

The Effects of Indoor Thermal-Light-Acoustic Environments on Undergraduate Students' Emotions under the Pressure of a Test

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ABSTRACT

The environmental qualities (thermal & acoustic) of dwellings and special affairs in campus lives (i.e., tests) are significantly affecting students' emotions. This issue is especially serious when approaching to the semester end since seasonal extreme weathers and high study pressures. This study explored the impacts of multiple factors on college students' emotions during the last month of the (spring) semester. Through field monitoring combining questionnaires about volunteers' sensations on various aspects, characteristics of students' perceptions under certain conditions were found. The students were emotionally affected by thermal and acoustic environments and the test commonly. Their neutral temperatures (indicated by operative temperatures, T_{op}), sound pressure levels (indicated by A-weighted continuous sound pressure, L_{Aeq}), and light intensities were 22.8 (males) and 24.1 °C (females). 45 and 49 dBA, as well as 31.07 (indicated by illuminations, lx) (males) and 55.33 (females) lx, respectively. Their neutral T_{op} dropped gradually as approaching to the test, i.e., from 26.54 (Week 1) to 22.29 (Week 4) °C (females). Their sensations on visual and acoustic environments varied for investigation periods unremarkably. Emotions, in multiple models, were confirmed being affected by various factors in different trends. Their emotions fluctuated considerably for the test. The emotion state vote decreased from 0 (Day 1) to -1 (Day 27). Linear decreases were witnessed between Day 15 (0.5) and Day 27 (-1). Proper design strategies combining with equipment

adjustments were capable to create nice indoor environments in physics. Yet it is needed to pay more attention to students' psychological conditions in the semester end.

KEYWORDS: Indoor thermal comfort; Acoustic environment; Undergraduates; Emotion vote; Distance from the test

ABBREVIATIONS

A /TSV acoustic/ thermal sensation vote

ACV acoustic

dB A-weighted decibel

LAeq A-weighted equivalent continuous sound pressure level(dBA)

LUX Illumination intensity (1 klx = 10^3 lx)

MLR multiple linear regression

MRT mean radiation temperature (°C)

DFTT distance from the test

ITC indoor thermal comfort

NT(s) neutral temperature(s)

NLAeq neutral LAeq

NLUX neutral illumination intensity

OCV overall comfort vote

OTC outdoor thermal comfort

SWUST Southwest University of Science and Technology

T_a air temperature (°C)

T_g globe temperature (°C)

V_a air velocity (m/s)

T_{op} Operative temperature(°C)

ESV Emotional statement vote

PSY Psychology

LSV light sensation vote

UndS undergraduate students

1. Introduction

The poor emotion has become a major mental problem of undergraduate students (UndS) in China (Qiu et al., 2024). Around 30% of them are suffering from that (Reinten et al., 2017). Academic pressure is a common factor causing poor psychology of UndS (Alduraywish et al., 2023). Students who fell in tests would restudy the subject (Philip A Gable et al., 2022). They would be forced to degree cancellation or withdrawal in certain extraordinary conditions (Dyson and Renk, 2006). Degree-relating tests were usually arranged at the semester end. Students suffer from serious psychological pressures when approaching to that (Wang et al., 2024). However, more significantly, most important tests and graduations take place at the early summer in the North Hemisphere. Thermal discomforts combining with mental stress resulted in more complex pressures (Yang et al., 2022). They were commonly influential on campus lives (Patwary et al., 2024), including low study efficiency (Bao, 2023) and physical (Jay et al., 2021) as well as mental health (Liu et al., 2021) etc. College students usually had the significantly emotional fluctuations when

approaching the semester-end test at warm seasons (Bao, 2023). The circumstance would be more serious under noisy conditions (Bao et al., 2022). Poor emotions were evidently affecting human negatively (Manarte et al., 2021). This included cognition (Manarte et al., 2021), perception (Manarte et al., 2021), and response towards the world (Nicolet-dit-Félix et al., 2023). It can also cause changes of physiological conditions (Tyng et al., 2017). Official authorities have explored strategies to combat these issues. They were relevant to any aspect relating to comforts or emotions.

Knowing the factors affecting emotions the vital step of resolving problems relating to that. This has been widely investigated in recent years. The emotion is a complex perception that is affected by a variety of factors, subjective and objective. Generally, the subjective factor is essentially impactful (Wang, Chuanyi, 2024). Objectively, people are emotionally affected by various factors. This includes affairs taking places in human domestic lives and comforts against environmental qualities. Comfortable indoor spaces (including suitable temperature (Pradhan et al., 2024), lighting (Emara et al., 2024), noise level (Gordon-Hickey and Lemley, 2012), and space features) are all crucial to the psychologies of UndS (He et al., 2016). Lee et al. (2012) have studied the effects of temperature and lighting conditions on student psychologies, further influencing their learning performances. The similar result was acquired by Xiong et al. (2018). Noises, especially traffic noises, were crucially mental influential (Chen and Ou, 2021). It may be impactful on the central nervous system, increasing the levels of depression and anxiety (Chau et al., 2023), even causing behavioral problems and suicide (Hahad et al., 2024). Tests are crucial affairs taking places in students' lives and affecting them emotionally. This resulted from study pressures (He et al., 2023). The timetable of examination is also significantly influential on the psychological statements of test participants (Zhiyan, 2023). Anyway, student emotions are complexly impactful, especially college students. Subjective factors were effective in other aspects, people's psychological traits (Kamboj and Garg, 2021), emotional intelligence (Mercader-Rubio et al., 2023), coping mechanisms (Iryanidar and Irwan, 2023) are all impactful. They are difficultly controllable. As to the light, the intensity range between 300 and 500 Lux is voted to be comfortable for reading and officing (Landvreugd et al., 2024). Lower illuminance (such as 200 – 300 Lux) may be more suitable for resting and relaxation (Cai et al., 2024). Studies have also confirmed that nice-lighting exposure has a positive effect on mood (Landvreugd et al., 2024).

Earlier works have explored subjective responses toward either negative factor. They might be helpful for understanding emotion characteristics of samples. Findings of them could be available for emotion improvements. Nevertheless, limitations of them should not be neglected. Proportional studies focused on only one aspect of them. As a complex feeling, it is hard to be evaluated accurately by singly focused investigations. Hence, their results would be partially available. In fact, earlier studies have found, there were interactive effects between thermal discomforts and emotional stress (Wang and Liu, 2020). Also, as a significant event affecting mental conditions negatively, the test was rarely significantly researched. More profound explorations about subjective emotions therefore are still needed.

This study aimed to find the impacts of multiple factors on individual emotions for a special group in a period with thermal discomforts and mental stress. The whole work was processed by the following steps: 1) Selecting various sites as samples for sensing parameters of indoor environment qualities and collecting occupants' sensations during the period that emotions would fluctuate significantly; 2) Statistically associating subjective sensations with affecting factors to find their interactive relationships; and 3) Advancing a variety of strategies relating to indoor space design and occupant caring emotionally based on findings of this study.

2. Methodology

2.1. Study area

Mianyang (Fig. 1) is situated in the northwest of the Sichuan and has a subtropical-humid climate. With about 1,100 hours of annual sunshine, mean relative humidity between 70% and 80%, as well as air velocity of 0.8 to 1.6 m/s (Weather China, 2024), Mianyang is a highly humid and poor windy inland city. The air quality index (AQI (Horn and Dasgupta, 2024)) data indicates the city having nice air quality in the summer but bad in the winter. Local residents need to suffer from discomforts resulting from natural/social issues in various aspects.

2.2. Site selection

There are a couple of official institutes around Mianyang, such as Southwest University of Science and Technology (SWUST), Mianyang Normal University, City School of Mianyang etc. SWUST is the most important one among them. The main campus of SWUST locates in the Fucheng District (Fig. 2). The original area used to be Sichuan Branch of Tsinghua University (Li and Zhao, 2019). The whole campus is divided into 4 sections functionally, which is education areas, officing buildings, sports fields, and residential spaces. This study selected student dwellings as experiment sites (Li and Zhao, 2019). Male and female students accommodate in different districts despite in a same course. UndS of different genders showed various attentions biases toward emotional faces (Gong et al., 2013). Separate studies of male and female students were carried out. There are discomforts in various aspects in student residences. Physically, students in their residences were influenced by heat-stress and noises. Meanwhile, till the last month of each semester, they might get emotional stressed. Students' rooms were all equipped with air conditioners. However, they were incapable to avoid side effects resulting from extremely natural conditions and study affairs thoroughly. Occupants were also affected by various affairs psychologically.

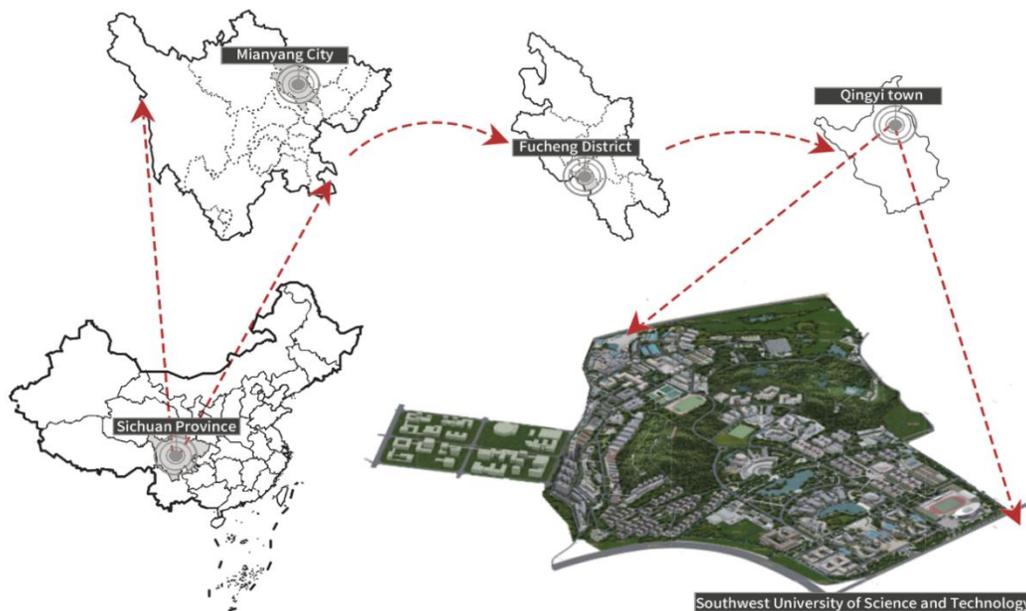


Fig. 1. Geographical locations of the sample city and research sites (Aliyun, 2022).

