48c	38.73±23.47d	34.45±36.97a	–0.05±1.20a
Autumn	1242	36.01±27.43c	15.42±12.60b	48.56±23.54a	20.59±35.61b	–0.55±1.16c
Winter	589	40.27±28.83b	17.41±14.75a	42.32±24.15c	22.87±38.91b	–0.33±1.20b
F value		34.36	18.32	25.71	33.71	36.13
P value		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Gender						
Female	3468	47.14±26.85a	13.47±11.76b	39.39±22.16b	33.66±35.03a	–0.05±1.09a
Male	1356	26.14±24.89b	20.61±14.66a	53.25±22.88a	5.53±33.84b	–1.05±1.13b
F value		301.45	147.05	187.22	307.85	395.83
P value		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Age						
Adolescent	21	32.11±33.79ab	10.02±13.40c	57.88±32.80a	22.09±39.59a	–0.72±1.55b
Youth	4420	41.37±26.48a	14.65±11.87c	43.97±22.26ab	26.72±34.47a	–0.33±1.12a
Middle age	364	40.65±29.51a	24.61±18.61b	34.74±22.90b	16.04±43.69a	–0.34±1.18a
Senior	19	30.14±32.15b	39.07±26.39a	30.79±24.51b	–8.92±53.47a	–0.82±1.44b
F value		5.52	25.46	30.19	0.63	7.91
P value		0.0009	<0.0001	<0.0001	0.5979	<0.0001
Place photographed						
Indoor	2396	38.07±26.53b	16.67±13.25a	45.26±22.43a	21.40±35.44b	–0.47±1.10b
Outdoor	2428	44.36±27.78a	14.31±12.38b	41.34±23.21b	30.05±36.21a	–0.20±1.18a
F value		25.51	7.83	19.29	23.42	27.51
P value		<0.0001	0.0052	<0.0001	<0.0001	<0.0001

[1]PRI, positive response index, calculated as difference of happy score minus sad score; [2]ENRI, emotional nonparametric relation index, calculated as logarithm of happy score divided by sum of sad and neutral scores; [3]different letters along a column for an independent variable indicate significant differences according to Duncan test at 0.05 level; [4]*F* and *P* values are adapted from analysis of variance results.

Combined effects of discipline number and place on emotional scores

As shown in Figure 4, outdoor volunteers showed higher happy scores than indoor volunteers in university campuses with at least one A+ discipline (Figure 4A). Volunteers in indoor places showed no difference in happy scores on university campuses with varied categories of A+ disciplines. Outdoor volunteers showed higher happy scores in the campuses of universities with A+ disci-pline numbers in the range of 10–20 than those in universities with discipline numbers in 1–10 (Figure 4A).

Volunteers at outdoor places showed lower sad scores than indoor volunteers in the campuses of universities with A+ disci-plines in numbers over 10 per university (Figure 4B). Again, indoor volunteers showed no difference in sad scores among universi-ties with varied A+ discipline numbers. Compared to campuses with zero A+ disciplines, those with over 10 A+ disciplines har-bored outdoor volunteers with lower sad scores.

Volunteers at outdoor places showed lower neutral scores than indoor volunteers only on the campuses of universities with 10–20 A+ disciplines (Figure 4C).

PRI score was higher for the faces of outdoor volunteers than for those of indoor volunteers on university campuses with at least one A+ discipline (Figure 4D). Indoor volunteers showed no difference in PRI scores among universities with varying num-bers of A+ disciplines. Outdoor volunteers showed higher PRI scores in universities with 10–20 A+ disciplines than in universities with no A+ discipline.

ENRI score was higher for outdoor volunteers than for indoor volunteers on university campuses with more than 10 A + dis-ciplines per campus (Figure 4E). Volunteers in outdoor places showed higher ENRI scores on campuses of universities with A+ disciplines of 10–20 than those with A+ disciplines in numbers fewer than 10 per university.