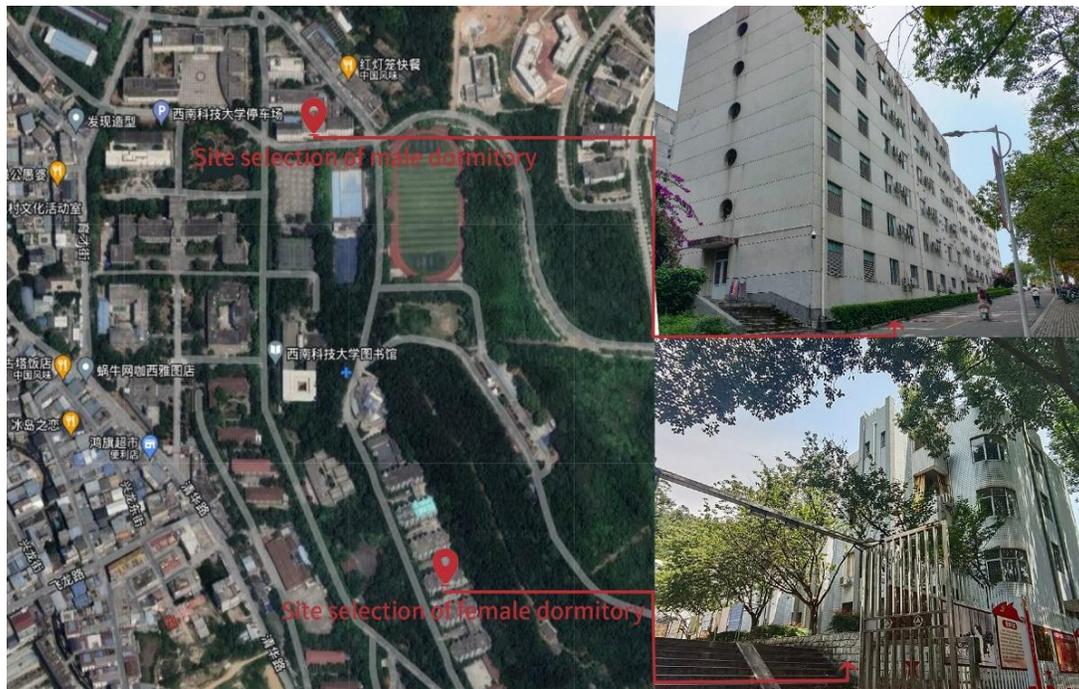


Fig. 2. The locations (in the campus) and surrounding environments of sample sites (Aliyun, 2022).

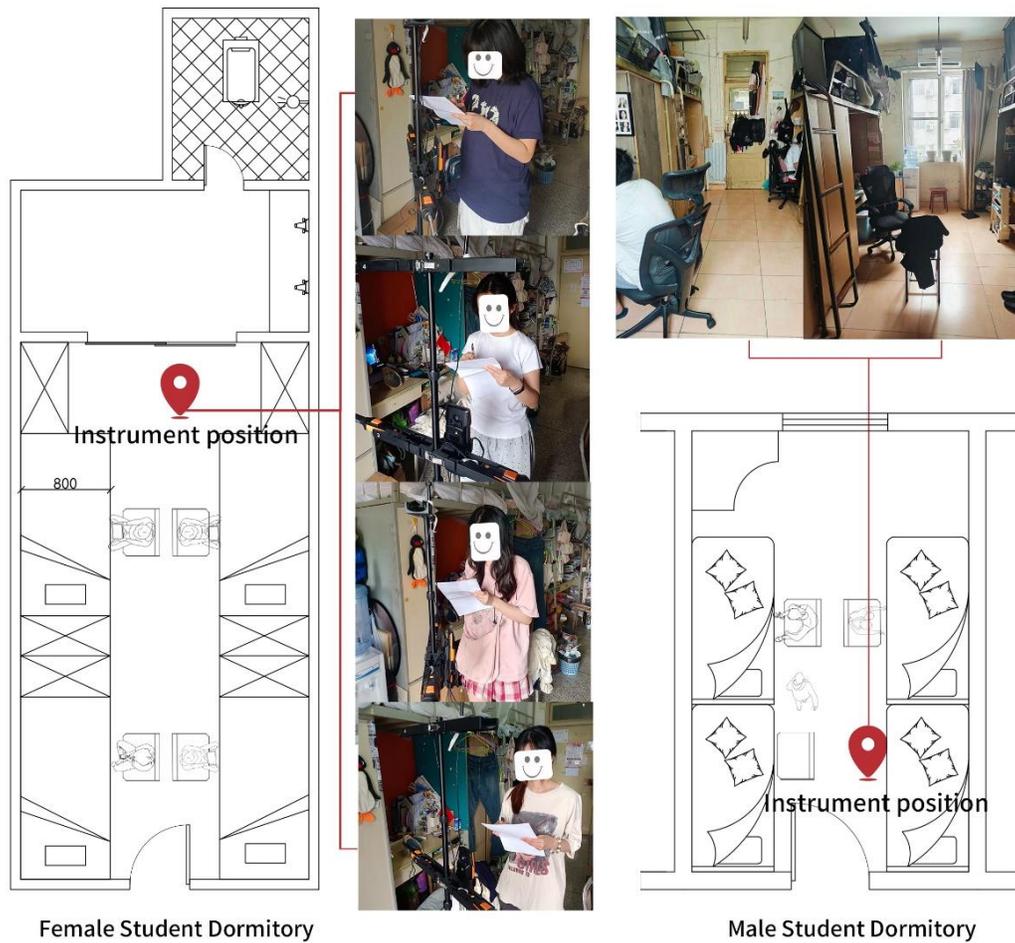


Fig. 3. Room plans and indoor environments of the sample residences.

2.3. Factors affecting emotions

2.3.1. Thermal, light, and sound environmental qualities (physics)

Indoor environmental qualities are complexly affected by various factors. This included thermal, visual, acoustic environments, and the air quality (An et al., 2024). Sample sites of this study are relatively significantly affected by extreme meteorology and noises; thus, factors about them were selected as keys for further exploration.

Dwellers suffered from severe heat stress during the summer (Wang et al., 2023). Indoor thermal comfort (ITC) (Buonomano et al., 2024) is a complex feeling affected by a variety of factors. Diverse meteorological parameters played different roles in that. There were a broad spectrum of complex indices proposed comprehensively evaluating that. The mean radiant temperature (MRT) is a popular one often available as the of root of complex indices, such as T_{op} (Zhang et al., 2023). It refers to the temperature of a black body that changes the same amount of thermal radiation with a human and the surroundings of the human (Hou et al., 2023), which is obtained from air temperature (T_a), globe temperature (T_g), and air velocity (V_a (Enescu, 2017)). MRT could be calculated by Equation (1).

$$MRT = [(T_g + 273)^4 + \frac{1.10 \times 10^8 V_{0.6}}{\epsilon D^{0.4}} (T_g - T_a)]^{\frac{1}{4}} - 273 \quad (1)$$

$$T_{op} = \frac{T_{mrt} + T_a}{2} \quad (2)$$

The T_{op} (Equation 2 (Yang et al., 2024)) is defined as the uniform temperature of an imaginary black enclosure in which an occupant would exchange the same amount of heat by radiation and convection as in the actual non-uniform environment. The T_{op} was used as the ITC index by a variety of studies (Sharma et al., 2024). Studies showed that during the summer, wearing light slacks, short-sleeved shirt chair, indoor operative temperature between 21.5 and 25.5 °C would be acceptable (Enescu, 2017). Indoor noises were impactful on people's health (Omeokachie et al., 2024), well-beings (Na et al., 2023), work efficiency (Shukla et al., 2024), and psychologies (Choi et al., 2023). The indoor acoustic environment has a significant influence on human task performing. The design of acoustic environment should consider the effect of sound (Reinten et al., 2017). According to sound pressure level (dB), noise that is abnormal or excessively loud might have a negative impact on people's health. Subjective sound sensations varied for A-Weighted equivalent continuous sound pressure level (LAeq, being united by A-dibel, dBA, Equation 3).

$$Leq = 10 \log \frac{1}{T} \int_0^T \left(\frac{P_i}{P_0} \right)^2 dt \quad (3)$$

The LAeq were divided into three ranges in regards with subjective responses, low (40 – 45 dBA), medium (50 – 55 dBA), and high LAeq (60 – 65 dBA) (Raimbault and Dubois, 2005), people would feel quiet, neutral, and loud in that ranges.

Humans are unable to survive without the supports of light. It affects human lives in various aspects. The influence of light environment on indoor life and mood is multifaceted (Landvreugd et al., 2024). Studies have revealed that indoor light environment not only affects visual comfort (Cai et al., 2024), but also has a profound impact on psychological and physiological feelings (Himschoot et al., 2024). Appropriate light intensity can reduce visual fatigue and enhance the experience of space use. LUX (symbolised as lx) is an international unit of illuminance that represents the luminous flux received per unit area. Specifically, when a luminous flux of 1 lumen (lm) is uniformly received over an area of 1 square meter, the illuminance is 1 LUX (Jay et al., 2021). Mianyang area belongs to Sichuan Basin, with more clouds and relatively low atmospheric transparency. The indoor natural illuminance varies significantly all year around (Tang et al., 2024).

2.3.2. Distances from the test

Students might be increasingly psychologically stressful as approaching to the test (Zhuo, 2010). The whole measurement was completed within 27 days. The distance from the test (DFTT) was defined as 1 to 27 regarding dates. It was used as another independent parameters. Volunteers would emotionally and/or psychologically vary between them.

2.4. Field measurement

2.4.1. Measurement location and objective data

The full-day measurements were carried out in students' (Class of 2021 in Architecture) residences in SWUST, which is titled as North 1 (N1, males, next to a campus avenue with vehicle sounds) and West 8 (W8, female, close to a hill with voices of birdsongs and insects), respectively. They are both air-conditioning rooms. Traffic and nature noises and extreme weathers might cause some discomforts.

The spring/ summer semester was chosen for measurement. The whole field survey ranged from late May to late June, totally around 4 weeks ahead the semester-end test. This period would be psychologically stressful and

emotionally fluctuated for academic obligations, including exams and assignments. Daily measurements ranged from 9:00 to 22:00, which is occupants' behaving period. There were two contents of data collected, objective physical environment qualities (acoustic & thermal environmental data) by instruments and subjective responses by questionnaire. There were two kinds of instruments, Testo 400 for meteorological parameters (T_a , T_g , & V_a), Delta OHM HD2102.2 for lx, and Testo 816-1 for LAeq. The instrument installation process (1.5 m above the ground) and selection were referring to ISO 7726 (1998) (Table 1).

Table 1

The instrument information (testo, 2024) (BLATN, 2019).

Instrument	Parameters	Range	Precision
Testo 400	Air temperature	-40 – +150 °C	±0.2 °C
	Relative humidity	0% – 100%	±1.8 %RH + 3 %
	Globe temperature	0 – 120 °C	±(0.3 + 0.1%)
	Air velocity	0 – 20 m/s	±(0.03 + 0.5%)
Testo 816-1	A-weighted sound pressure level	30 dB – 130 dB	/
Delta OHM HD2102.2	illumination intensity	0.01199-99LUX	1 LUX
		199.99-1999.9LUX	
		1999.9-19999 LUX	

2.4.2. Questionnaire

Subjective perceptions were collected by the questionnaire combining with the field monitoring simultaneously. This included their responses toward every emotionally influential factors. All responses were numerically modelled in regards with ISO 7726 (1998) and/or Standard (1992). They mostly divide people's sensations into seven scales, from -3 to 3. This study used thermal sensation vote (TSV, cold -3 – hot 3 (Yuan et al., 2023)), light sensation vote (LSV, very dark -3 – very light 3 (Lam et al., 2020)), acoustic sensation vote (ASV, very quiet -3 – very loud 3 (Bhandari et al., 2024)), emotion state vote (ESV, very angry -3 – very pleasant 3 (Kim and Hong, 2023)), and psychology state (very anxious -3 – carefree 3 (Gamero-Salinas et al., 2024)). Participants were asked to stand for 10 minutes at the sensors before being interviewed to ensure they have been adapted to the current environment. Each questionnaire took about 1 or 2 minutes. A total of 1267 questionnaire sheets were collected. The detail contents of questionnaire are listed in Table 2.

2.5. Data analysis

The multiple linear regression (MLR) was used for data analyses (Scribbr, 2024). A dependent variable's linear correlation with a or several independent variables could be predicted. People's perceptions would be influenced by many elements. There were Bayesian or multiple models utilised in different steps of the analyses. People had specific response towards a certain single element, such as TSV on T_{op} . They were associated by the Bayesian model. In contrast, some perceptions would be affected by a variety of factors complexly, i.e., the emotion being impacted by environments and/or personal affairs. The multiple models were applied by them. This study has considered interactive correlations between various parameters varying for time. As a result, further analyses were implemented by separated periods. The whole field survey was carried out by 27 days, which can be divided into four weeks. The

week starting since 20 May 2024 was defined as Week 1. The analyses included two parts, Step 1 focused on data of the whole period, while Step 2 analysed that for each week, which is a division from Week 1 to Week 4.

Table 2

Questions in the questionnaire sheets

1. What is your current location (fill in the room number)?

2. Current time (by instrument reading) ___Year, ___month, ___day, ___hour

3. What is your gender?
A. Male B. female

4. What is your current thermal Sensation Vote (accurate to 0.1)?

-3 -2 -1 0 1 2 3
 Cold Cool slightly cool Neutral Slightly warm Warm Hot

5. What is your current acoustic sensation vote (accurate to 0.1)?

-3 -2 -1 0 1 2 3
 quiet Very quiet slightly quiet moderate slightly noisy noisy very noisy

6. At present, the time of the nearest test you are to is ___ days (fill in the number directly).

7. What is your current emotion vote (to the nearest 0.1)?

-3 -2 -1 0 1 2 3
 Very angry angry slightly angry moderate slightly pleasant pleasant very pleasant

8. What is your current psychological state (to be accurate to 0.1)?

-3 -2 -1 0 1 2 3
 Very anxious anxious slightly anxious moderate slightly relaxed relaxed very relaxed

9. What is your current light sensation vote (accurate to 0.1)?

-3 -2 -1 0 1 2 3
 Very dark Dark slightly dark moderate slightly light light Very light

10. What kind of behavior are you currently hoping to regulate your emotions?

3. Results

3.1. Neutral points towards various environments

3.1.1. Responses toward thermal environments

The TSV was associated with T_{op} of different genders by bin method for the whole period. They showed significantly positive correlations. The increases of T_{op} by 1 °C resulted in TSV rises of 3.4 (male) and 0.9 (female)

respectively. This exported NT_{op} of 23.22 (males) and 24.20 °C (females). Male students were less thermally tolerable than females since the lower NT_{op} output.

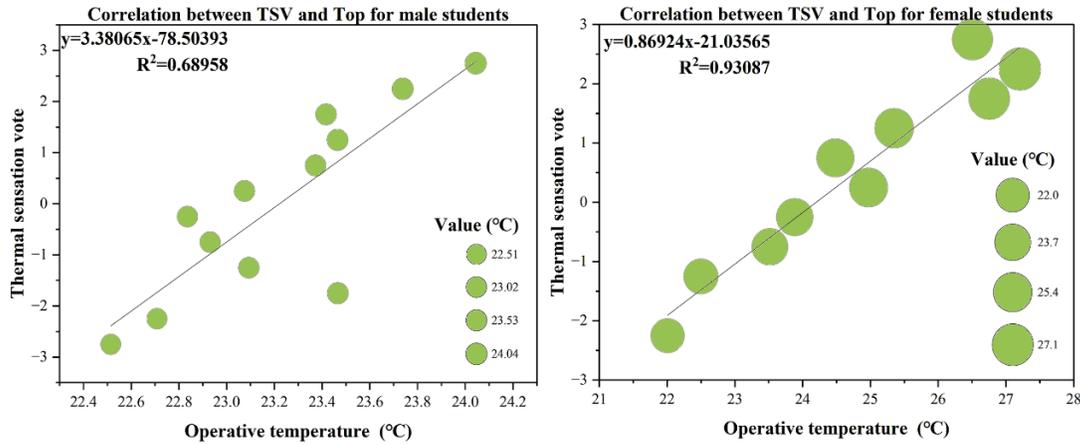


Fig. 4. Linear correlations between TSV and T_{op} for students of different genders

Volunteers’ thermal responses varied for psychological conditions. As their psychologies changed for distance to the test, the TSV were associated with T_{op} weekly (Figs. 5 & 6). They varied for each other slightly despite of all significantly positively correlating, which exported various NT_{op} in various weeks. Male students’ NT_{op} were 23.6, 23.6, 22.5, and 23.2 °C, whereas that for girls 26.5, 25.4, 23.5, and 23.3 °C (from Week 1 to Week 4). It can be seen, indoor occupants’ NT_{op} descent as getting closer to the tests. Thus they were less thermal (hot) tolerable as being more mentally stressful.