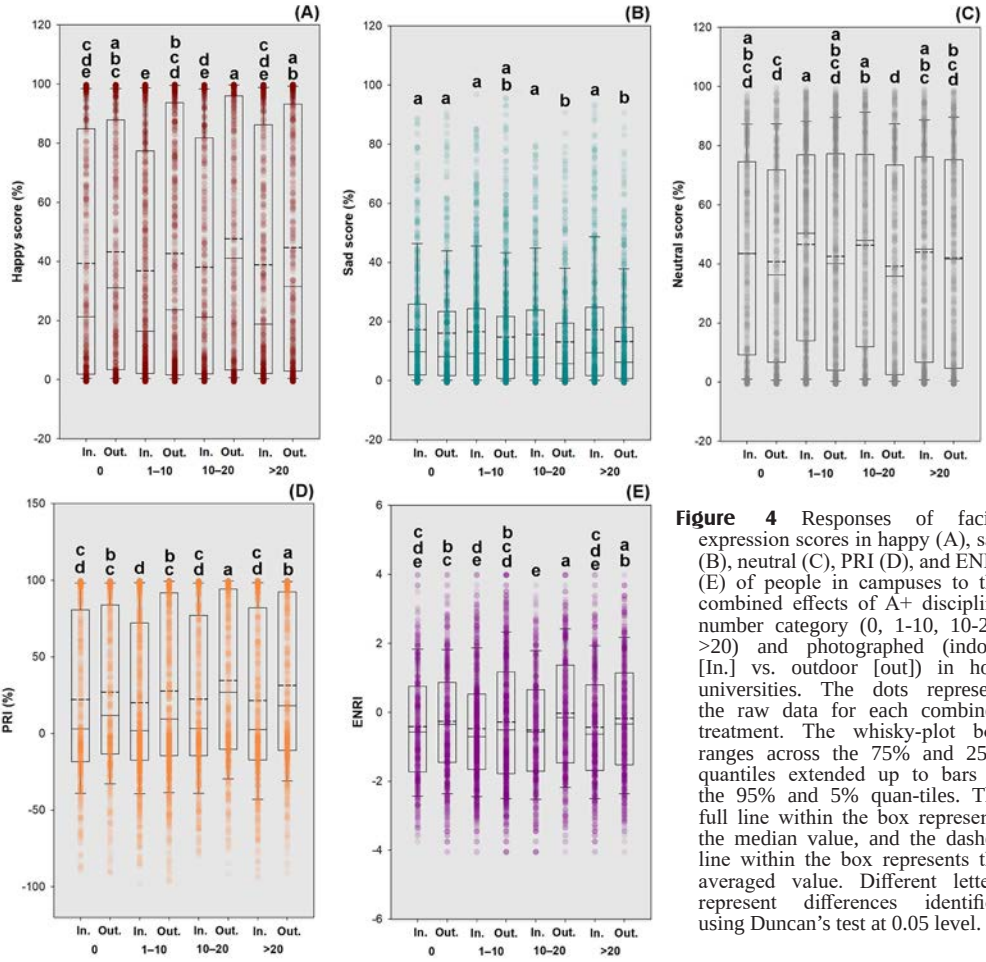

Figure 4 Responses of facial expression scores in happy (A), sad (B), neutral (C), PRI (D), and ENRI (E) of people in campuses to the combined effects of A+ discipline number category (0, 1-10, 10-20, >20) and photographed (indoor [In.] vs. outdoor [out]) in host universities. The dots represent the raw data for each combined treatment. The whisky-plot box ranges across the 75% and 25% quantiles extended up to bars at the 95% and 5% quan-tiles. The full line within the box represents the median value, and the dashed line within the box represents the averaged value. Different letters represent differences identified using Duncan's test at 0.05 level.

Relationship between A+ discipline number and human emotional scores

As shown in Table 3, among the scores of all types of emotions, only neutral scores showed negative relationships with the A+ discipline number for volunteers in host universities. Furthermore, the neutral score also showed negative relationships with happy score for volunteers at indoor and outdoor places. The neutral score had a negative relationship with the PRI and ENRI scores for the outdoor volunteers. Happy scores had a positive relationship with PRI and ENRI, which showed negative relationships with sad scores.

Spatial distributions of emotional scores and landscape metrics

Indoor volunteers showed high happy scores mainly on campuses in southern regions compared to northern regions (Figure 5A, B). Typically, on campuses in Zhejiang, Hunan, Guizhou, and Tibet, both indoor and outdoor volunteers showed higher happy scores than in most other regions.