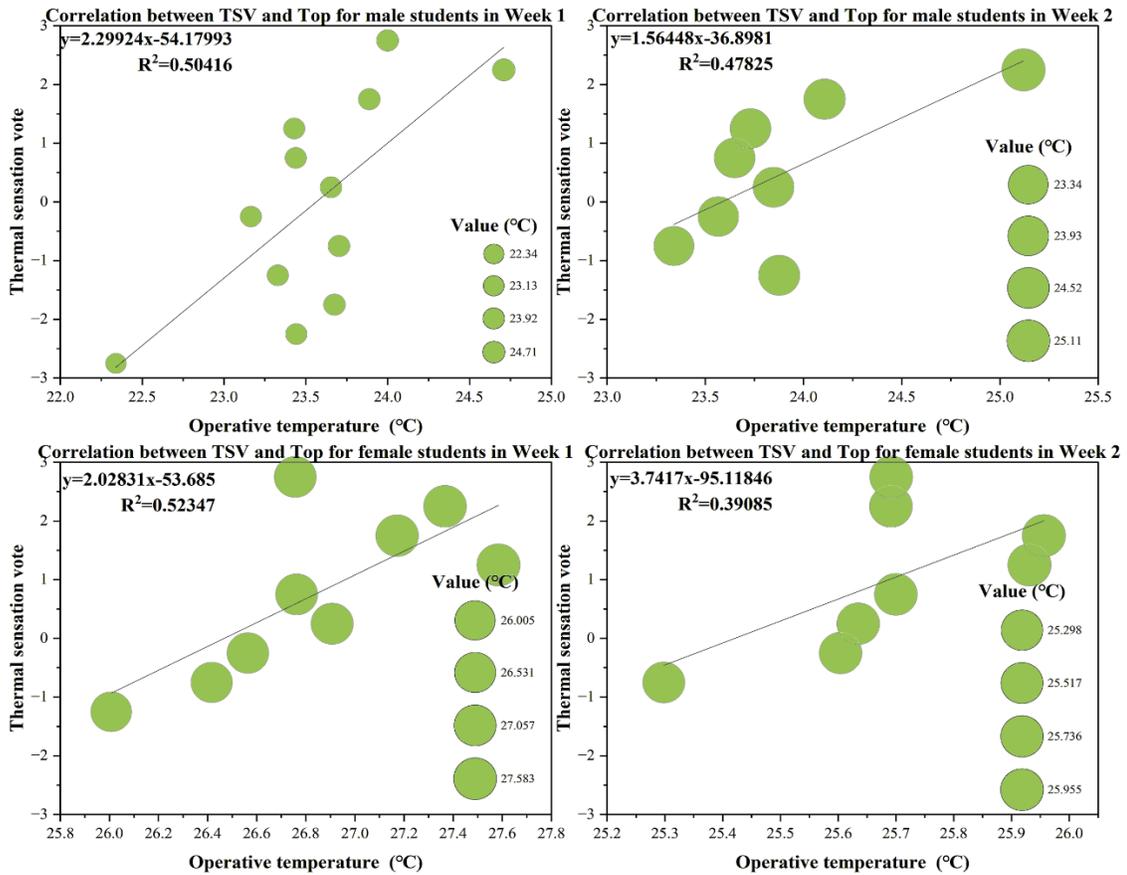


Fig. 5. Linear correlations between TSV and T_{op} indifferent genders for Weeks 1 & 2.

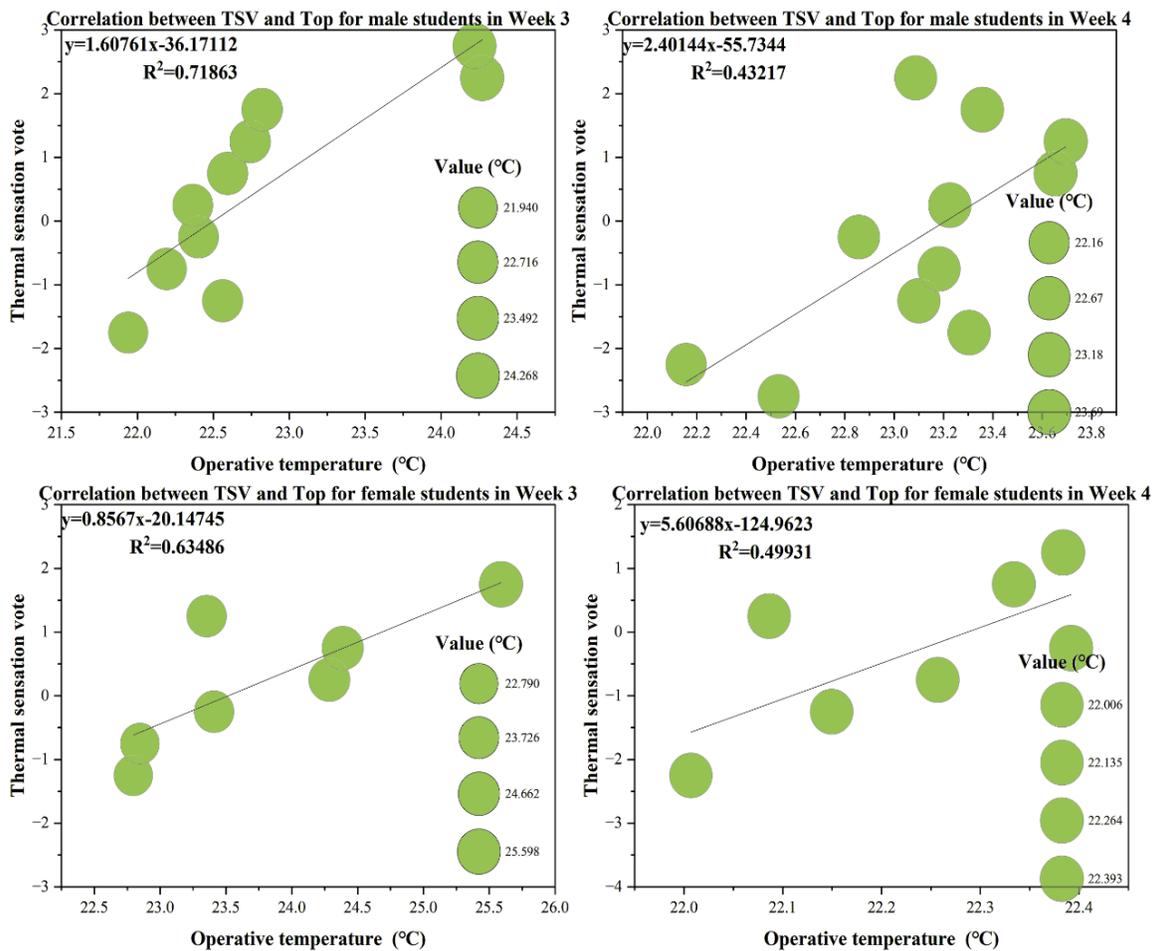


Fig. 6. Linear correlations between TSV and T_{op} for different genders in Weeks 3 & 4.

3.1.2. Responses toward acoustic environments

Linear correlations between ASV and LAeq for the whole period are illustrated in Fig. 7. They were generally positive correlating but slightly different. The study findings of acoustics showed comparable patterns with thermal perceptions. They showed similar trends but were considerably different. Male students were less acoustically sensitive than females in the image. This output NLAeq values of 45.80 dBA (male students, $R^2 = 0.24$) and 47.14 dBA (female students, $R^2 = 0.72$). Data of males expressed poor correlations (the low R^2 value).

Acoustic data in each week was further analysed (Figs. 8 & 9). There were some unusual phenomena on weekly acoustic sensation found. Apart from poor correlations (males in Week 2, $R^2 < 0.24$), even negative associations (males in Weeks 2 & 3 and females in Week 3) were witnessed. That is to say, students were not significantly affected by noises in their rooms. Therefore, they were not always acoustically sensitive in their rooms. They might enjoy good sound environments. Thus, based on this situation, further discussion about the NLAeq variation would be poor valuable.

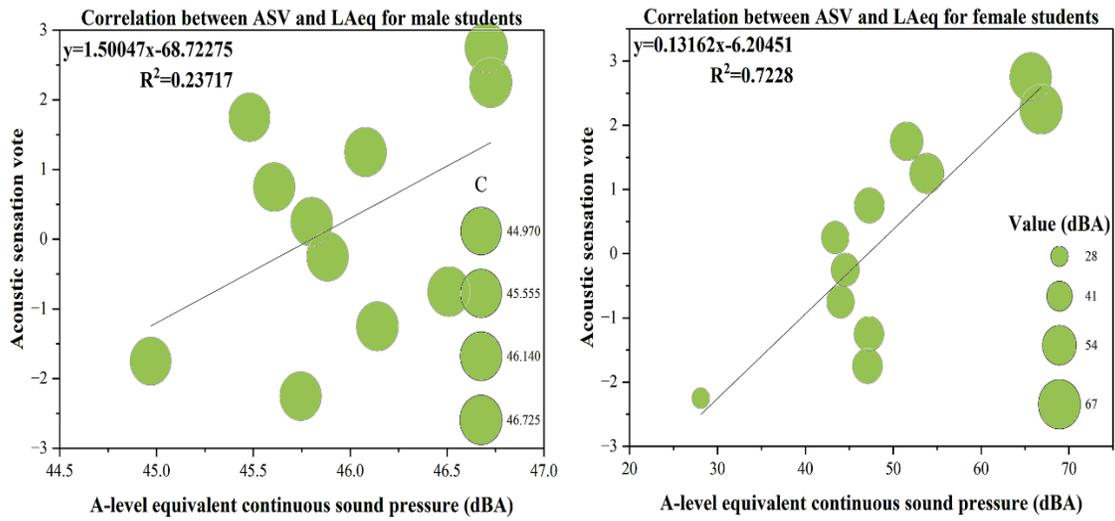


Fig. 7. Linear Correlation between ASV and LAeq for male and female students in the whole period.