Sad scores were high for both indoor and outdoor volunteers in cities near coastal regions, such as Anhui, Henan, Fujian, and Guangdong (Figure 5C, D). In addition, indoor volunteers also showed high sad scores on campuses in the western regions of Gansu and Qinghai.

Table 3 Correlation between A+ disciplines in universities and emotional scores of campus visitors with data split by photographs taken indoors versus outdoors.

Parameters	Correlation coefficients	Happy	Sad	Neutral	PRI [1]	ENRI [2]
Indoor data						
A+ [3]	*R* [4]	-0.1845	0.0668	-0.3635 [5]	-0.1530	-0.2115
	P [6]	0.1997	0.6449	0.0095	0.2888	0.1403
Happy	*R*	1	-0.6086	-0.3340	0.9375 [7]	0.9736
	P		<.0001	0.0178	<.0001	<.0001
Sad	*R*		1	-0.1887	-0.8467	-0.6050
	P			0.1893	<.0001	<.0001
Neutral	*R*			1	-0.1413	-0.2765
	P				0.3277	0.0519
PRI	*R*				1	0.9182
	P					<.0001
ENRI	*R*					1
	P					
Outdoor data						
A+	*R*	0.1121	-0.090	-0.3565	0.1177	0.1223
	P	0.4385	0.5338	0.0111	0.4155	0.3976
Happy	*R*	1	-0.5304	-0.6687	0.9532	0.9767
	P		<.0001	<.0001	<.0001	<.0001
Sad	*R*		1	-0.1035	-0.7620	-0.5308
	P			0.4744	<.0001	<.0001
Neutral	*R*			1	-0.4739	-0.6469
	P				0.0005	<.0001
PRI	*R*				1	0.9355
	P					<.0001
ENRI	*R*					1
	P					
Both indoor and outdoor data						
A+	*R*	-0.0422	0.0006	-0.4457	-0.0298	-0.0484
	P	0.7712	0.9969	0.0012	0.8374	0.7385
Happy	*R*	1	-0.5500	-0.4658	0.9340	0.9814
	P		<.0001	0.0007	<.0001	<.0001
Sad	*R*		1	-0.1934	-0.8121	-0.5525
	P			0.1785	<.0001	<.0001
Neutral	*R*			1	-0.2426	-0.4313
	P				0.0896	0.0018
PRI	*R*				1	0.9221
	P					<.0001
ENRI	*R*					1
	P					

[1]PRI, positive response index; [2]ENRI, emotional nonparametric relation index; [3]A+, number of A+ disciplines per university; [4]*R*, determinative coefficient; [5]values in white font and dark-grey cells indicate negative relationships; [6]*P*, probability of significance; [7]values in black font and light-grey cells indicate positive relationships.

The neutral scores of indoor volunteers were distributed mainly in the northern and southern regions (Figure 5E). The neutral scores of the outdoor volunteers were higher in the northeastern and southwestern regions (Figure 5F).

PRI score showed a similar spatial distribution pattern to the happy score, which was generally higher in the southern regions (Figure 5G, H).

Indoor volunteers showed higher ENRI scores in the southern regions, while outdoor volunteers showed higher ENRI scores in the northern and western regions (Figure 5I, J).

GreenA was mainly high in the eastern and western regions and the central parts of Jiangxi and Hubei (Figure 6A). The northern and southern campuses had lower GreenA values than most of the other regions. BlueA was mainly high on campuses in extremely northwestern and southeastern regions (Figure 6B). VegH was high in the western regions,