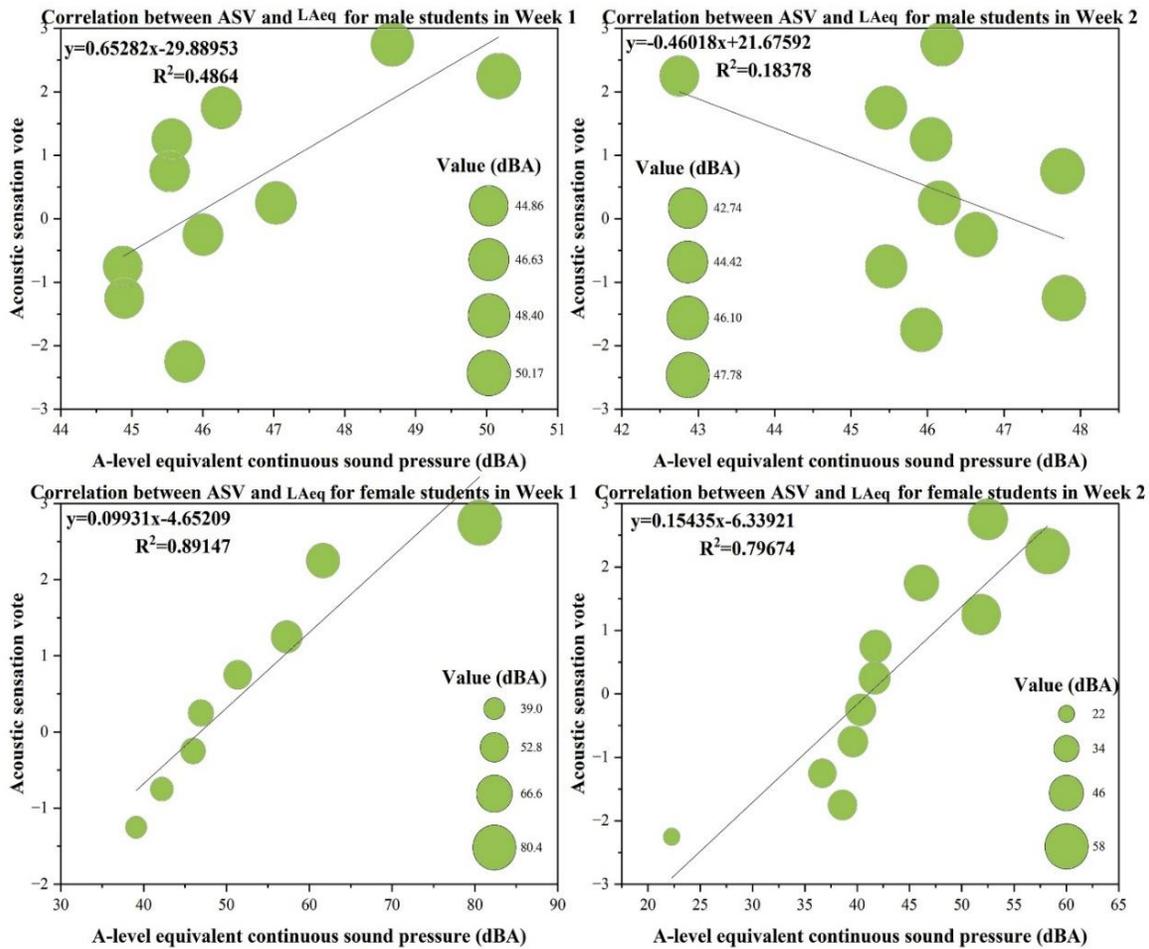


Fig. 8. Linear correlations between ASV and LAeq indifferent genders for Weeks 1 & 2.

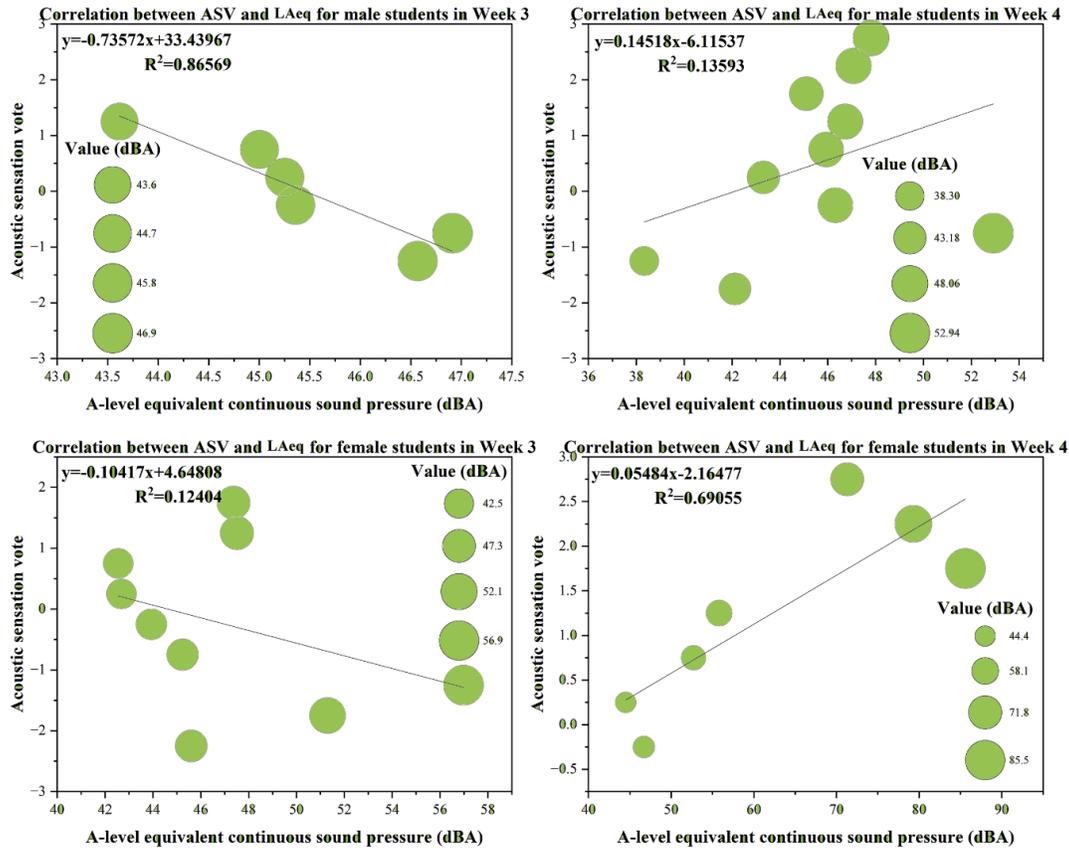


Fig. 9. Linear correlations between ASV and LAeq for different genders in Weeks 3 & 4.

3.1.3. Responses toward light environments

Volunteers were found sensitive with light environments. Significant positive linear correlation between LSV and illumination intensity were witnessed over the whole period. This output NLUX values of 31.07 LUX (male students, $R^2 = 0.67$) and 55.33 LUX (female students, $R^2 = 0.91$). Females were more tolerable on strong lighting (higher neutral value) and more visual sensitive ($R^2 = 0.91$).

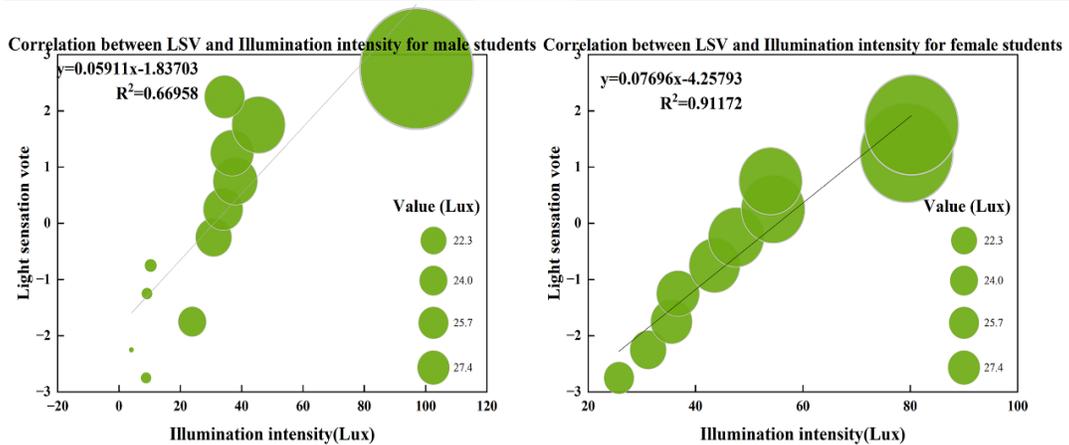


Fig. 10. Linear Correlation between LSV and illumination intensity for male and female students in the whole period.

Their light sensations were also further regressed in various periods separately. Nevertheless, still some unexpected phenomena revealed. Occupants' responses varied between the four weeks significantly irregularly. Significant and poor correlations were observed, and unusual neutral values were exported. For instance, as to males in Week 1, very little sensitivity was witnessed ($R^2 < 0.1$). This exported a non-valid neutral lux value. Hence, it is hard to say, whether people would be affected by the test timetable visually.