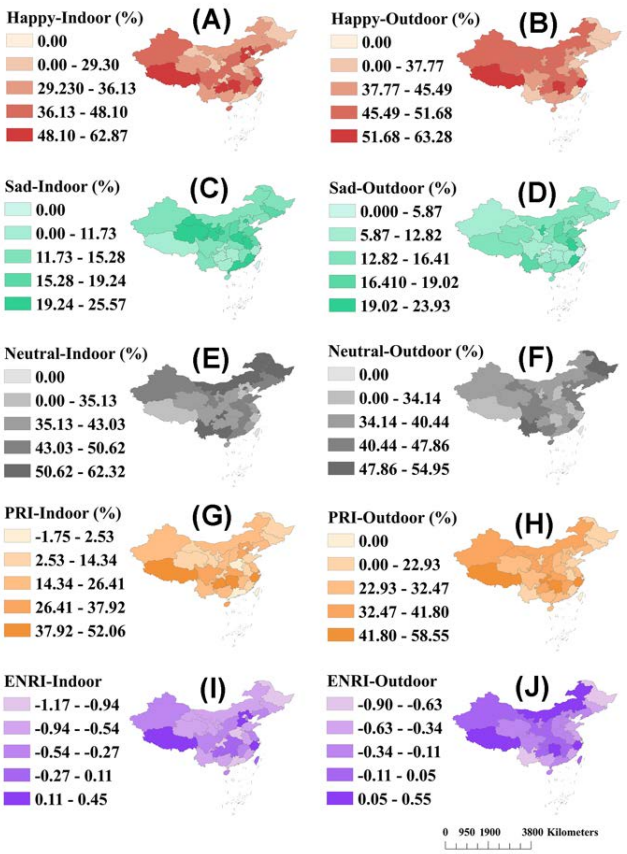

Figure 5 Spatial distributions of facial expression scores for happy (A, B), sad (C, D), neutral (E, F), PRI (G, H), and ENRI (I, J) for volunteers indoors (A, C, E, G, I) and outdoors (B, D, F, H, J) in campuses of universities in China. The figure was generates using ArcGIS Pro version 15.0 (esri, 2025).

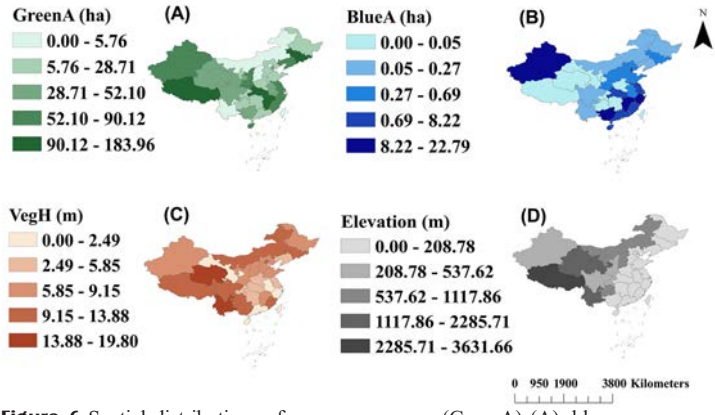

Figure 6 Spatial distributions of green space area (GreenA) (A), blue space area (BlueA) (B), vegetation height (VegH) (C), and elevation (D) on university campuses in China. The figure was generates using ArcGIS Pro version 15.0 (esri, 2025).

especially in Yunan and Qinghai, and most of the eastern campuses had lower VegH (Figure 6C). The elevation of the campus was generally lower in the eastern regions than in the western regions (Figure 6D).

Multiple landscape metrics determining emotional scores

Longitude had a negative contribution to happy scores, while BlueA, GreenA, and elevation had positive contributions (Figure 7A). In contrast, BlueA had a negative contribution to the sad scores for outdoor volunteers (Figure 7B). Additionally, BlueA and GreenA generated negative contributions to the neutral score (Figure 7C). Again, longitude generated negative contributions to the PRI score and BlueA generated positive contributions (Figure 7D). BlueA also generated a tiny and positive contribution to ENRI (Figure 7E).

Discussion

Landscape environment and subjects' sentiments in campus

In this study, the matching accuracies (generally greater than 73.8%) were higher than the suggested critical value of 70% (Wei et al. 2021b). The critical of 70% was required to be rigorous as it was even higher than that in another study, which was only ap-proximately 60% (Guan et al. 2021). The variation in the matching accuracies in these studies was due to the data (Liu et

al. 2025b). The matching accuracies in this study were higher because data were provided by volunteers acquired from hosts' social networks, where emotions were posted more as gestures than random performance. However, the 70% critical value was calcu-lated from a pool of randomly photographed pedestrians at the entrance of a park, and most of them showed only subtle emo-tions (Wei et al. 2021b). In another study, a 60% critical value was calculated from a pool of data collected from 20 publications (Guan et al. 2021).

In my study, the human-machine difference was not statistically significant, which demonstrated the validity of the emotional data analysis. The matching accuracies for happy, sad, and neutral scores were 73.8%, 79.9%, and 75.4%, re-spectively, and sad scores showed the highest recovery of machine recognition from artificial approaches. This was reasonable because humans naturally show sadness when negative emotions are perceived, but this is not the case for smiles with positive emotions (Liu et al. 2025b).

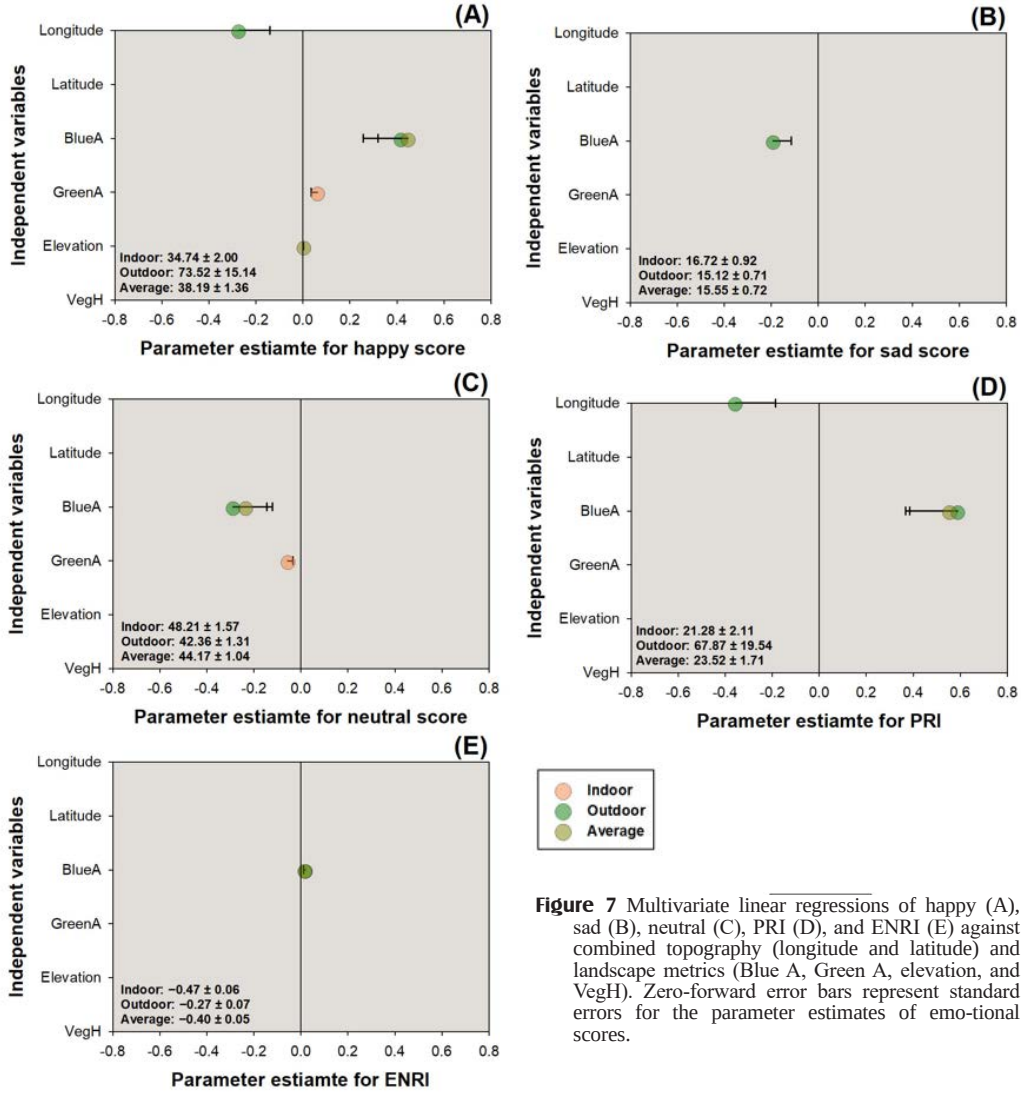

Figure 7 Multivariate linear regressions of happy (A), sad (B), neutral (C), PRI (D), and ENRI (E) against combined topography (longitude and latitude) and landscape metrics (Blue A, Green A, elevation, and VegH). Zero-forward error bars represent standard errors for the parameter estimates of emo-tional scores.