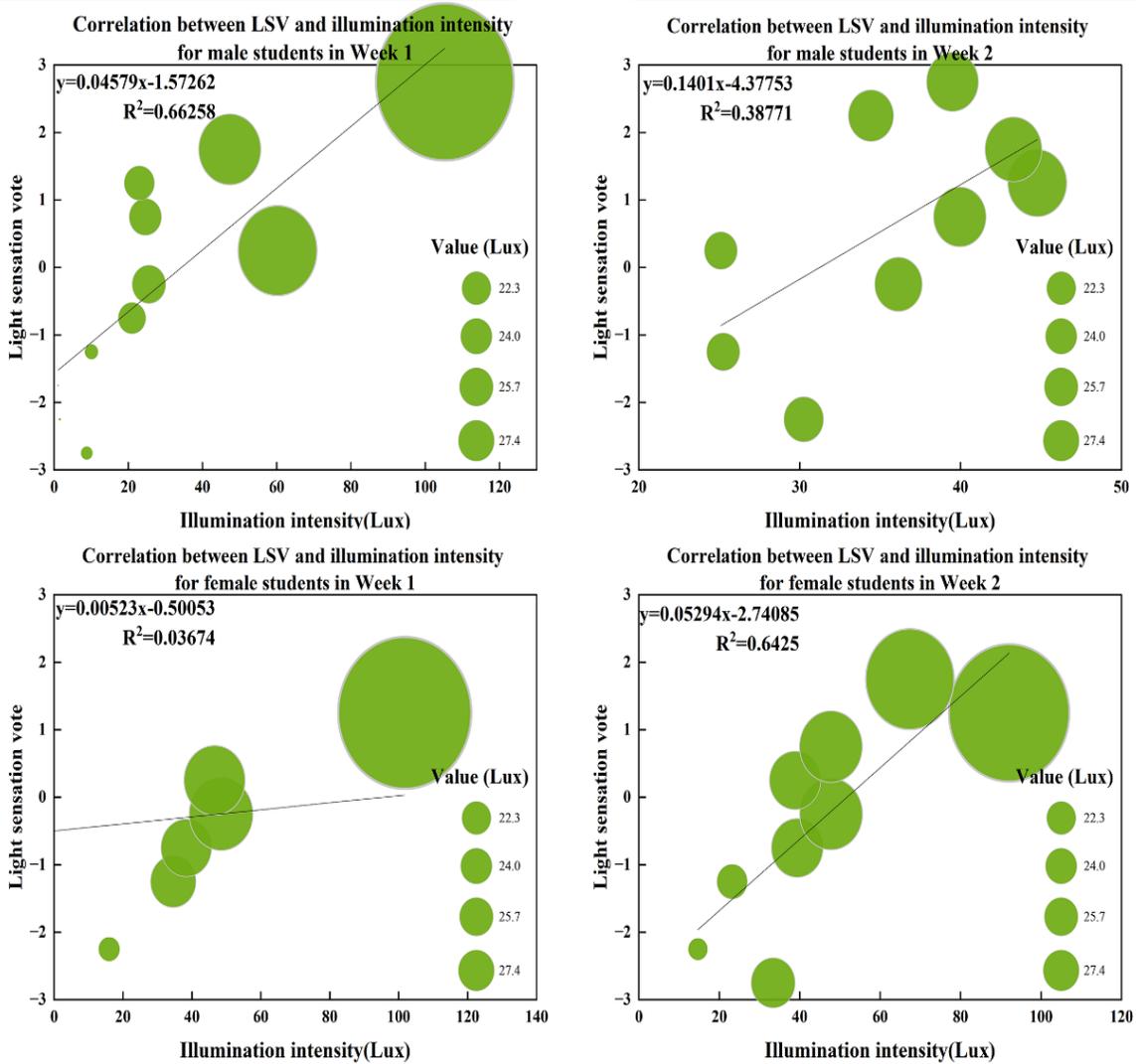


Fig. 11. Linear correlations between LSV and illumination intensity in different genders for Weeks 1 & 2.

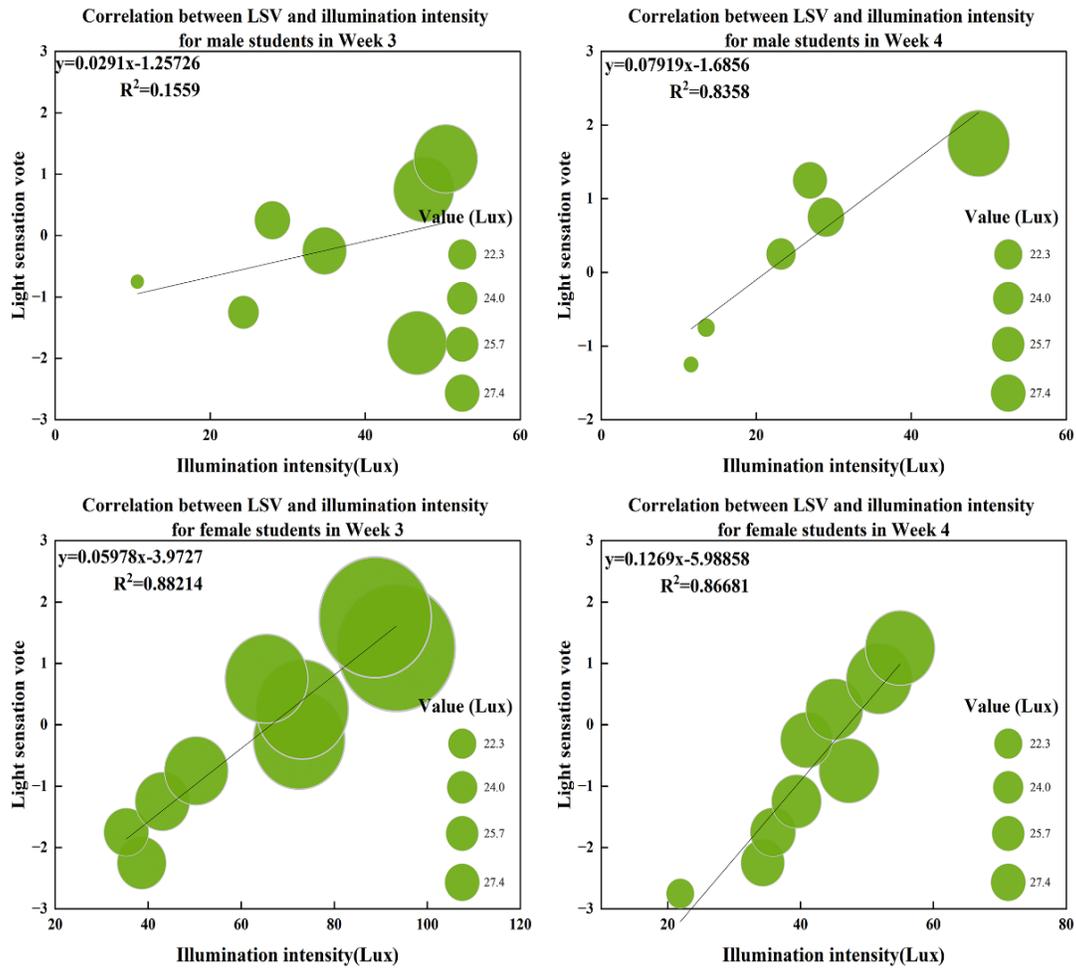


Fig. 12. Linear correlations between LSV and illumination intensity in different genders for Weeks 3 & 4.

3.2. Crossed effects of various factors

3.2.1. The effects of factors on emotions

a) The effects for the whole period

The student emotion is a complex feeling that would be affected by many factors. This study considered environmental problems faced by them regarding the test timetable (DFTT) for deep analyses. They were associated with each other by multiple models linearly, which exports Table 3. Models 1 (males) and 2 (female) were established based on them. They showed significant statistical associations.

Model 1 Males: $ESV = 0.417T_{op} - 0.070 LAeq + 0.006DFTT + 0.006LUX - 6.307$ ($R^2 = 0.397$, sig. < 0.001)

Model 2 Females: $ESV = -0.457T_{op} - 0.019 LAeq + 0.139 DFTT + (-4.502E-5) LUX + 10.437$ ($R^2 = 0.597$, sig. < 0.001)

The four factors were impactful differently. This was. Male and female students both were emotional free at quieter circumstances and/or when being far from the test. The sound expressed slight effects, increasing LAeq by 1 point caused the ESV decreases of 0.070 (males) and 0.019 (females) only, respectively. Meanwhile, they had better

emotions at time farther from the test. Approaching to the test by 10 days would reduce ESV declines of 0.006 (male) and 0.139 (females), respectively. It means, female students might be more intensively affected by the test. Thermal environments were impactful with confusion. They expressed opposite trends between two genders. The increase of T_{op} by 1 °C resulted in ESV decrease by 0.417 for females whereas increase by 0.457 for male ones. For every 1 lx increase in male students, ESV increases by 0.006 (sig. < 0.01), meaning they preferred becoming lighter. Light environments in female room showed very insignificant emotional impacts as a high significance value witnessed (sig. = 0.970). Apart from DFTT, all the three parameters presented confused effects on emotions, which might result from the variation their study contexts.

Table 3
The relationship between objective factors and ESV in male and female students

Model 1	Unstandardised Coefficients		Standardised Coefficients		t	Sig.
	β	Std. Error	Beta			
(Constant)	-6.307	1.619			-3.896	< 0.001
T_{op}	0.417	0.051	0.455		8.174	< 0.001
LAeq	-0.070	0.021	-0.158		-3.294	0.001
DFTT	0.006	0.004	0.090		1.528	0.128
LUX	0.006	0.001	0.214		4.182	< 0.001

Model 2	Unstandardised Coefficients		Standardised Coefficients		t	Sig.
	β	Std. Error	Beta			
(Constant)	10.437	1.204			8.665	< 0.001
T_{op}	-0.457	0.053	-1.613		-8.616	< 0.001
LAeq	-0.019	0.002	-0.366		-8.948	< 0.001
DFTT	0.139	0.012	2.185		11.799	< 0.001
LUX	-4.502E-5	0.001	-0.001		-0.037	0.970

3.2.2. Cross-influence of subjective perception on sentiment perceptions

a) Emotions toward various subjective perception for the whole period

Subjects’ responses towards various aspects played different roles in their emotions. They were associated with ESV for finding the performance of either perception (Table 8). Overall, students’ emotions were affected by thermal and psychological conditions more significantly. They both expressed positive correlations. That is to say, warmer environments and/or better psychologies could cause nice emotions. In contrast, acoustic environments were insignificantly impactful with the emotions. This could be explained by low coefficients and confused trends. They were positive for males but negative for females. Performances subjective perceptions were slightly different from that of objective parameters but little side effect.

Model 3: Total (males): $ESV = 0.229TSV + 0.075ASV + 0.546PSY + 0.046LSV + 0.081$ ($R^2=0.759$, sig. = 0.003)

Model 4: Total (females): $ESV = 0.478TSV - 0.193ASV + 0.181PSY - 0.049LSV - 0.046$ ($R^2=0.661$, sig. = 0.164)

Table 4

The relationship between subjective factors and ESV in male and female students.