Volunteers at outdoor places showed higher happy scores and lower neutral scores than those at indoor places. Happy scores had a negative relationship with neutral scores; hence, outdoor subjects perceived more positive sentiments than others staying inside buildings. This was attributed to the higher exposure to nature in the external environment than in the internal en-vironment. Neutral emotions were also found to be negatively related to happiness scores in studies of urban parks (He et al. 2023a, Wang et al. 2023).

Regarding the negative relationship between neutral score and university A+ discipline number, univer-sity competitiveness had the potential to be positively related to the positive emotions of subjects on campus due to the rule of a positive derived from dual negatives. The neutral score was not related to sadness; hence, the negative emotions of subjects were perceived to an extent that was not strong enough to cause sadness. Reduced indifference reverses to indicate a high frequency of positive sentiments, which may promote competitiveness by activating learning attitudes (Turki et al. 2018), enhancing self-efficacy (Pedditzi & Spigno 2018), and increasing the sense of innovation (Blasková & Blasko 2013). Hence, it makes sense to continuously detect landscape environments that can benefit from this positive effect.

Two-way ANOVA detecting the combined effects of competitive discipline number and place photographed on neutral scores revealed that outdoor volunteers would show significantly lower neutral scores than indoor volunteers only in campuses of universities with 10 20 A + disciplines. This suggests that outdoor volunteers showed more positive sentiments than indoor volunteers, contributing to the competitiveness of universities of this type. These findings can be explained by the fact that a higher dose of nature is touched in the external environment than in buildings. This was supported by multivariate linear regression, which indicated that BlueA and GreenA generated positive contributions to happy score, and BlueA showed a stronger contribution than GreenA. BlueA was also the unique to promote PRI and ENRI at the time when GreenA effect disappeared. These findings synchronize the spatial distributions in Xinjiang, Heilongjiang, and Yunnan. A large area of green space has proven to be a strong trigger for evoking positive emotions in urban parks (Wang et al. 2023).

This study illustrates that blue space areas can also result in this effect by bringing about benefits that overcome those provided by green space. This concurs with previous findings on urban forest parks (Wei et al. 2022b) and wetland parks (Li et al. 2022b).

In the neighborhood landscape, BlueA was also found to benefit more perceptions of positive emotions than GreenA (Chen & Guo 2022). These results contradict the gen-eral belief that an experience of any type of nature can directly promote the perception of positive sentiment (Kong et al. 2022; Li et al. 2022b). Thus, previous studies rarely focused on the nature-touch effects of green versus blue spaces on perceived senti-ments, and this study and the findings we cited together revealed a color-specific effect on emotional responses. Most of the cur-rent studies obtained data from visitors in parks, where most people spend time with random attention. However, on a university campus, people may pay more attention to self-efficacy and self-focus in their time with neighboring GBS (Pedditzi & Spigno 2018; Ponseti et al. 2019; Yan & Sun 2024); hence, attention recovery can be more sensitive to the type of nature they come across. Overall, experiencing GBS on campus can evoke positive emotions and reduce negative mood. This was achieved by experiencing the blue space and perceiving its area, which showed a stronger effect than experiences in the green space.

Academic and demographic effects on sentiments

In China, competitive universities were qualified as the type ‘211’ (Wei et al. 2020a) and recently as the type ‘985’ (Ministry

of Education of the People's Republic of China, 2020). Although these two evaluation types had rare common spaces that could be compared together, the 985-type universities appeared to be more competitive than those identified by the 211-type, probably because of the number of A+ disciplines. Typical provincial areas include Northeast China, Beijing, Zhejiang, and Hubei. Com-pared to sentiments posted on 211-university campuses, emotions for 985-universities were more positive, but no difference oc-curred in neutral scores. As discussed in the preceding paragraphs, this means that the difference in emotional perceptions be-tween the 211- and 985-type university campuses had no business with discipline-dependent competition. This could be attribut-ed to the larger areas of GBS in the campuses of 985-type universities than in 211-univesities according to the above discussed contents.