Model 3	Unstandardised Coefficients		Standardised Coefficients		t	Sig.
	β	Std. Error	Beta			
(Constant)	0.081	0.027			2.998	0.003
TSV	0.229	0.027	0.320		8.636	<0.001
ASV	0.075	0.022	0.100		3.356	<0.001
PSY	0.546	0.033	0.614		16.518	<0.001
LSV	0.046	0.020	0.075		2.301	0.022

Model 4	Unstandardised Coefficients		Standardised Coefficients		t	Sig.
	β	Std. Error	Beta			
(Constant)	-0.046	0.033			-1.395	0.164
TSV	0.478	0.043	0.619		11.101	<0.001
ASV	-0.193	0.049	-0.192		-3.953	<0.001
PSY	0.181	0.054	0.213		3.369	<0.001
LSV	-0.049	0.056	-0.034		-0.880	0.380

3.2.3. Emotional and psychological status

DFTT was the factor showing significant and fixed effects on emotions. It was associated with the ESV and Psy by Bayesian linear models independently. Males and females expressed slightly different emotional and psychological changes toward DFTT (Fig. 10). They expressed general positive correlations although polynomial associating. That is, students were increasingly psychologically stressful as approaching to the test. Nevertheless, female students showed more significant positive relationships ($R^2 = 0.76$ and 0.45), compared with 0.61 and 0.37 (males). Meanwhile, relative noticeable changes were seen from DFTT 1 to 15, they were kept steady even falling from Day 16 to 27. That is to say, people's mental stresses were more significantly correlating with the distance if closing to that, especially the last two weeks. Students were insignificantly affected by the test timetable if 2 weeks or more away from that. This regular generally echoed the results in multiple models.

3.3. Approaches for emotional adaptations

Students were interviewed about their preferred actions for emotion adjustments. Their selections focused on sleeping (nearly 50%), adjusting modes of air-conditioners (10% for on or off), and studying (10% in females). There was also slight difference between males and females. Their percentages of preferring sleeping were close. However, more men (17.9%) thought that air conditioners were emotionally adjustable than women (7.6%). Females also relied on cell phones (11.4%) or going over (8.9%) for emotion stress release. There were also other options, such as sports, playing games, rests, sharing ideas with others were all available. They were voted by around 5% of volunteers.

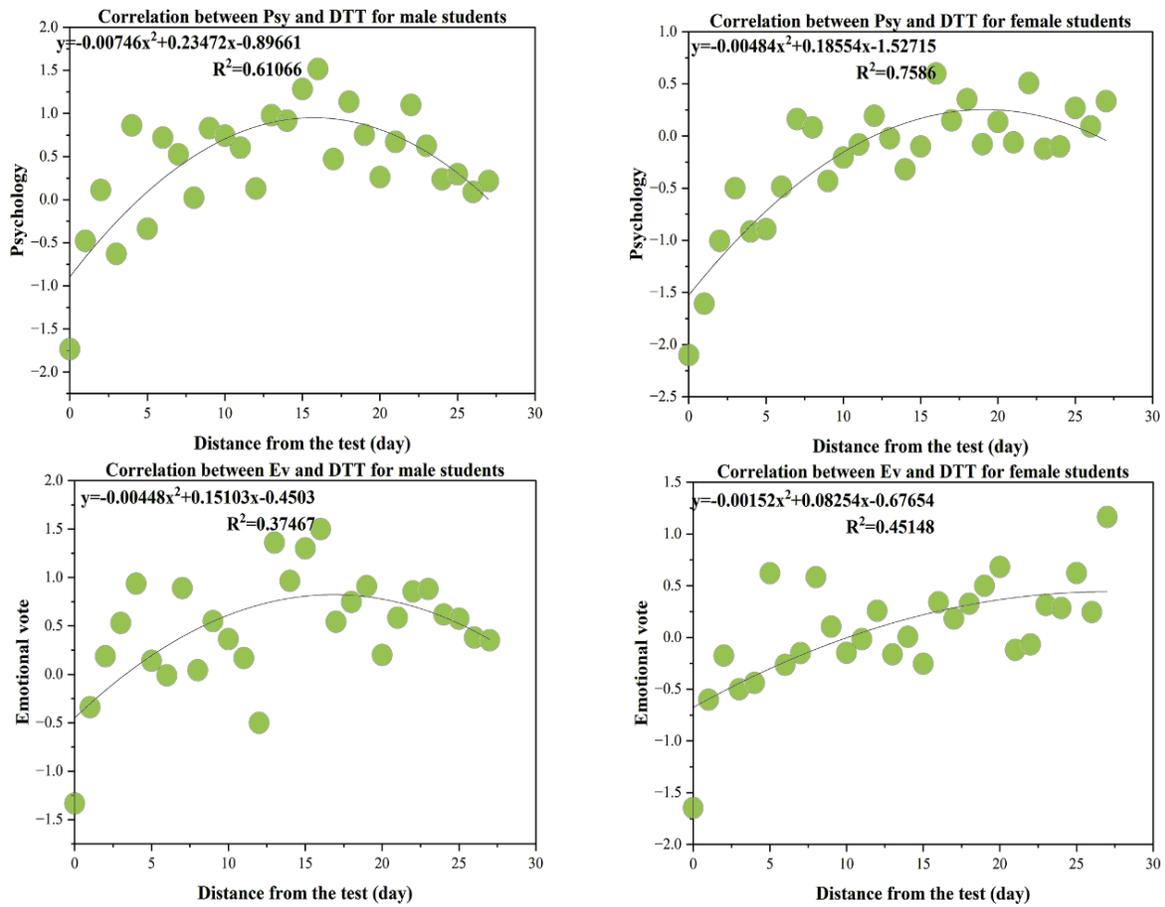


Fig. 13. Correlation between Psy and ESV and DFTT for all students during the survey period.

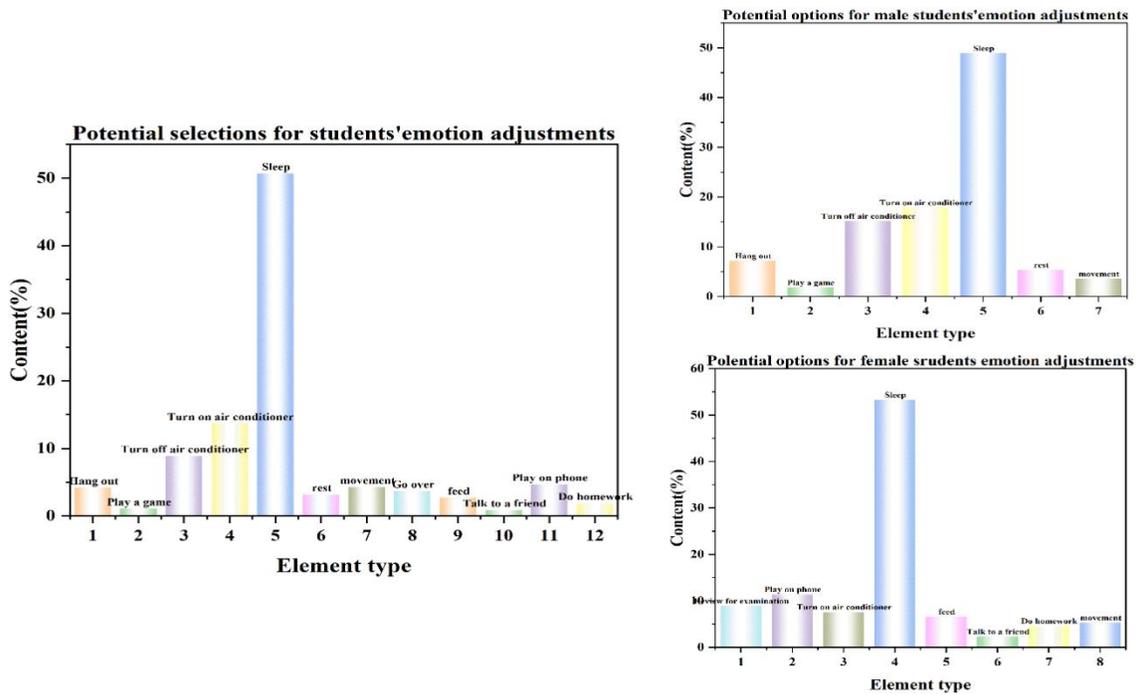


Fig. 14. Potential selections for students' emotion adjustments.

4. Discussion

This study has explored the factors affecting students' emotions during the period close to the test. There were several pieces of findings acquired: students were significantly thermally sensitive but partially acoustically sensitive in their rooms; they were emotionally depressing as approaching to the test; emotional impacts of various factors change for distance from the test. These findings could be explained by various principles (Xu Yao et al., 2024)

There is a positive linear relationship between TSV and operative temperature (T_{op}). They output NT_{op} of 23.22 °C (male) and 24.1 °C (female). This was reasonable in regards with the latitude of Mianyang (Zhang et al., 2023). Female students presented slightly higher NT_{op} than males. That is to say, males were less hot tolerable than females. This was similar with the results of outdoor studies (Cohen et al., 2019).

Volunteers were partially acoustically sensitive and relatively low $NLAeq$ was found. This might be because of the good acoustic environments of the rooms. Fig. 12 illustrates ranges (Boxplots) of indoor acoustic conditions during the measurement. The L_{Aeq} ranges of males kept steady (proportionally 40 – 50 dBA) and were remarkably lower than that of females. It was mostly below human neutral points. Meanwhile, volunteers (male students) were hard to have considerable sensation variation in such a narrow range. This could explain their poor acoustic sensitivities of male students. They were generally under persons' acoustic accepting range (Peng et al., 2023).

Female students expressed a higher neutral illumination value. This might result from, the variation of their contextual lighting conditions. Girl students might have adapted to the lighter context physiologically, causing their higher neutral value, which is observable in Fig. 15.