In this study, volunteers showed more positive emotions and less negative or indifferent sentiments in summer than in the other seasons. In contrast, positive emotions were found to be lower in summer than in autumn and winter for community mem-bers. For most people dwelling in university campuses, summer refers to the end of a semester or the termination of a period of academic education and the start of a long vacation. These are promotions for most locals to perceive positive subjective emo-tions.

This study found that male volunteers showed more negative but less positive sentiments than did female volunteers. Smaller seasonal fluctuations can be seen in the dynamics of all emotional scores across the year 2023. This has been reported several times in previous studies (Wei et al. 2019, Guan et al. 2021), which suggests that males are more likely to perceive mental stressors than females, especially when facing a competitive atmosphere on campus. The senior volunteers in this study were over 60 years of age, which touched the age of retirement. This group of volunteers posted more negative emotions and fewer smiles than younger generations, which disagrees with parks (Guan et al. 2021; Wei et al. 2021a).

In China, urban parks are recreational places that naturally attract senior walkers (Zhai & Baran 2017, Guo et al. 2023), who are unlikely to have any occupational relations with the senior population. However, senior citizens on university campuses are mostly retired from the academic facul-ty or office staff. According to Chaichian (2021), the negative mood of retired faculty in higher educational institutions may result from limited contact and reduced involvement in campus-related activities (Chaichian 2021). It is noteworthy that the ENRI also reflected more negative sentiments posted by senior volunteers than by middle- and young-aged populations. The ENRI was designed to detect emotional differences when both positive and negative emotions were associated with a dependent variable (Garau et al., 2024). As the ENRI was calculated to be negative for all ages of volunteers, senior volunteers posted more negative sentiments than younger generations.

Relationship between competitive discipline number and sentiment

In this study, the competitiveness of universities was evaluated by their A+ discipline numbers instead of other parameters, such as knowledge sharing, employment ease, and information documentation (Dachyar & Dewi 2015, Krägeloh et al. 2019). Many parameters remained at the identification stage and were unlikely to be adopted by universities to evaluate competitiveness in a remarkable number that can support an essential study. The number of A+ disciplines was indicated to reflect the host universi-ty's overall competitiveness (Abramo et al. 2016); hence, the increase in these highly evaluated disciplines can make a large con-tribution to the overall competitiveness of host universities (Abramo et al. 2016). More importantly, the

competitive discipline number is an easily obtained parameter for universities in China that can work as a useful source of data to support this study.

My results failed to detect any relationship between the A+ discipline number and facial emotional scores in the campuses of host universities. Among all emotional parameters, only the neutral score showed a negative relationship with the number of A+ disciplines. This suggests that universities with more competitive disciplines tend to accommodate people with rare appearances of indifferent emotions on their faces. This further suggests the potential for more motivated people with positive sentiments re-garding the negative relationship between neutral and happy scores for both indoor and outdoor volunteers.

Emotional scores were rated from intentional sentiments provided by volunteers who were asked to show off their beautiful cheeks in one of the given campuses. People have a polite habit of intentionally smiling in front of a camera, but this does not mean that people consider a smile to mean their self-beauty (Southwick et al. 2023). In Chinese, 'beauty' may also mean 'attrac-tive' or 'satisfaction.' According to self-perception theory, one may take a smile as a trait of attractiveness in the social dimension or satisfaction in an individual dimension (Van der Geld et al. 2007). As no hints were delivered to the volunteers that they had better send a photo with a smile, their general understanding of self-perceived beauty should not be limited to posting positive sentiments. Lower neutral scores found for volunteers in more competitive universities may result from two driving explanations: inward intension and outer implication. A neutral mood is usually taken as a reference to which self-focus can be assessed against happy or sad moods. Several studies have found that people in happy moods have a higher self-focus than those in neu-tral moods (Wood et al. 1990; Salovery 1992; Sedikides 1992). This argument partly agrees with the finding that happiness contradicts neutral emotion. A university campus is mainly characterized as a place for studying, where indoor people should be more typical to show their high self-focus in competitive university campuses. However, my results showed that neutral scores had no relationship with either the PRI or the ENRI for indoor volunteers, which were both negatively related to sadness. There-fore, a neutral score that had a negative relationship with host university competition rarely contributed to net positive emotions when sadness was involved with indoor volunteers. Together, these findings suggest a failure of inward intentions to bridge the relationship between sentiment and university competition. In contrast, outdoor people showed a negative relationship between neutral scores and PRI/ENRI scores. Similar results were reported in previous studies on people who posted facial photos outdoors (Wei et al. 2022a).

Overall, we surmise that the nature of the campus landscape affected local people's emotions by evoking limited effects on neutral mood in competitive university campuses.

Priority vs degradation to use facial expression scores

In this study, the use of facial expression scores is a different instrument compared to the conventional methodology using subjective ratings (Aerts et al. 2018, Guo et al. 2023). This methodology has the advantage of overcoming the shortcomings of con-ventional methodologies. First, regardless of whether it was intentional to send photos for analysis in this study, the moment when a subject took a photo was irrelevant with consciousness about being used in this study. Nevertheless, self-reported data are conscious of the aim of being asked for disclosure as soon as the requirement is delivered (Wei et al. 2021b). Second, facial expres-sion scores are easily documented in big-scale studies (Wang et al. 2023, Liu et al. 2025b). Although it is unlikely to reject the possibility of making subjective rating data

available in a large-scale study, its efficiency remains lower than that of the novel instrument. Finally, regarding the shortcomings in facial expression scores, it is not perfect to use an approach that is different from the conventional approach. My methodology has the merit of a lower probability of suffering subjective biases than self-reported scores.

Limits of this study

This study has four limitations. First, the way that we recruited volunteers lacked control to screen realities in photos and in the attached proof. One may fraud by sending a photo outside campus but proved to be therein; the emotion shown in a photo may also be the result of being continuous before its host stepped into the campus. Thus, more rigorous screening should be conducted to check the original records mirrored from the subjects' social network blogs. We surmise that all photos were subjected to the same level of error, and it is unusual for volunteers to fraud for just one CNY.

Second, there are no official reports claiming that the number of A+ disciplines is an index for competition ranking for universities. We employed this parameter based on the national evaluation of discipline performance in China (Ministry of Education of the People's Republic of China, 2020, 2023). It is necessary to determine an index that can be used to rank Chinese universities.

Third, the results of this study were published within a single year. Future studies should repeat the study design and validate the results across different years. Finally, green and blue space areas rely heavily on regional climates because regional transpiration and vegetation acclimation are both limited by meteorological conditions. The combined effects of regional climate and green space on emotions in university campuses (Yan & Sun 2024), but this combined effect was not considered in this study. Further studies should consider this combined effect in a larger context.

Conclusions

According to a survey of recruited volunteers, we found that the number of highly competitive disciplines was only negatively related to the scores of neutral moods of people in campuses of host universities. Neither positive sentiment nor promoted moti-vations for volunteers to stand in campuses can be directly activated by perceptions of the host university's competition. Senti-ments were posted to be more positive in outdoor places than in indoor places on campuses, especially in universities with 10-20 highly competitive disciplines. A large area of blue space triggered perceptions of reduced neutral moods and promoted positive emotions in outdoor places, whereas green space areas benefited indoor perceptions of happiness. Using the A+ discipline number as an index for ranking universities in China, competitive universities were mainly distributed in Heilongjiang, Beijing, Hubei, Shanghai, and Zhejiang. Local campuses were also constructed with large areas of blue and green spaces, which functioned to reduce indifferent emotions and evoked positive motivations.

Declaration

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Department of Faculty of Shanghai Normal University Tianhua College (protocol code: ECDF2024001; date of approval: 4 March 2022). Informed consent was obtained from all subjects involved in the study.

Conflict of interest

The authors declare no financial or personal interests that could influence the work presented in this paper.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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