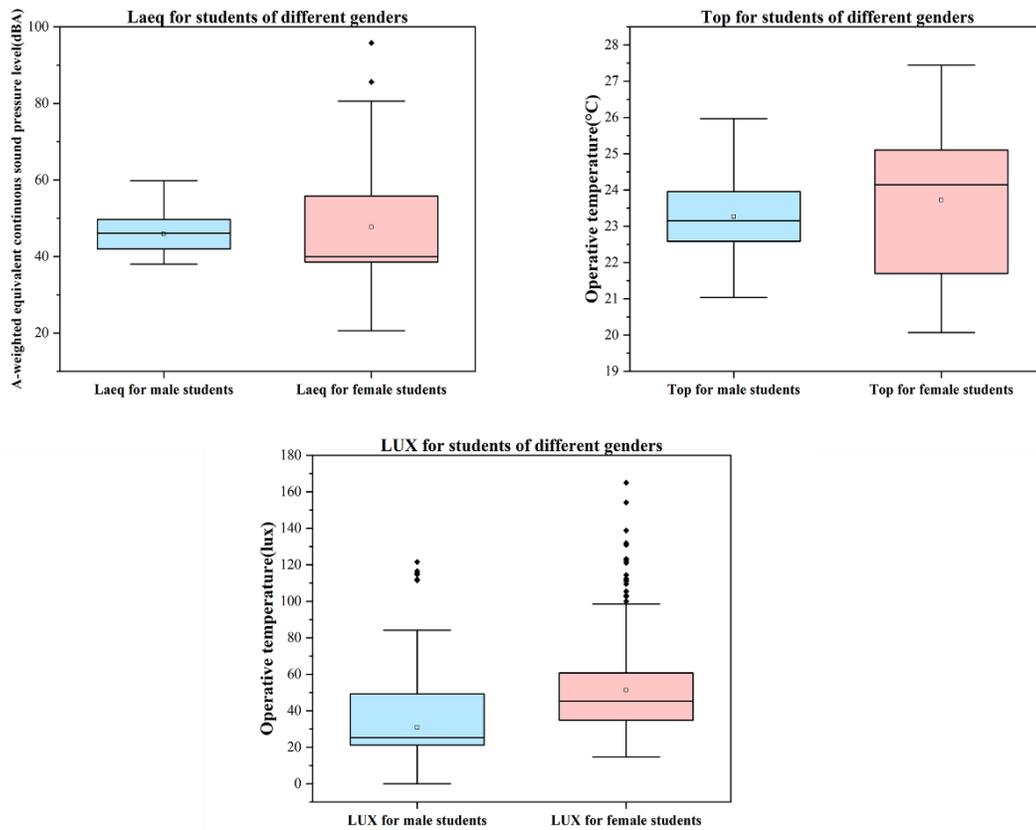


Fig. 15. Ranges of LAeq ,T_{op} and LUX for male and female students for the whole measurement period.

People’s thermal sensations varied for distance from the test. Their NT_{op} decreased as closer to the test (Wang and Liu, 2020). Earlier studies have confirmed the interactive impacts between thermal comfort and mental conditions (Gillerot et al., 2024). This could be explained by total comforts. During the summer, higher temperatures mean more heat stress, and being closer the test mean more psychological stress (Xinyan et al., 2016). The emergencies of both would cause more significant overall discomforts. As a result, occupants hoped suffering from less heat stress as psychological pressure increasing; they need to reduce one aspect of stress to balance their physiological conditions. Moreover, the four weeks witnessed poor regulars against light and acoustic environments. The Fig. 15 has illustrated the ranges of LAeq and LUX. They would be more acceptable than seasonal heat stress.

Students’ emotions were commonly affected by various factors and their impacting levels varied for psychological contexts. The T_{op}, LAeq, and DFTT were found influential in different trends and degrees. As to their effects in the whole period, DFTT showed positive correlations with ESV for both males and females. However, LAeq was generally negatively associating in two models, and T_{op} was confusedly influential. This is conflicting with some general knowing. Higher temperatures would cause more heat stress during the summer (Strengers et al., 2024), while louder environments might result in bored emotions (Thompson et al., 2022), regarding normal conditions. There were also some unusual phenomena found. Factually, Figs and have illustrated the ranges environmental quality parameters. It can be seen, they had mean values of 23 (males) and 24 (females) °C as well as 45 and 39 dBA. They were kept around or lower than their neural points. The volunteers also stated that they set very low temperatures for air-conditioners during the survey. Hence, they hoped being warmer and/or loud to be emotionally

well. Humans' bad emotions against poor environment quality could be resolved by proper design works or equipment.

Volunteers' emotions positively correlated with thermal environments but varied for periods. This could be explained by the special conditions of the experimental environments. As the effects of air conditioners and nice soundproof design works of building envelopes, occupants might have enjoyable indoor environments relating to physics. Insignificant thermal and acoustic stresses cause unusual findings of this study. Acoustically, in addition to male rooms being insignificantly affected by noises, females were found relatively sensitive with nature sounds around from the nearby hill. There are a vast of people enjoying this type of voice, but not all (China, 2021). This might be another reason of the confused emotional impacts of acoustic environments. Affecting intensities of various factors varied for contexts, especially psychology fluctuations. This could be explained by both coefficients and significances. As to males, the coefficients expressed positive changing trends from Week 3 to Week 4. Therefore, the test was increasingly impactive as getting close to the test. As the increase of pressure from one aspect, people's attentions on other aspects reduced (Jiajue, 2024). They might focus on the test schedule and ignore the effects resulting from hot stress. There is a close relationship between light perception (Liu et al., 2024) and emotional state (Li et al., 2024), and physical factors (Tamura et al., 2021) such as light intensity, color temperature and light cycle have significant effects on emotional state. Light not only directly affects mood, but also indirectly affects emotional states by regulating physiological rhythms. In optics, there are significant differences in sensitivity and preference for light (Oh and Lim, 2025). The human eyes have a strong adaptation to light intensities (Zhang et al., 2024). They may not feel remarkable unsuitable if long-term exposure. Influences of that varied between the two genders. This could be explained by the variation of their lighting conditions. Fig. 15 has presented, rooms of female students were obviously lighter. They might feel respective dark (males) or light (females). Anyway, it can be seen clearly, lighting conditions showed significant effects on occupants' emotions. Darker or lighter environments would cause emotional fluctuation. Female students were affected lighting very inconsiderably. Fig has illustrated, the indoor environments were closer to volunteers' points. That is, suitable lighting environments could cause nice perceptions.

They were also emotionally and psychologically affected by the test (Loder, 2024). This could be seen from their emotion waves toward distance from the test. Fig. 10 illustrates that they have better emotions when farther from the test; this was expressed by the positive correlations between votes and DFTT. They showed, in addition, polynomial relationships more exactly. Relative noticeable changing trends were witnessed in the DFTT range between 1 and 14 (the last 2 weeks to the test). On the contrary, within the DFTT range from 15 to 27; their votes kept steady and even declining trends. That is to say, students were significantly affected by the test as the last 2 weeks. This is similar with that revealed in multiple models. They entered into the conditions of test psychologically as finally two weeks from that. In fact, students are not only affected by the test during the final half a month of the semester. Undergraduates majoring in Architecture (volunteers of this study) need overnight graphing for their assignments (architecture, 2022). The test and drafting have resulted in overload works causing serious mental pressures (Souza-Talarico and Coelho, 2023).

There were a variety of approaches selectable for students' emotion adjustment. Sleeping was opted by the most (approx. 50%), which is followed by switching the air-conditioners (about 10%). They could enjoy their cell phones, go over, and/or communicate with others to release emotion stress (less than 10%). This was expressed in the statistics of Fig. 11. It can be seen, a lack of sleep is the key problem faced by current university students (Daily, 2023), especially architectural undergraduates (architecture, 2022). Cell phones have been the key element in the

present-day lives. They are broadly used for daily leisure (Technology, 2023) and pressure release (Zhi, 2023). Studying was selected by some persons as finishing the academic task is essential for students. Taking to others has been proved physiologically adjustable.

Findings of this study would be practically impactful. Students' emotions toward environment qualities relating to physics could be adjusted by proper design and/or equipment. Their emotions were influenced by affairs in domestic lives. As to tests and/or academic assignments, the last two weeks were essential. Undergraduates need to be specially cared during this period. Current students are seriously lacking sleep. They require more resting time instead of endless overload missions. University staff are responsible to communicate with students to know their situations timely for avoiding certain consequences in root.

5. Conclusions

This study has explored the effects of environment qualities and subjective factors on undergraduates' perceptions during the examination month. It was found that they were sensitive comprehensively and various influential factors were interactively influential. Essential findings are presented as follows.

- ✓ Students were significantly thermal sensitive in rooms, outputting NT_{op} of 22.8 °C (males) and 24.1°C (females), respectively.
- ✓ They were partially affected by acoustic environments, since nice indoor sound conditions.
- ✓ Light environments showed important sensation impacts, exporting neutral values of
- ✓ 31.07 (males) and 55.33 (females) lx.
- ✓ Volunteers were increasingly heat sensitive as getting closer to the test, e.g., female NT_{op} decreased from 26.5 to 23.3 23.3 °C between Week 1 and Week 4.
- ✓ Thermal, light, and acoustic environments as well as distance from the test affected people emotionally commonly; they were increasingly stressed as getting closer to the test; nevertheless, all the three factors to physics might positively affect ESV as proper settings.
- ✓ Students' ESV decreased from Day 1 to Day 27 but remarkable linear change took place in the last 2 weeks before the test.
- ✓ Volunteers preferred sleeping, switching air-conditions, and playing cell phones as behaviours for emotion adaptation and pressure release.

Undergraduates have very complex emotions under the pressure of test; that relating to environment qualities could be adjusted by building equipment (thermal, lighting, & acoustics); but they still need specific caring, such as communication.

Conflict of interests

There is no conflict of interest in this study.

Data availability statement

The data of this manuscript are temporally unavailable dur to other uses.

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